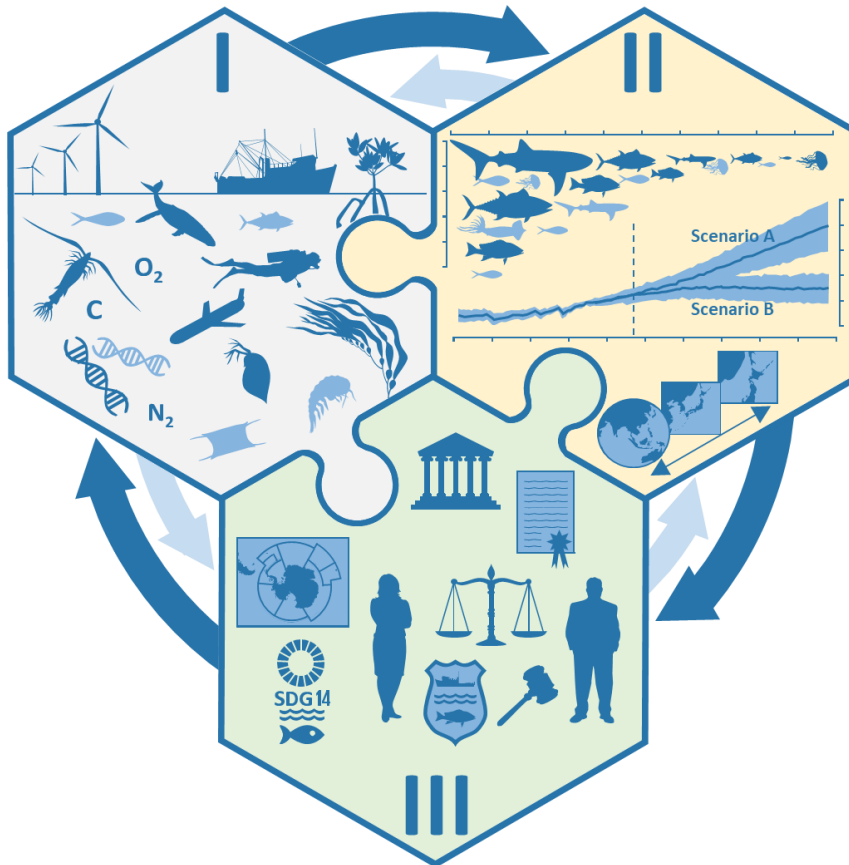


**Annual Report to SCOR**



**2022 - 2023**

**Ocean Sustainability under Global Change  
for the Benefit of Society**

prepared by John Claydon

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### A. IMBeR STRUCTURE and OPERATIONS

Integrated Marine Biosphere Research (IMBeR) is an international research project with a vision towards *Ocean sustainability under global change for the benefit of society*. IMBeR is co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and Future Earth.

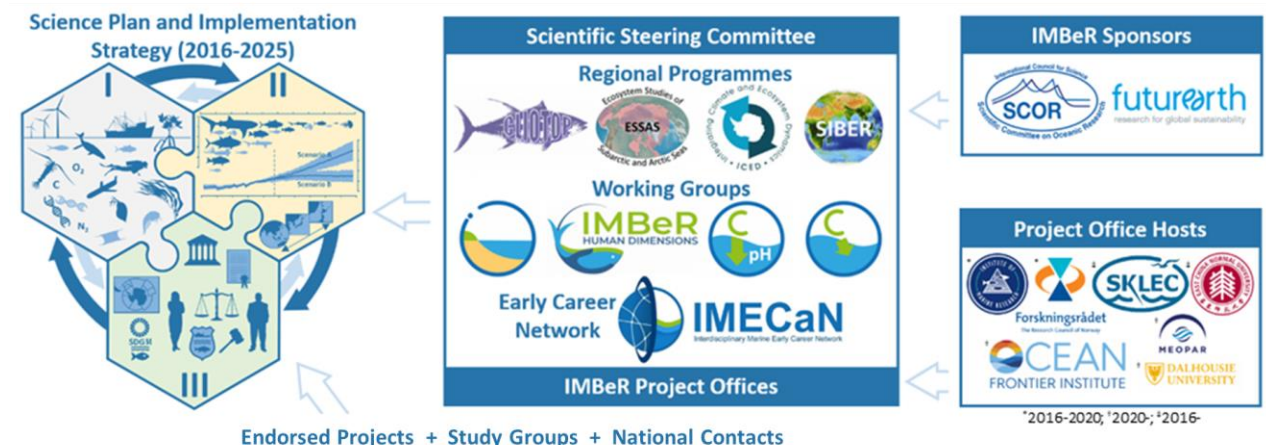


Figure 1. Schematic overview of IMBeR’s structure and operations.

All the research and events undertaken by IMBeR are directed towards implementing the IMBeR **Science Plan and Implementation Strategy 2016-2025 (SPIS)**. The SPIS is structured around three **Grand Challenges (GCs)**. Three **Priority Research Objectives** focus the research for each of the GCs for the time remaining to complete the current SPIS (2022-2025):

- **Grand Challenge I:** Understanding and quantifying the state and variability of marine ecosystems.
- The Challenge: To develop whole system-level understanding of ecosystems, including complex biogeochemical cycles and human interactions, together with understanding of the scales of spatial and temporal variability of their structure and functioning. ([GCI Fact Sheet 2021](#))

- Priority Research Objectives:
  1. Cumulative effect of multiple stressors
  2. Integration of climate change and climate variability
  3. Impacts on society – preparation for a changed future
  
- **Grand Challenge II:** Improving scenarios, predictions and projections of future ocean-human systems at multiple scales.
- The Challenge: To incorporate understanding of the drivers and consequences of global change on marine ecosystems and human societies at multiple scales into models to project and predict future states. ([GCII Fact Sheet 2021](#))
- Priority Research Objectives:
  4. Integration of data systems and approaches for predictions and projections
  5. Development of predictive models and projections for use at regional scales
  6. Development of alternative scenarios to bridge the gap between physical climate sciences and humanities
  
- **Grand Challenge III:** Improving and achieving sustainable ocean governance.
- The Challenge: To improve communication and understanding between IMBeR science, policy and society to achieve better governance, adaptation to and mitigation of global change, and transition towards ocean sustainability. ([GCIII Fact Sheet 2021](#))
- Priority Research Objectives:
  7. Develop knowledge on best practices for multilevel governance approaches to ocean climate adaptation and mitigation
  8. Develop understanding on key ingredients for transformation towards more sustainable, equitable and inclusive governance approaches to fisheries and aquaculture
  9. Support implementation of post-2020 biodiversity targets for marine spatial planning, marine protected areas

In addition to the GCs, **Innovation Challenges (ICs)** focus on research topics that can be addressed within three to five years, and thereafter mainstreamed into the GCs once deliverables have been completed. There are currently four ICs:

- **Innovation Challenge 3:** advancing understanding of ecological feedbacks in the Earth System;
- **Innovation Challenge 4:** advancing and improving the use of social science data for ocean management, decision making and policy development;
- **Innovation Challenge 5:** interventions to change the course of climate impacts;
- **Innovation Challenge 6:** sustainable management of Blue Carbon ecosystems.  
(ICs 1 and 2 were mainstreamed into the GCs in 2019)

The science outlined in the SPIS is advanced via:

**Challenge Champions** (from within and outside of the IMBeR SSC) who lead each of the Grand and Innovation Challenges (read [more](#));

four **Regional Programmes:**

- **Climate Impacts on Oceanic Top Predators** ([CLIOTOP](#)) and its [task teams](#);
- **Ecosystem Studies of Subarctic and Arctic Seas** ([ESSAS](#); and see [factsheet](#)) and its [working groups](#), [national](#) and [multinational programmes](#), and [endorsed projects](#);
- **Integrating Climate and Ecosystem Dynamics** ([ICED](#); and see [factsheet](#)), co-sponsored by the Scientific Committee on Antarctic Research ([SCAR](#)); and
- **Sustained Indian Ocean Biogeochemistry and Ecosystem Research** ([SIBER](#)), co-sponsored by the Indian Ocean Global Ocean Observing System ([IOGOOS](#));

four **Working Groups**:

- **Continental Margins Working Group (CMWG)**, a joint working group with [Future Earth Coasts](#);
- **Human Dimensions Working Group (HDWG)**;
- **Integrated Ocean Carbon Research (IOC-R)**, a joint working group involving IMBeR, the Intergovernmental Oceanic Commission of the United Nations Educational, Scientific and Cultural Organization ([IOC-UNESCO](#)), the Intergovernmental Oceanic Commission – International Ocean Carbon Coordination Project ([IOCCP](#)), the World Climate Research Programme ([WCRP](#))/Climate and Ocean - Variability, Predictability, and Change ([CLIVAR](#)), the Surface Ocean – Lower Atmosphere Study ([SOLAS](#)), and the Global Carbon Project ([GCP](#));
- **SOLAS-IMBeR Ocean Acidification (SIOA)**, a joint working group with SOLAS;

six **Endorsed Projects**

- **Atlantic Meridional Transect (AMT)**; 2012-)
- **Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems (CREPSUM)**; 2021-)
- **Gulf of Trieste – Time-series (GoTTs)**; 2021-)
- **Marine Ecosystem-based Management Progress Evaluation Group: tracking the global progress of EBM (MEBM-PEG)**; 2020-)
- **Negotiating Ocean Conflicts among Rivals for Sustainable and Equitable Solutions (NoCRISES)**; 2021-)
- **Importance of Physico-Chemical Cycling of Nutrients and Carbon in Marine Transitional Zones (NUTS&BOLTS)**; 2020-)

the **Interdisciplinary Marine Early Career Network (IMECaN)**, with around 1184 members from 103 countries.

and three **Study Groups**

- **Indo-Pacific Region: marine biogeochemistry, biodiversity, sustainability study group (IMBeR IPR)**
- **Ocean Color-based Plant species identification and Carbon flux in the Indo-Pacific oceans (IMBeR OC-PC)**
- **IMBeR Eutrophication Study Group (IMBeR ESG)**

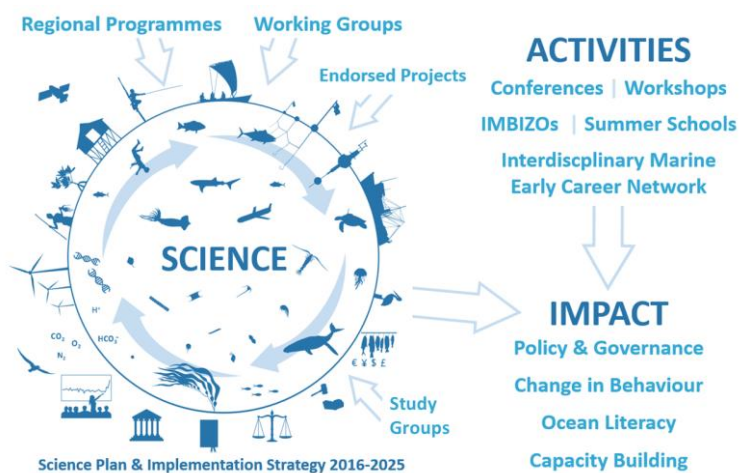


Figure 2. Contribution of the Regional Programmes, Working Groups, Endorsed Projects, Interdisciplinary Marine Early Career Network, Study Groups, and IMBeR activities towards addressing the Grand and Innovation Challenges.

IMBeR has two **International Project Offices (IPOs)**: IPO-Canada in Halifax, Canada, hosted by the [Ocean Frontier Institute, Dalhousie University](#), and [MEOPAR](#), and IPO-China in Shanghai, China, at the [State Key Laboratory of Estuarine and Coastal Research \(SKLEC\)](#), [East China Normal University \(ECNU\)](#). The IPOs are responsible for all the administrative and logistical aspects of the project, as well as communicating with the IMBeR community via the [website](#), the biweekly [IMBeR eNews](#) bulletin, and a monthly [IMBeR newsletter](#) that is published in English and Chinese, 'X' (formerly Twitter; [@imber\\_ipo](#)) and [IMBeR WeChat](#).

## B. SELECTED SCIENCE HIGHLIGHTS in 2022-2023

### Pan-Arctic marine biodiversity and species co-occurrence patterns under recent climate. ([Alabia et al., 2023](#))

Alabia et al. (2023) explored marine biodiversity across eight Arctic marine regions over the last two decades (2000-2019). Species occurrences for 69 marine taxa (26 apex predators and 43 mesopredators) and potential environmental drivers of their spatial distribution were used to predict taxon-specific distributions using a multi-model ensemble approach. Results showed an Arctic-wide trend of increasing species richness over the last 20 years (Fig. 3), highlighted areas where new species are accruing due to climate-driven species redistributions. This ESSAS publication contributes to Grand Challenge I.

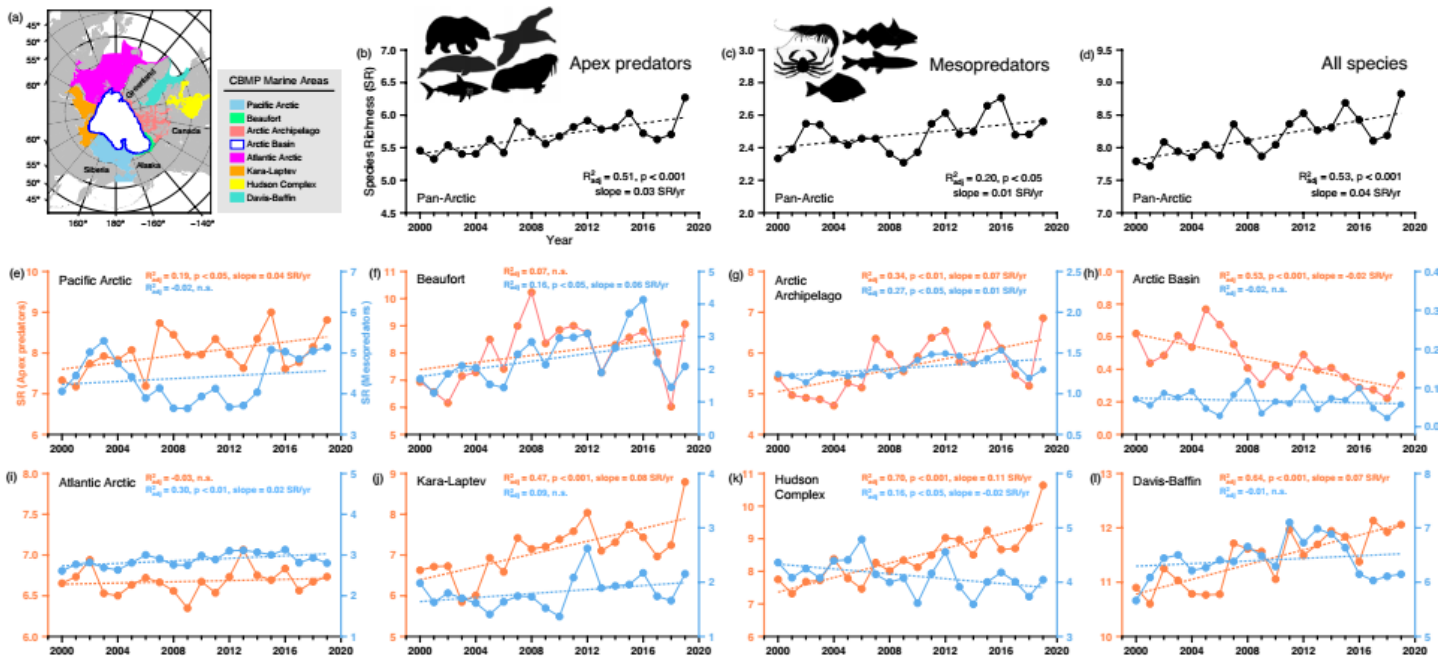


Figure 3: (a) Geographic map of the study area and annual time-series of predicted pan-Arctic species richness for (b) apex predators, (c) mesopredators, and (d) all species combined. Second and third row of panels show regional species richness by year with estimated linear trends over time for apex predators (orange) and mesopredators (blue) in the (e) Pacific Arctic, (f) Beaufort, (g) Arctic Archipelago, (h) Arctic Basin, (i) Atlantic Arctic, (j) Kara-Laptev, (k) Hudson complex, and (l) Davis-Baffin between 2000 and 2019. From [Alabia et al. \(2023\)](#).

### Integrating human dimensions in decadal-scale prediction for marine social-ecological systems: lighting the grey zone ([Melbourne-Thomas et al., 2022](#))

The dynamics of marine systems at decadal scales are notoriously hard to predict—hence references to this timescale as the ‘grey zone’ for ocean prediction. Nevertheless, decadal-scale prediction is a rapidly developing field with an increasing number of applications to help guide ocean stewardship and sustainable use of marine environments. Such predictions can provide industry and managers with information more suited to support planning and management over strategic timeframes, as compared to seasonal forecasts or long-term (century-scale) predictions. The most significant advances in capability for decadal-scale prediction over recent years have been for ocean physics and biogeochemistry, with some notable advances in ecological prediction skill. In this paper, Melbourne-Thomas et al. argue that the process of ‘lighting the grey zone’ by providing improved predictions at decadal scales should also focus on including human dimensions in prediction systems to better meet the needs and priorities of end users. The paper reviews information needs for decision-making at decadal scales and assesses current capabilities for

meeting these needs. They identify key gaps in current capabilities, including the particular challenge of integrating human elements into decadal prediction systems. They suggest approaches for overcoming these challenges and gaps, highlighting the important role of co-production of tools and scenarios, to build trust and ensure uptake with end users of decadal prediction systems. They also highlight opportunities for combining narratives and quantitative predictions to better incorporate the human dimension in future efforts to light the grey zone of decadal-scale prediction.

This paper is an output from the [IMBIZO 6](#) conference workshop *Lighting the 'grey zone': how can we integrate human dimensions in decadal-scale prediction systems?* The publication contributes to Grand Challenge II and Innovation Challenge 4. Authors are workshop co-conveners, speakers and participants.

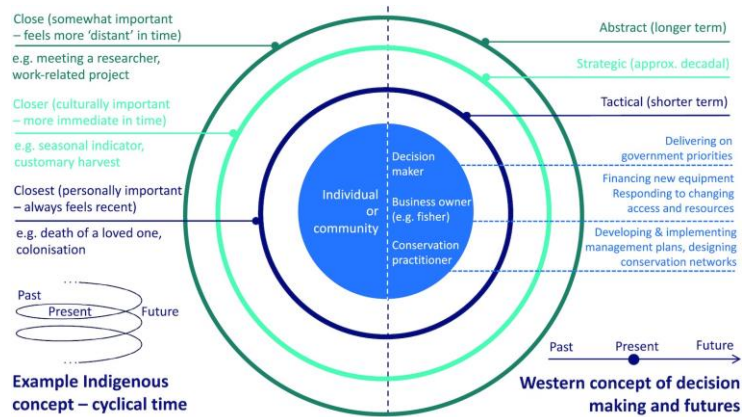


Figure 4. Decision-making timescales for marine social-ecological systems. The right side of the figure shows the Western concept of decision-making and future time horizons, with example decadal-scale decision types for different stakeholders. The left side of the figure contrasts an example Indigenous concept of cyclical time, where events such as the death of a loved one or colonization are experienced as being more immediate and recent than events that are more peripheral (such as meeting a researcher).

### Ocean sustainability: act before it's too late ([Murphy et al., 2022](#))

Continuing on the ideas developed in 'The Global Pandemic Has Shown We Need an Action Plan for the Ocean' ([Murphy et al., 2021](#)), the authors highlighted the urgency of coordinating global strategy that is flexible, scalable, responsive to ocean changes, and applicable in different contexts. The paper also directed the community to register their interest in developing an '[Action Plan for the Ocean](#)' and has paved the way for a series of workshops starting in October 2023.



Figure 5. Action Plan for the Ocean

### A dynamic framework for assessing and managing risks to ecosystems from fisheries: demonstration for conserving the krill-based food web in Antarctica ([Constable et al., 2023](#))

This ICED publication provides a dynamic framework for spreading the ecosystems risk of fisheries in space and time, a method that can be used from the outset of developing fisheries and continually updated as new knowledge becomes available. Importantly, this method integrates qualitative and quantitative approaches to assess risk and provides mechanisms to both spread the risk, including enabling closed areas to help offset risk, and adjust catch limits to keep regional risk to a baseline level. Also, the framework does not require uniform data standards across a region but can incorporate spatially and temporally heterogeneous data and knowledge. The approach can be coupled with the conservation of biodiversity in marine protected areas, addressing potential overlap of fisheries with areas of high conservation value. It accounts for spatial and temporal heterogeneity in ecosystems, including the different spatial and temporal

scales at which organisms function. The framework is developed in the first section of the paper, including a simple illustration of its application. In the framework the authors include methods for using closed areas to offset risk or for conserving biodiversity of high conservation value. They also present methods that could be used to account for uncertainties in input data and knowledge. In the second section, they present a real-world illustration of the application of the framework to managing risks of food web effects of fishing for Antarctic krill in the Southern Ocean. Last, they comment on the wider application and development of the framework as information improves. This publication contributes to Grand Challenge I and III.

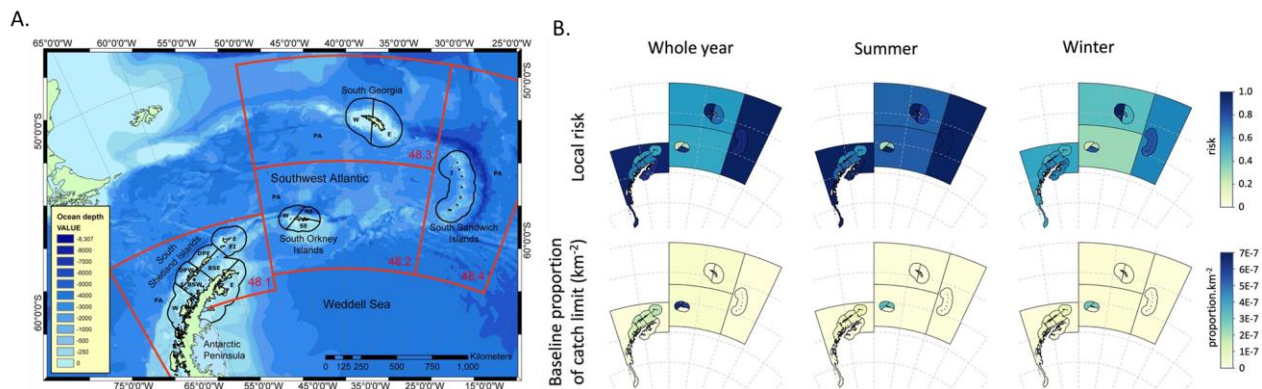


Figure 6. (A) Small-scale management units in FAO Statistical Area 48 established by the Scientific Committee of CCAMLR in 2002 (SC-CAMLR, 2002). FAO Subareas (numbers shown in red) are 48.1 (Antarctic Peninsula, AP), 48.2 (South Orkney, SO), 48.3 (South Georgia, SG) and 48.4 (South Sandwich, SS). Small-Scale Management Units are shown with acronyms relating to the Subareas: PA, Pelagic Area; E, East; NE, North East; SE, South East; W, West; BSE, Bransfield Strait East; BSW, Bransfield Strait West; DPE, Drake Passage East; DPW, Drake Passage West; EI, Elephant Island; I, Islands. (B) Local risk in each assessment area and the baseline proportion of the catch ( $\alpha$ ) displayed as proportion per  $\text{km}^2$  for the whole year, and for the seasonal assessment splitting the year into summer and winter. See [Constable et al., 2023](#) for further details.

### Biogeochemistry-ecosystem-social interactions on the Chinese continental margins ([Liu et al., 2023](#))

Chinese continental margins are experiencing remarkable environmental changes driven by anthropogenic activities and climate change. As an important habitat and sea-based fish farming resource in China, the Bohai was selected as a case study to understand how ecosystems and social interactions are influenced by multi-stressors. The Bohai ecosystem has been considerably modified. The Bohai coastline has been significantly changed (e.g., total sea area decreased and morphology changed) by sea reclamation and riverine sediment transport related to agriculture and erosion. Therefore, the strict reclamation policy and “Grain-for-Green” program have been issued to protect the coastline. Nutrient concentrations and composition have been changed by fertilizer application, wastewater discharge, and variations in seasonal patterns of riverine nutrient fluxes. Hence, pollution control and prevention are necessary. More seriously, fishing resources have been altered, as a result of environmental changes and overfishing. Therefore, a summer fishing ban and stock enhancement should be vital besides environmental improvement. This study can help to predict and mitigate impacts on global continental margins that are experiencing similar environmental stress.

This paper is an output from the CMWG Chinese Case Study and addresses Grand Challenges I and III and Innovation Challenge 3.

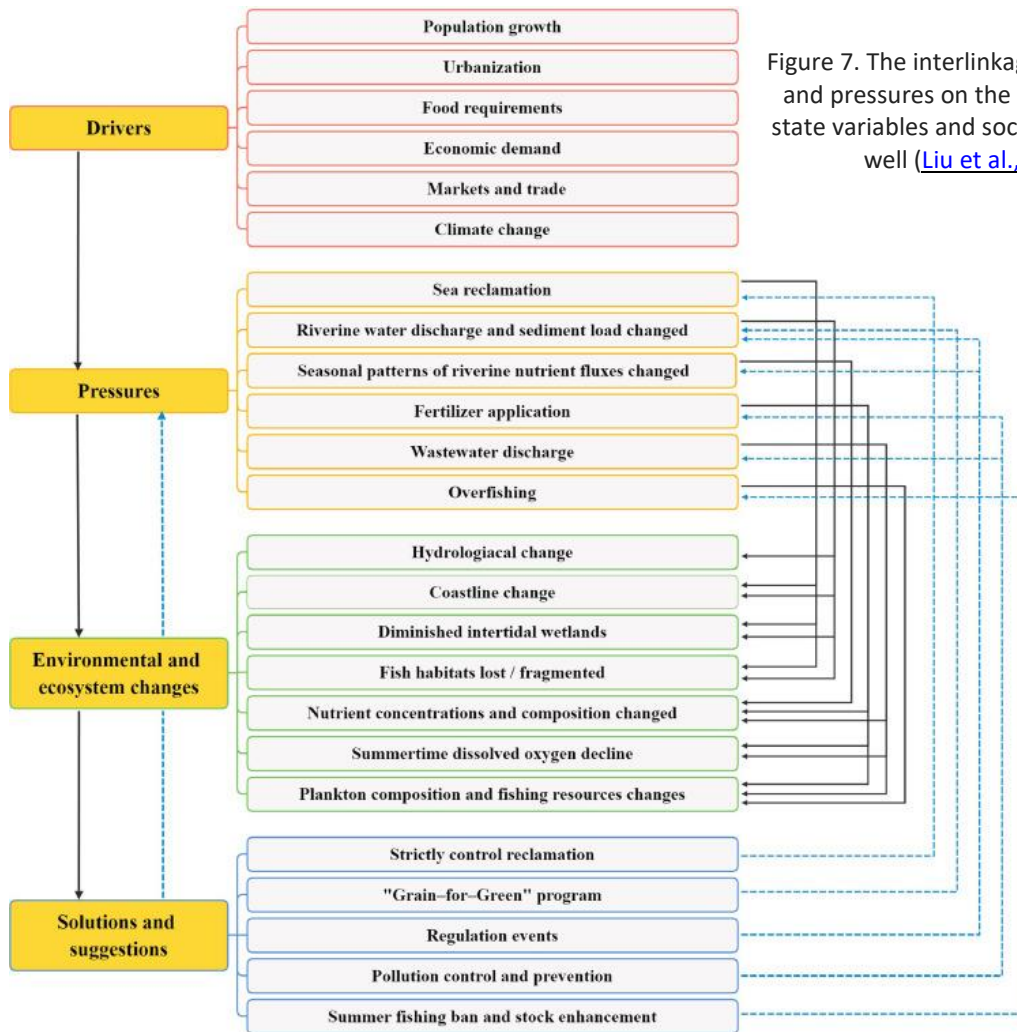


Figure 7. The interlinkage of the drivers and pressures on the environmental state variables and social responses as well (Liu et al., 2023).



## C. SELECTED SCIENCE ACTIVITIES 2022-2023

### IMBeR ClimEco8 Summer School – Sustaining the Ocean We Need for the Future We Want 9-13 June 2023, UN Decade of Ocean Science for Sustainable Development endorsed activity ([link](#))

IMBeR convened its 8<sup>th</sup> International ClimEco Summer School (ClimEco8), in Koper, Slovenia, to help develop the next generation of marine researchers who will be at the forefront of addressing ocean challenges. The summer school was attended by 46 marine science students, postdocs and early career researchers from 22 countries, and expanded participation into new geographic areas. Sponsorship was secured to support attendance of 19 participants. Under the guidance of a group of internationally-recognised experts from the marine natural and social sciences ([see lecturers](#)), participants developed a strong theoretical and applied understanding of different disciplines, and how they can be integrated to help generate solutions to the grand challenges facing the world's oceans. To complement this, participants also gained practical skills in science communication and how to operate effectively at the science-policy-society interface, so that they can influence decision-making processes in relation to the world's oceans – to help secure the ocean we need, for the future we want. The last two ClimEco summer schools (ClimEco7 and ClimEco8) have been endorsed as UN Decade of Ocean Science for Sustainable Development activities. More information is available [here](#).



Figure 8. ClimEco8 Flyer.

### ESSAS Annual Science Meeting 19-22 June 2023, Bergen, Norway ([link](#))

The 2023 ESSAS Annual Science Meeting was held as a hybrid meeting in June in Bergen, Norway (see [full conference program](#)). The sessions had strong links to Grand Challenge 1, Innovation Challenge 5, and Innovation Challenge 6 –

- Cooperative studies of coastal ecosystems engaging local communities in the subArctic and Arctic
- Natural disasters, multiple stressors and cumulative impacts along sub-arctic and arctic coasts
- Blue Carbon, mariculture and climate change mitigation and adaptation in the Subarctic and Arctic
- Cod and climate change at the coastal interface
- Workshop: AnalogueART - Using natural analogues to investigate the effects of climate change on northern ecosystems.

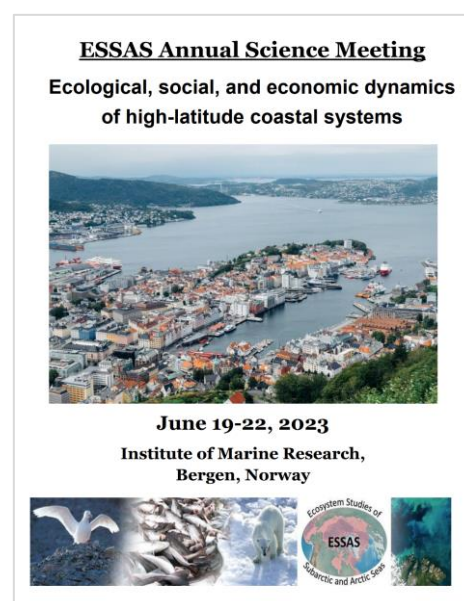


Figure 9. ESSAS Annual Science Meeting booklet front cover.

**IMECaN Workshop: Fostering Diversity, Equity and Inclusion into Interdisciplinary Marine Research**  
11<sup>th</sup> October 2023, virtual ([video recording](#))

IMBeR's Interdisciplinary Marine Early Career Network (IMECaN) held a virtual workshop on 11 October 2022, that addressed Diversity, Equity, and Inclusion in interdisciplinary marine research. Early Career Researchers (ECRs) are increasingly expected to work across disciplines, and to have an array of skills to navigate ocean sustainability challenges. ECRs are well placed to initiate new approaches to address critical research priorities. However, challenges around Diversity, Equity, and Inclusion (DEI) may affect ECR participation in interdisciplinary research. The workshop started with three invited speakers: Ingrid van Putten, Stephanie Brodie and Becca Shellock, who shared their personal experiences and approach to DEI in their interdisciplinary research. The workshop then moved into breakout groups where DEI issues and opportunities were discussed in greater detail. The facilitated discussions were focused around three overarching questions: What does DEI mean for you and your research community? What are the main challenges or barriers to DEI that you face as an interdisciplinary marine researcher? How can DEI be improved or fostered within interdisciplinary marine research? A perspective paper on the topics mentioned above is planned, and all workshop attendees are invited to contribute as co-authors.



Figure 10. IMECaN Workshop: Fostering Diversity, Equity and Inclusion into Interdisciplinary Marine Research 11th October 2023, virtual

**IMBeR Contribution to the 2022 UN Ocean Conference** ([link](#))

IMBeR SSC and community members contributed to the 2022 UN Ocean Conference that took place in Lisbon, Portugal in late June and early July:

- **Interactive Dialogue 3: Minimizing and addressing ocean acidification, deoxygenation and ocean warming** – ([see recording](#)) – SIOA involvement through co-chair of event Stephen Widdicombe (GOA-ON), and representation of the International Atomic Energy Agency (IAEA) - Ocean Acidification International Coordination Centre through IAEA Director General Rafael Mariano Grossi.



Figure 11. UN Ocean Conference 2022 ([link](#))

IMBeR involvement as co-organisers of and/or contributors to four side-events:

- **Ocean Negative Carbon Emission and Sustainable Development** ([video recording](#)) The event focused on addressing, in particular, ocean negative carbon emission (ONCE) approaches and relevant ocean-based solutions for the mitigation of climate change and the sustainable

development of coastal ecosystems and the society as a whole. Prof. Carol Robinson, past IMBeR SSC Chair, was the session moderator. IMBeR was an organizing partner. Read more [here](#).

- **Future Earth's marine networks: a trans- and interdisciplinary scientific community working toward the achievement of the SDGs** ([video recording](#)). Future Earth presented its marine networks and their co-production of knowledge to contribute to achieving SDG14, SDG13, and others by connecting, amplifying, and scaling knowledge for sustainability. Dr. Alice Newton, IMBeR SSC Vice-Chair, presented about IMBeR as a network.
- **Developing the capacity we need for the ocean we want** ([video recording](#)). This side event focused on how to design and implement the capacity development we need to achieve the 2030 agenda by showcasing: existing global and regional initiatives that build upon the foundation of capacity development for ocean sciences; lessons learned from case studies and/or success stories from beneficiaries of training programs; and recommendations on an action plan for the ocean for scientists, policymakers, local communities and the private sector to accelerate global CD efforts and responses to achieve SDG14 in the current decade. Read more [here](#). Prof. Carol Robinson, past IMBeR Scientific Steering Committee Chair, spoke at the SCOR organized virtual side event 'Developing the capacity we need for the ocean we want'.
- **From the Southern Ocean to the Arctic - a Call to Action via the UN Ocean Decade** ([video recording](#)). For the first time, the two Polar Ocean initiatives came together in one session to discuss cross-cutting issues from both the Southern Ocean and the Arctic Ocean. This side event was co-organised by IMBeR Regional Programme ICED.

**5th CSD Annual Conference on Sustainable Development 2022 – Unpacking Sustainability, Resilience, and Equity** – Dhaka, Bangladesh, 11 to 15 October 2022, co-organised by IMBeR Human Dimensions Working Group, endorsed project [NoCRISES](#), and IMBeR partner project [V2V](#).



Figure 12. 5th CSD Annual Conference on Sustainable Development 2022

The changing climate of our current world poses challenges to practically every domain of human society, from food security to health and well-being, and prosperity. In a warming world, one of the most pressing concerns is the need to manage and govern our natural resources in a way that promotes equitable outcomes, ensuring that the poorest and most marginalised groups, including women and minorities, can access the resources they need to reverse the entrenched exclusion that continues to make them the most

vulnerable to a changing climate. This is among the most wicked of wicked problems, and constitutes a vital and wide-ranging research agenda for the decades ahead, both in Bangladesh and across the world. This interdisciplinary and transdisciplinary conference brought together local and international experts to explore the most pressing and nexus issues relating to the Sustainable Development Agenda. The focus of the conference was on a number of interconnecting issues - climate change, blue growth, equity, migration, well-being, and resilience. This Conference offered a transdisciplinary space for academics, practitioners, and students working on transformations towards sustainability to come together in dialogue and practice. The conference included sessions on: Climate Change, Mental Health and Well-Being; The Migration-Poverty Nexus: Informal Economy, Mobility of Labor and Overall Well-being of Migrants in the Megalopolises; Climate Displacement in South Asia; Art Exhibition: **NoCRISES**- Creative Practices and Knowledge Generation through Art Exhibition; **HDWG**: Making our Science more inclusive and impactful; **V2V**: Viability of Small Scale Fisheries – Sharing Successful Stories; **V2V**: Transboundary Opportunities and Challenges in the Sunderban Delta; **NoCRISES**: Blue Economy Governance and Way forward in Bangladesh Additional Online Session; and **IMECaN**: Fostering Diversity Equity and Inclusion into interdisciplinary marine research. Read more [here](#).

**Chinese Marginal Seas Case Study Annual Meeting 2022** virtual meeting, 14-15 November 2022 ([full agenda](#))

The Chinese Marginal Seas Case Study is subprogram of the CMWG and its annual meeting included a three-hour webinar entitled ‘Tour of Asian Marginal Seas’ ([see recording](#)). During the internal session, six tasks were set up, discussed and fixed:

1. The ecosystem and physicochemical environment change in the last 60 years
2. Impacts of mariculture on eco-environment and options for sustainable sea food supply
3. China’s Blue Carbon Ecosystems in the context of global change: evolution, conservation and management
4. Integrated spatial planning for food-secure and carbon neutral blue economy
5. Sustainable pollution prevention strategies in coastal zones
6. Scientific measures to ensure sustainable development of marginal seas

Figure 13. The Chinese Marginal Seas Case Study 2022 Annual Meeting - banner for the ‘Tour of Asian Marginal Seas’ webinar.

These tasks are closely related to GC1, GC3, and IC3.

**Marine Ecosystem Assessment for the Southern Ocean: Meeting the Challenge for Conserving Earth Ecosystems in the Long Term** Frontiers Research Topic (Editors: [Constable et al., 2023](#))

The Marine Ecosystem Assessment for the Southern Ocean (MEASO) is a core project of IMBeR’s ICED regional programme. This 24-article Frontiers Research Topic (now closed to submissions) has 210 contributing authors from 19 countries. The articles fall under several MEASO themes: (i) global and local drivers of change in Southern Ocean ecosystems; (ii) status and trends of marine biota in Antarctica and the Southern Ocean, including details of their critical limits and relationships (attribution of change) to key drivers, such as habitats; (iii) spatial differentiation and trends in Southern Ocean food webs; (iv) challenges for policy makers, including ecosystem services, changing habitats and coastal and shelf systems, and sentinels of change; (v) lessons, methods, gaps, and future priorities from MEASO-1 and other environmental assessments; and (vi) foundations and extensions of MEASO.

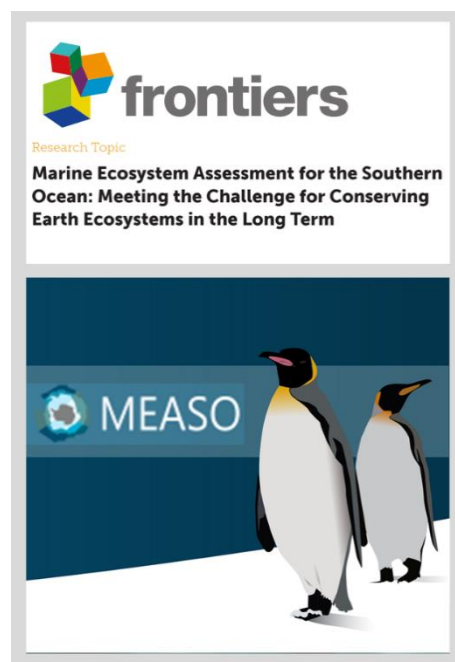


Figure 14. MEASO Frontiers Research Topic.

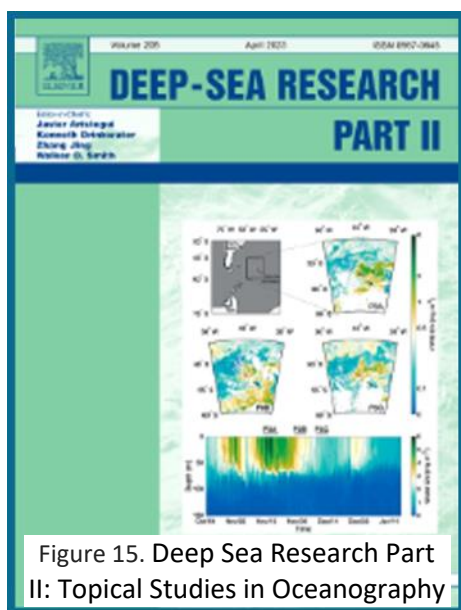


Figure 15. Deep Sea Research Part II: Topical Studies in Oceanography

**IMBeR West Pacific Symposium: Changing West Pacific Ocean: Science and Sustainability** [Volume 1](#) and [Volume 2](#) (Editors: Hong et al., 2023) Special Issues in Deep Sea Research Part II: Topical Studies in Oceanography

The West Pacific is the essential lifeline for half of the world’s population. To improve the ocean’s contribution to people, observing and predicting variabilities of marine ecosystems are foci of scientific research. The IMBeR West Pacific Symposium in 2021 addressed the ecosystem and biogeochemistry of the West Pacific, including the coastal blue carbon, coral reef, dried small fish, human interactions with coastal oceans, the Indo-Pacific, and connectivity with the Southern Ocean. The main objective of this special issue is to bring highlights from the symposium to provide a holistic view of the West Pacific. Since September 2022, 17 research papers from the symposium have been published, and an editorial article is under review.

**D. ACHIEVEMENTS and ACTIVITIES 2022-2023**

**--- Implementation of the IMBeR Science Plan and Implementation Strategy**

The restrictions on activities that IMBeR experienced in previous years due to COVID-19 were largely absent in 2022-2023, with in-person meetings, research cruises, and field work being more feasible over the period of this report. The progress IMBeR was able to make towards achieving the objectives of the Grand and Innovation Challenges are outlined below:

- - **Grand Challenge I:** Understanding and quantifying the state and variability of marine ecosystems

#### CLIOTOP

- **'The climate impacts of marine heatwaves on top predators in tropical oceans'** Task Team was initiated in 2023. ([see task teams](#))

#### ESSAS

- **R/V Mirai Arctic Ocean Cruise in 2022**, 12 August to 29 September 2022. Under the Arctic Challenge for Sustainability II (ArCS II) project, to understand ongoing catastrophic environmental change in the Arctic Ocean and its impact on the marine ecosystems.

#### ICED

- **PolarRES annual General Assembly Meeting**, September 2022, Bergen, Norway (read [more](#))
- **BIPOLE Annual Meeting** 1-3 March 2023, Northumbria, UK (read [more](#))
- **State and Variability of Antarctic and Southern Ocean ecosystems** - Joint ICED-AntICON session at SCAR Biology Symposium 2023, 31 July – 4 August, Christchurch, New Zealand (read [more](#))
- ICED continues to work with other key programmes and initiatives to outline future collaborations/links to improve understanding of the state and variability of Southern Ocean ecosystems, including with Commission for the Conservation of Antarctic Marine Living Resources ([CCAMLR](#)) and International Whaling Commission ([IWC](#)), and SCAR's new Scientific Research Programmes [Ant-ICON](#) and [AntClim<sup>now</sup>](#), and the SCAR Krill Expert Group ([SKEG](#))

#### SIBER

- **Joint Steering Committee meetings of IIOE-2 and SIBER**, Perth, Australia, 6-9 February 2023 (read [more](#))

#### CMWG

- **CMWG Chinese Marginal Seas Case Study 2022 Annual Meeting** – online, 14-15 November 2022 ([read more](#))
- **Overview of the Chinese Marginal Seas Case Study** ([Liu et al., 2022](#)) presentation at the Scoping Workshop for Third World Ocean Assessment (WOA III), Belitung, Indonesia, 13-15 November 2022
- **Biogeochemistry-ecosystem-social interactions on the Chinese continental margins** ([Liu et al., 2023](#))

#### Ocean Color based Plant species identification and Carbon flux in the Indo-Pacific oceans Study Group Study Group (OCPC)

- **Enhanced Ocean Carbon Sinks Triggered by Climate Change Seen from Space** ([Shen et al., 2022](#)) - Poster at Earth Information Day, COP27, Egypt, 9 November 2022
- **Updated manual 'Ocean Color Sensors and Their Data Access: A Brief Overview'** ([link](#))
- **Expanding EO data usage to address climatic changes in the marine biosphere of the northwest Pacific and Indo-Pacific regional seas (EO-WPI)** - ESA-Future Earth-funded project launched (read [more](#))

#### Eutrophication Study Group

- The Study group was launched in 2022 and directly addresses priority research area 1 – 'Stressors-combined effects: Eutrophication pathways described for coastal seas around the world'. Six study group meetings have been held (read [more](#)).

#### OTHER

- **Friends of Marine Biosphere** initiative launched in 2023 to catalogue phenological changes in tidal rivers, estuaries, coastal wetlands, lagoons, and offshore areas including oceans. Individual observations can be reported through online form (in English or in Chinese or in Arabic; read [more](#)).

- **Grand Challenge II:** Improving scenarios, predictions and projections of future ocean-human systems at multiple scales.

#### IMBeR General

**Integrating human dimensions in decadal-scale prediction for marine social–ecological systems: lighting the grey zone** - [Melbourne-Thomas et al., 2022](#) – Output from [IMBIZO 6](#) conference, authors are workshop co-conveners, speakers and participants.

#### CLIOTOP

**‘Exploring new horizons, barriers, and bottlenecks in marine ecological forecasting for oceanic top predators’** Task Team was initiated in 2023 ([see task teams](#))

- **‘Global trophic linkages in the mesopelagic zone’** Task Team was initiated in 2023. ([see task teams](#))

#### ICED

- **UN Decade Collaborative Centre (DCC) meeting on Ocean Prediction**, January 2023. This was held in association with activities of the UN Decade Southern Ocean Task Force. ([link](#))

#### AMT

- Rapid public availability of AMT data has enabled sophisticated model and machine learning outputs. The use of neural networks has linked AMT and remote sensing observations to project accurate fields of pCO<sub>2</sub> across the sparsely sampled South Atlantic (Ford et al., 2022).

#### NUTS&BOLTS

- NUTS&BOLTS is a test case for the Marine Institute database to develop a pipeline with QA/QC checks and appropriate metadata for upload onto their database for Ireland. It is hoped that the acquisition of data on key parameters will enable predictive models in cooperation with the Marine Institute (e.g. the newly funded ‘Changing Ocean Ireland’ project examining future climate scenarios and their potential impact on fisheries, and potential pilot studies like alkalization of the coastal marine zone). ([read more](#))

- **Grand Challenge III:** Improving and achieving sustainable ocean governance  
IMBeR’s Regional Programmes have worked with a range of stakeholders to ensure that the science under GCI and GCII is relevant to, accessible to, and incorporated into adaptation, mitigation and sustainable management and conservation procedures, by improving communications, facilitating knowledge-exchange and enhancing understanding between science, policy and society.

#### HDWG

- **5th CSD Annual Conference on Sustainable Development 2022 – Unpacking Sustainability, Resilience, and Equity** – Dhaka, Bangladesh, 11 to 15 October 2022 (see ‘SELECTED SCIENCE ACTIVITIES 2022-2023’)
- **The role of small-scale fisheries and communities in ocean governance, with a focus on equity and agency** - Session at ICES Annual Science Conference 2022, Dublin, Ireland, 19-23 September 2022 -

#### IMBIZO 6 output –

- **Ocean Governance and Climate Adaptation: Comparing Responses, Charting Future Courses** – Frontiers Research Topic – (Editors: [Belgrano, Evans, Selim, and VanderZwaag, 2023](#)) – 7 articles, 36 authors

The Research Topic addresses various governance approaches to ocean climate adaptation that have emerged. They include: the establishment of marine protected areas and other effective area-based measures to enhance resilience; implementation of precautionary and ecosystem approaches; ecological restoration; integrated coastal and ocean management and marine spatial planning; and reduction of other human stressors, such as overfishing and pollution. The need for adaptive and science-informed policy responses has been highlighted in the Implementation Plan for the UN Decade of Ocean Science for Sustainable Development 2021-2030. The Research Topic is a collection of manuscripts emerging primarily from the IMBeR IMBIZO6 workshop '[Ocean governance and climate adaption: comparing responses, charting future courses](#)'.

#### SCOR Scholarship and V2V Global Partnership ([link](#))

- Academic visit by Micaela Trimble to join Derek Armitage (both Grand Challenge III co-champions) at the University of Waterloo, Canada, 14 to 20 March 2023. The focus of the visit was on Grand Challenge III priority research area 'To develop understanding on key ingredients for transformation towards more sustainable, equitable, and inclusive governance approaches for fisheries and aquaculture. Work included: Planning for IMBIZO 7 workshop 'Governance transformations for resilient coastal fisheries and aquaculture'; presentations to undergraduates, graduates, and faculty on IMBeR-related research; Discussions about how V2V can support Grand Challenge III objectives and their engagement in IMBIZO7 workshop.

#### ICED

- **From the Southern Ocean to the Arctic - a Call to Action via the UN Ocean Decade** - UN Oceans Conference (see 'SELECTED SCIENCE ACTIVITIES 2022-2023 - From the Southern Ocean to the Arctic - a Call to Action via the UN Ocean Decade')
- **Antarctic Treaty System:** ICED is continuing its work with the Antarctic Treaty Commission via SCAR, within which ICED is a 'Co-Sponsored Programme,' and with a number of Antarctic Treaty agreements including the Committee for Environmental Protection (CEP) and CCAMLR. ICED is also continuing to work with other international environmental treaties and organisations, conservation groups, and international committees, including the International Whaling Committee (IWC).
- **Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR):** Over the past year, the CCAMLR Working Groups took place virtually (for the third year running), whereas the Scientific Committee and Commission meetings took place in person for the first time since 2019. In addition, CCAMLR held its five-yearly Scientific Committee Symposium which took place virtually. Key topics within CCAMLR over the past year have included krill management strategies and climate change. ICED scientists continue to have an important role taking the inter-sessional science forward in these and other priority areas, building on contributions and work undertaken by ICED to date, and there will continue to be an important role for ICED as this work progresses within CCAMLR. This is reflected in recommendations that CCAMLR continues to actively engage with ICED and SCAR, particularly with respect to krill research and climate change. Preparations are now underway for the 2023 CCAMLR meetings. The focus will be on krill management strategies with important contributions from ICED scientists and activities listed above, while also keeping climate change, MPAs and other topics on the agenda. ICED scientists contributed to a large number of papers submitted to CCAMLR in 2022 and will be contributing to many more to be submitted in 2023 (through their national delegations) in support of conservation and management in the region.
- **International Whaling Commission (IWC):** ICED scientists have continued to work with the IWC and this will be ongoing, including as interactions between CCAMLR and IWC increase.
- **SCAR:** ICED is a co-sponsored programme of SCAR and as such interacts with a range of SCAR programmes and initiatives. Over the past year ICED has also contributed to meetings, activities and publications through SCAR's next generation of scientific research programmes [Ant-ICON](#) and



[AntClim<sup>now</sup>](#), ensuring that they utilise the outputs of the ICED programme to avoid duplication of effort across the Southern Ocean and wider community, and encourage collaborations in areas of mutual interest across our research challenges. ICED scientists are represented on the steering committees of both these programmes. ICED also maintains interactions with the SCAR Expert Group on Antarctic Krill.

- **UNFCCC Conference of the Parties 2022 (COP27)** - November 2022, Egypt. The work of ICED-MEASO was featured at COP27. ICED scientist delivered a presentation in the Polar Oceans event as part of the '*Southern Ocean Ecosystems: Need for Augmented Understanding, Research Efforts and Protection*' ([recording](#)). This presentation focussed on past, present, and future changes in Southern Ocean ecosystems, drawing on the work of the world's first Marine Ecosystem Assessment for the Southern Ocean (ICED-MEASO) This session featured the latest research and recommendations of the SCAR (of which ICED is a co-sponsored programme - [link](#)).

#### MEBM-PEG endorsed project

- **MEBM-PEG online workshop on the global progress of EBM implementation** - 11-14 October 2022. 34 invited experts from across the globe and various ocean-use sectors participated in the workshop. They were invited with the objective to be representative of disciplines, global distribution and gender. Before the workshop, the participants and other experts in the field completed a pre-workshop poll developed by the MEBM-PEG. The preliminary poll results were used to guide the discussions during the workshop. The workshop will result in a peer reviewed publication and help IMBeR address GC I and GC III.

- **Innovation Challenge 3:** To advance understanding of ecological feedbacks in the Earth System

#### CLIOTOP

- CLIOTOP task teams '**Global trophic linkages in the mesopelagic zone**' and '**Global analysis of white shark trophic role**' (both initiated in 2023) will directly assist CLIOTOP in addressing the overarching scientific questions in relation to advanced understanding of marine ecology, food web dynamics, movements of top predators in a changing climate, and ocean biogeochemistry.

[\(see task teams\)](#)

- **Innovation Challenge 4:** To advance and improve the use of social science data for ocean management, decision making and policy development

Work in progress through the Innovation Challenge 4 co-champions – 10 case studies and collaborating institutions identified, but no outputs during the reporting period.

- **Innovation Challenge 5:** Interventions to change the course of climate impacts

#### ESSAS

- **Blue Carbon, mariculture and climate change mitigation and adaptation in the Subarctic and Arctic** session at ESSAS Annual Science Meeting in Bergen, Norway, 19-22 June 2023  
[Also addresses **Innovation Challenge 6:** Sustainable management of Blue Carbon ecosystems]

- **Innovation Challenge 6:** Sustainable management of Blue Carbon ecosystems

#### Blue Carbon Working Group

- **Beyond blue carbon: Ocean-based carbon dioxide removal (CDR) approaches** – session at Effects of Climate Change on the World’s Ocean 5 conference ([ECCWO-5](#)), Bergen Norway, 17-21 April 2023

#### ESSAS

- **Blue Carbon, mariculture and climate change mitigation and adaptation in the Subarctic and Arctic** session at ESSAS Annual Science Meeting in Bergen, Norway, 19-22 June 2023 ([link](#))

### -- Capacity Development and Outreach

#### ESSAS

- **ArCS II Outreach Cruise in the Arctic Ocean** – Faculty of Fisheries Sciences, Hokkaido University conducted a cruise on the training ship (T/S) Oshoro-maru in July 2023 with ten students who belong to universities in relation to social science, art, medical, education, agriculture, veterinary medicine etc. participated in a trial, domestic cruise on the training ship (T/S) Oshoro-maru in July 2023. The students carried out marine surveys and studies of oceanography, marine ecosystem, social issues, mass media, etc., in the Arctic during the cruise.

#### CLIOTOP and IMBeR Young Scholar Program

- The CLIOTOP SSC have worked together to ensure that Peng Lian co-leader of CLIOTOP task team ‘**The climate impacts of marine heatwaves on top predators in tropical oceans**’ and three of his postgraduate colleagues are well set up for success through the mentorship of Barbara Muhling.

#### IMECaN

- **Project management for academics** - 7 March 2023 - webinar hosted for IMECaN members on project management for academics.

#### SIBER

##### - **Coastal Observation Lab in a Box (COLaB)**

SIBER has continued to develop the Coastal Observation Lab in a Box (COLaB) initiative (a collaboration between SIBER and the CLIVAR Indian Ocean Resoure Panel). The project involves development of portable packages of low-cost instrumentation, and protocols for standardised physical, biological and biogeochemical observations, to be applicable in diverse coastal settings (from wetlands to shelf edges) and without the need for major infrastructure (research vessels or formal laboratories). The instrument packages and methods will be accompanied by modelling and data management tools, and in-person and online training. Important progress has been made over the last year through involvement in and Ocean Best Practices task team and a series of in-person and hybrid workshops (Mozambique, Ghana, India, and France).

#### SIOA

- **Multiple stressors training course** – Monaco, October 2022, in partnership with FPA2 and OACIS ([link](#))

#### NUTS&BOLTS endorsed project

- **Marine data to inform policy** - public lecture - 12<sup>th</sup> Annual Marine Economics and Policy Research Symposium, Marine Institute, Galway, Ireland, 6 Dec 2022
- **Science communication in the framework of the UN Decade of Ocean Science for Sustainable Development** – public lecture - iCrag2022, Croke Park, Dublin, Ireland, 1 Dec 2022.
- **Activities with local schools** - 7 local schools in Ireland visited by NUTS&BOLTS scientific educator Benny Joyce, in late 2022 and early 2023.



Figure 16. NUTS&BOLTS scientific educator Benny Joyce visits to local schools 2022-2023.

#### CREPSUM endorsed project

- **Application of Advanced Genomic Tools for Conservation of Marine Biodiversity** ICGEB-USM-CREPSUM course, Penang, Malaysia, 6-10 June 2022 ([link](#))
- **General Management Guide for Harmful Jellyfish Stings** ([link](#))
- **Identification Guide to Pufferfishes (Tetraodontidae, Tetraodontiformes) of the South China Sea**, [link](#)

#### Ocean Colour-based Plant species identification and Carbon flux in the Indo-Pacific oceans (OCPC) study group

- **Expanding EO data usage to address climatic changes in the marine biosphere of the northwest Pacific and Indo-Pacific regional seas (EO-WPI)** – training courses held in 2022/2023 ([read more](#))

#### OTHER

- **Developing the capacity we need for the ocean we want** – SCOR side event at the 2022 UN Ocean Conference, 29 June (read more [here](#)). IMBeR talk by Prof. Carol Robinson, past IMBeR Scientific Steering Committee Chair ([video recording](#)).
- **International Network Connector** – online, 22 September 2022. This online forum was open to all students, researchers and ocean professionals from any discipline, who were keen to expand their marine science networks. The event was a collaboration between IMBeR, Marine Environmental Observation, Prediction and Response ([MEOPAR](#)) and the Ocean Frontier Institute ([OFI](#)), and was endorsed as a UN Decade of Ocean Science for Sustainable Development activity.
- **IMBeR Coffee Receptions** - State Key Laboratory of Estuarine and Coastal Research, East China Normal University. Capacity development events for students addressing various topics ([read more](#))
- **Communicating with the IMBeR community** - [IMBeR website](#) and its 'news' items; the biweekly [IMBeR eNews](#) bulletin, and a monthly [IMBeR newsletter](#) (published in English and Chinese), both highlighting IMBeR-related research, the latter through a newly included 'Editor Picks' section; 'X' (formerly Twitter; [@imber\\_ipo](#)) and [IMBeR WeChat](#).

## -- Diversity, Equity, and Inclusion

### HDWG and V2V

- **Making our Science more inclusive and impactful** – workshop at 5<sup>th</sup> CSD Annual Conference on Sustainable Development 2022 – *Unpacking Sustainability, Resilience, and Equity* – Dhaka, Bangladesh, 11 to 15 October 2022 (more [here](#)):

The workshop addressed how global and local science and knowledge can work together for capacity development at all levels to inform practice, policy, and theoretical outcomes. This HDWG session brought knowledge producers, managers and scientists working at the global level, together with Bangladeshi stakeholders (NGOs, local government institutions, community leaders, and local scientists). This session was held as a dialogue between the research managers and local stakeholders to co-develop and shape a focus on how to best support local science and stakeholders to have better visibility, and to be better integrated, i.e. to make that much-needed step into being an integral part of those (national/regional/international) research projects of direct relevance to their everyday life and livelihoods.

### IMECaN

- **Workshop: Fostering Diversity, Equity and Inclusion into Interdisciplinary Marine Research** 11<sup>th</sup> October 2022, virtual ([video recording](#); see details above)

## --- Additional IMBeR activities

- **China-Europe Frontier Forum on Progress in Ocean Science and Technology**, 28-29 September 2022, online ([synthetic report](#)). Meeting facilitated by IMBeR IPO-China.
- **Physics of Estuaries and Coastal Seas 2022**, biennial conference ([link](#)), 24-28 October 2022, Shanghai, China. IMBeR IPO-China assisted facilitation of the meeting.

## E. SCIENTIFIC STEERING COMMITTEE

The 2023 Scientific Steering Committee consists of the chair Diana Ruiz-Pino (F, Sorbonne Université), three vice-chairs: Marion Gehlen (F, LSCE/IPSL), Alice Newton (F, University of Algarve) and Micaela Trimble (F, South American Institute for Resilience and Sustainability Studies) and 14 other normal members (i.e. full, non- *ex officio* members; 6 male and 8 female). Five new members joined the SSC in July 2023: Marta Ballesteros (F, Centro Tecnológico del Mar-Fundación CETMAR), Ron Vave (M, USA), Wen-Chen Chou (M, National Taiwan Ocean University), Jessica Melbourne- Thomas (F, CSIRO Environment), Rowan Trebilco (M, CSIRO Environment, and Centre for Marine Socioecology). In January 2023, the co-chairs of IMECaN joined the SSC as *ex officio* early career representatives: Laura Kaikkonen (F, University of Helsinki), Shenghui Li (F, Guangdong Ocean University), and Rebecca Shellock (F, University of Tasmania). At the end of 2023, three members (Alice Newton, David VanderZwaag, and Suvaluck Satumanatpan) will rotate off the SSC and four members are up for possible renewal for a second term: Andrea Belgrano (M, Swedish University of Agricultural Sciences, University of Gothenburg), Thorsten Blenckner (M, Stockholm Resilience Centre), Micaela Trimble (F, South American Institute for Resilience and Sustainability Studies), Nireka Weeratunge Starkloff (F, International Centre for Ethnic Studies).

The IMBeR Scientific Steering Committee (SSC) held its annual meeting in Paris, France, 3-5 April 2023 (more details [here](#)). This was the first in-person SSC meeting since 2019, and also facilitated online participation. The meeting also included a half-day 'mini-symposium' highlighting hot topics from French researchers as context for discussions of future planning for IMBeR post-2025 (i.e. after the end of the current IMBeR project).

While the Regional Programmes (CLIOTOP, ESSAS, ICED and SIBER), Working Groups (CMWG, HDWG, IOC-R, and SIOA) and IMECaN have always played an *ex officio* role in SSC meetings, the Chair of the IMBeR SSC decided to substitute the usual November/December 2022 virtual SSC meeting with individual meetings with Co-Chairs of each Regional Programme, Working Group and IMECaN. These meetings were held from December 2022 to February 2023. The aims of these meetings were to understand the respective contributions to the SPIS in the remaining period until August 2025; how syntheses and collaborations can be facilitated; and where the Regional Programmes, Working Groups and IMECaN will fit into the strategy for IMBeR post-2025.



Figure 17. IMBeR SSC 2023. (Co-chairs of IMBeR Regional Programmes and Working Groups are also *ex-officio* members, but are not shown).

## F. COLLABORATIVE PARTNERS

IMBeR science is strengthened, and its impacts extended, through on-going and new partnerships and collaborations with international and national organisations. These include the IMBeR co-sponsors - the Scientific Committee on Oceanic Research (SCOR) and Future Earth. Also, the World Climate Research Programme (WCRP), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the Global Ocean Observing System (GOOS) and the International Ocean Carbon Coordination Project (IOCCP). The Scientific Committee on Antarctic Research (SCAR) is a co-sponsor of the ICED regional programme.

IMBeR continues to have long standing collaborations with the SCOR and Future Earth global research projects, SOLAS (e.g. SIOA working group) and Future Earth Coasts (e.g. CMWG).

The IOC-R working group is a joint initiative involving IMBeR, IOC-UNESCO, IOCCP, WCRP, and Climate and Ocean - Variability, Predictability, and Change (CLIVAR), SOLAS, and the Global Carbon Project (GCP). IMBeR continues to have exchanges and collaborations with IOC-R.

1. Too Big To Ignore ([TBTI](#))  
IMBeR is a partner of the TBTI global research network that focuses on addressing issues and concerns affecting the viability and sustainability of small-scale fisheries. TBTI was originally to finish in 2018, but is still ongoing and hosted the '[4<sup>th</sup> World Small-Scale Fisheries Congress](#)' and published '[Blue Justice: Small-Scale Fisheries in a Sustainable Ocean Economy](#)' in 2022.
2. Ocean Carbon Biogeochemistry ([OCB](#))  
OCB continues to actively support IMBeR by advertising its activities and events, and by providing financial support for activities. Most recently, OCB supported IMBeR's ClimEco7 summer school (2021).
3. World Climate Research Project ([WCRP](#))  
CLIVAR, a core project of WCRP, and its Indian Ocean Panel works closely with SIBER. CLIVAR is also part of the Integrated Ocean Carbon Research (IOC-R). A letter of cooperation between WCRP and IMBeR was produced in 2022.
4. Global Ocean Observing System ([GOOS](#))  
SIBER has strong connections with the Global Ocean Observing System in the Indian Ocean (IOGOOS).
5. Vulnerability to Viability ([V2V](#)): Global Partnership for Building Strong Small-Scale Fisheries Communities  
V2V was developed by members of the IMBeR HDWG and IMBeR is a partner in the project. V2V will use the decision support tool IMBeR-ADaPT (Assessment based on Description, responses, and Appraisal for a Typology) which was developed within the IMBeR HDWG. Activities this year include the [V2V Thematic Webinar Series](#).
6. Global Ocean Negative Carbon Emissions ([GlobalONCE](#))  
IMBeR is a lead partner on this recently formed UN Decade programme. The programme links with IC5 and aims to provide data, knowledge and best practices to enable society to develop mitigation and adaptation approaches to climate impacts. Global ONCE will establish a network of instrumented marine field stations and research facilities available to evaluate such approaches, develop the decision rules for initiation and evaluation, undertake and facilitate co-designed interdisciplinary research on key ecosystem carbon processes, build technical and personnel capacity and enhance knowledge exchange between scientists, policy makers, industries, managers and communities. The ONCE approaches span nature-based interventions to optimise organic carbon sequestration capability alongside biodiversity, as well as chemical and engineering technologies. Global ONCE will promote equitable ocean governance of adaptation and mitigation approaches, through enhanced interaction with local, regional and global industries, decision makers and legislators. The programme convened a side event at the UN Ocean Conference to which IMBeR contributed (see 'SELECTED SCIENCE ACTIVITIES 2022 - IMBeR Contribution to the 2022 UN Ocean Conference').

## **G. IMBeR INTERNATIONAL PROJECT OFFICES**

### **International Project Office Canada (IPO-Canada)**

John Claydon continues as Executive Director, Lisa Maddison as Deputy, and Paula George as the part-time Executive Assistant to IPO-Canada.

### **International Project Office China (IPO-China)**

GiHoon Hong continues as Strategy Director, Fang Zuo as Deputy Director, and Kai Qin as Executive Assistant. Six part-time student interns Wei Jiang, Qing lv, Qianmeng Qi, Ao Shen, Jing Wen, and Kun Xiong, joined the IPO-China and finished the 2023 Spring-semester Internship Program (see [intern feedback](#))

## **H. PUBLICATION SUMMARY**

Since 2016, IMBeR has produced more than 990 publications ([Class 1 and Class 2](#)), and 96 papers were published over the last year (31 Class 1; 53 Class 2). A full list of Class 1 publications (2021-2021) can be found in the Appendices.

IMBeR Publication databases: [since 2016 \(2016-2023\)](#) | [prior to 2016 \(1999-2015\)](#)

## **I. SUPPORT from SCOR**

We greatly appreciate the ongoing support received from SCOR. In particular, we would like to thank the past SCOR Executive Director, Patricia Miloslavich, the current Executive Director, Emily Twigg, and Financial Officer Ed Urban for their continued help.

**J. BUDGET**

<b>Calendar Year</b>	<b>2022</b>	<b>2023</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>
All values USD	<b>Actual</b>	<b>Budgeted</b>	<b>Revised prediction</b>	<b>Budgeted</b>	<b>Budgeted</b>
<b>BALANCE from previous year</b>					
<b>Total balance from previous year</b>	<b>156,311</b>	<b>197,640</b>	<b>197,640</b>	<b>147,459</b>	<b>95,740</b>
<b>INCOME</b>					
SCOR (NSF 3-yr grants, Sept-Aug)	50,000	50,000	50,000	50,000	0
Future Earth (April-March)	5,400	5,400	5,400	5,400	5,400
Future Oceans: reg fees + sponsorship	0	0	0	0	365,000
ClimEco: reg fees+ sponsorship	0	105,000	66,378	0	0
IMBIZO: reg fees + sponsorship	0	0	0	145,000	0
West Pacific Symposium: reg fees + sponsorship	0	0	0	145,000	0
<b>Total income</b>	<b>55,400</b>	<b>160,400</b>	<b>121,778</b>	<b>345,400</b>	<b>370,400</b>
<b>TOTAL AVAILABLE FUNDS</b>	<b>211,711</b>	<b>358,040</b>	<b>319,418</b>	<b>492,859</b>	<b>466,140</b>
<b>EXPENSES</b>					
<b>Meetings</b>					
IMBeR SSC meeting*	0	37,000	25,975	37,000	37,000
Future Oceans (excl. ECR Day)	0	0	0	0	342000
Future Oceans: IMECaN ECR Day	0	0	0	0	23000
Future Oceans contingency	0	0	0	0	53,250
ClimEco	0	105,000	67,084	0	0
ClimEco contingency	0	15,750	0	0	0
West Pacific Symposium	0	0	0	145,000	0



West Pacific Symposium contingency	0	0	0	21,750	0
IMBIZO	0	0	0	145,000	0
IMBIZO contingency	0	0	0	21,750	0
<b>Subtotal meetings expense (without contingencies)</b>	<b>0</b>	<b>142,000</b>	<b>93,059</b>	<b>327,000</b>	<b>402,000</b>
<b>IMECaN, WGs + RPs</b>					
IMECaN	2,650	3,000	3,000	3,000	3,000
Carbon WG (IOC-R)	0	2,000	2,000	2,000	2,000
Ocean Acidification	3,936	7,500	7,500	7,500	7,500
Continental Margins WG	0	5,000	5,000	5,000	5,000
Human Dimensions WG	3,564	7,500	7,500	7,500	7,500
CLIOTOP	0	15,500	15,500	7,500	7,500
ESSAS	3,921	8,519	8,400	7,619	7,500
ICED	0	7,500	7,500	7,500	7,500
SIBER	0	7,500	7,500	7,500	7,500
<b>Subtotal IMECaN, WGs + RPs expenses</b>	<b>14,071</b>	<b>64,019</b>	<b>63,900</b>	<b>55,119</b>	<b>55,000</b>
<b>'30K' Support Fund</b>	<b>0</b>	<b>15,000</b>	<b>15,000</b>	<b>15,000</b>	<b>0</b>
<b>Total EXPENSES</b>	<b>14,071</b>	<b>221,019</b>	<b>171,959</b>	<b>397,119</b>	<b>457,000</b>
<b>BALANCE at end of year</b>					
<b>without contingency</b>	<b>197,640</b>	<b>137,021</b>	<b>147,459</b>	<b>95,740</b>	<b>9,140</b>
including contingency		24,971	-	-5,935	3,159
* 2023 SSC Meeting in Paris France was also sponsored by Sorbonne Université and l'Institut de l'Océan. Their USD value contributions are not reflected in this budget.					

## K. APPENDICES

### Annual Reports to IMBeR

#### Regional Programmes

- [Climate Impacts on Oceanic Top Predators \(CLIOTOP\)](#)
- [Ecosystem Studies of Subarctic and Arctic Seas \(ESSAS\)](#)
- [Integrating Climate and Ecosystem Dynamics \(ICED\)](#)
- [Sustained Indian Ocean Biogeochemistry and Ecosystem Research \(SIBER\)](#)

#### Working Groups

- [Continental Margins Working Group \(CMWG\)](#)
- [Human Dimensions Working Group \(HDWG\)](#)
- [Integrated Ocean Carbon Research \(IOC-R\)](#)
- [SOLAS-IMBeR Ocean Acidification \(SIOA\)](#)

#### Early Career Network

- [Interdisciplinary Marine Early Career Network \(IMECaN\)](#)

#### Endorsed Projects

- [Atlantic Meridional Transect \(AMT\)](#)
- [Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems \(CREPSUM\)](#)
- [Gulf of Trieste – Time-series \(GoTTs\)](#)
- [Marine Ecosystem-based Management Progress Evaluation Group: tracking the global progress of EBM \(MEBM-PEG\)](#)
- [Negotiating Ocean Conflicts among Rivals for Sustainable and Equitable Solutions \(NoCRISES\)](#)
- [Importance of Physico-Chemical Cycling of Nutrients and Carbon in Marine Transitional Zones \(NUTS&BOLTS\)](#)

#### International Project Offices

- [IPO – Canada](#)
- [IPO – China](#)

### Class 1 Publications 2021-2022

The publications listed below are ‘[Class 1](#)’ - i.e. they have been specifically generated through/by/from/during IMBeR activities (e.g. publications arising from IMBeR conferences, and from the activities of the working groups and regional programmes). Where stated, the activity in question is listed under the publication. Class 2 publications IMBeR Publication databases: [since 2016 \(2016-2022\)](#)

#### ICED publications

Constable, A.J., Kawaguchi, S., Sumner, M., Trathan, P.N., Warwick-Evans, V., 2023. A dynamic framework for assessing and managing risks to ecosystems from fisheries: demonstration for conserving the krill-based food web in Antarctica. *Frontiers in Ecology and Evolution* 11.

<https://doi.org/10.3389/fevo.2023.1043800>

Class 1; ICED

Bonnet-Lebrun, A.-S., Sweetlove, M., Griffiths, H.J., Sumner, M., Provoost, P., Raymond, B., Ropert-Coudert, Y., Van de Putte, A.P., 2023. Opportunities and limitations of large open biodiversity occurrence databases in the context of a Marine Ecosystem Assessment of the Southern Ocean. *Frontiers in Marine Science* 10.

<https://doi.org/10.3389/fmars.2023.1150603>

Class 1; ICED

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Biogeochemistry-ecosystem-social interactions on the Chinese continental margins. *Oceanologia* 65, 278–296.

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Class 1; CMWG

### **IOC-R Working Group publications**

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Class 1; IOC-R

### **IMBIZO6 publications**

Melbourne-Thomas, J., Tommasi, D., Gehlen, M., Murphy, E.J., Beckensteiner, J., Bravo, F., Eddy, T.D., Fischer, M., Fulton, E., Gogina, M., Hofmann, E., Ito, M., Mynott, S., Ortega-Cisneros, K., Osiecka, A.N., Payne, M.R., Saldívar-Lucio, R., Scherrer, K.J.N., 2022. Integrating human dimensions in decadal-scale

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Afzal, M.S., Takeuchi, K., Iguchi, A., Sakai, K., Dirgantara, D., Nakamura, T., 2023. An assessment of Ryukyu Archipelago's coral communities over a wide latitudinal range. Deep Sea Research Part II: Topical Studies in Oceanography 208, 105270. <https://doi.org/10.1016/j.dsr2.2023.105270>

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<https://doi.org/10.1016/j.dsr2.2023.105308>

Class 1; West Pacific Symposium 2021

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<https://doi.org/10.1016/j.dsr2.2023.105262>

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<https://doi.org/10.1016/j.dsr2.2023.105272>

Class 1; West Pacific Symposium 2021

Dirgantara, D., Afzal, M.S., Nakamura, T., 2023. Distinct patterns of coral lesion composition from national/quasi-national marine parks of Kerama and Yoron Islands, Ryukyu Archipelago. Deep Sea Research Part II: Topical Studies in Oceanography 210, 105309.

<https://doi.org/10.1016/j.dsr2.2023.105309>

Class 1; West Pacific Symposium 2021

Hartog, J.R., Spillman, C.M., Smith, G., Hobday, A.J., 2023. Forecasts of marine heatwaves for marine industries: Reducing risk, building resilience and enhancing management responses. *Deep Sea Research Part II: Topical Studies in Oceanography* 209, 105276. <https://doi.org/10.1016/j.dsr2.2023.105276>  
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Liu, S., Tian, Y., Liu, Y., Alabia, I.D., Cheng, J., Ito, S., 2023. Development of a prey-predator species distribution model for a large piscivorous fish: A case study for Japanese Spanish mackerel *Scomberomorus niphonius* and Japanese anchovy *Engraulis japonicus*. *Deep Sea Research Part II: Topical Studies in Oceanography* 207, 105227. <https://doi.org/10.1016/j.dsr2.2022.105227>  
Class 1; West Pacific Symposium 2021

Park, S., Chung, H., Lee, W.Y., 2022. Behavioral responses of Adélie penguins confronting a giant ice floe. *Deep Sea Research Part II: Topical Studies in Oceanography* 203, 105152. <https://doi.org/10.1016/j.dsr2.2022.105152>  
Class 1; West Pacific Symposium 2021

Safi, K.A., Rodríguez, A.G., Hall, J.A., Pinkerton, M.H., 2023. Phytoplankton dynamics, growth and microzooplankton grazing across the subtropical frontal zone, east of New Zealand. *Deep Sea Research Part II: Topical Studies in Oceanography* 208, 105271. <https://doi.org/10.1016/j.dsr2.2023.105271>  
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Sartimbul, A., Nakata, H., Herawati, E.Y., Rohadi, E., Yona, D., Harlyan, L.I., Putri, A.D.R., Winata, V.A., Khasanah, R.I., Arifin, Z., Susanto, R.D., Lauro, F.M., 2023a. Monsoonal variation and its impact on the feeding habit of Bali Sardinella (*S. lemuru* Bleeker, 1853) in Bali Strait. *Deep Sea Research Part II: Topical Studies in Oceanography* 105317. <https://doi.org/10.1016/j.dsr2.2023.105317>  
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Class 1

**Class 2 Publications 2022-2023** – Class 2 publications benefitted from some interaction with IMBeR or IMBeR activities and are listed in the [online database](#).

## List of Acronyms

AMT	Atlantic Meridional Transect	<a href="#">link</a>
AntClim <sup>now</sup>	Near-Term Variability and Prediction of the Antarctic Climate System	<a href="#">link</a>
Ant-ICON	Integrated Science to Inform Antarctic and Southern Ocean Conservation	<a href="#">link</a>
ArCS II	Arctic Challenge for Sustainability II	<a href="#">link</a>
BIOPOLE	Biogeochemical processes and ecosystem function in changing polar systems and their global impacts	<a href="#">link</a>
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources	<a href="#">link</a>
CEP	Committee for Environmental Protection [Antarctic Treaty]	<a href="#">link</a>
CLIOTOP	Climate Impacts on Oceanic Top Predators	<a href="#">link</a>
CLIVAR	Climate and Ocean - Variability, Predictability, and Change	<a href="#">link</a>
CMWG	Continental Margins Working Group	<a href="#">link</a>
CoLaB	Coastal Lab in a Box	
COP	Conference of Parties	<a href="#">link</a>
CREPSUM	Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems	<a href="#">link</a>
ECNU	East China Normal University	<a href="#">link</a>
ECR	Early Career Researcher	
EIOURI	Eastern Indian Ocean Upwelling Regime Initiatives	
ESSAS	Ecosystem Studies of Sub-arctic and Arctic Seas	<a href="#">link</a>
GCP	Global Carbon Project	<a href="#">link</a>
GoTTs	Gulf of Trieste – Time-series	<a href="#">link</a>
HDWG	Human Dimensions Working Group	<a href="#">link</a>
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean	<a href="#">link</a>
ICES	International Council for the Exploration of the Sea	<a href="#">link</a>
IEA	Integrated Ecosystem Assessment	
IIOE-2	Second International Indian Ocean expedition	<a href="#">link</a>
IIOSC	International Indian Ocean Science Conference	<a href="#">link</a>
IMBeR	Integrated Marine Biosphere Research	<a href="#">link</a>
IMECaN	Interdisciplinary Marine Early Career Network	<a href="#">link</a>
IOCCP	Intergovernmental Oceanic Commission – International Ocean Carbon Coordination Project	<a href="#">link</a>
IOC-R	Integrated Ocean Carbon Research Working Group	<a href="#">link</a>
IOC-UNESCO	Intergovernmental Oceanographic Commission of United Nations Educational, Scientific and Cultural Organization	<a href="#">link</a>
IOGOOS	Indian Ocean Global Ocean Observing System	<a href="#">link</a>
IPCC	Intergovernmental Panel on Climate Change	<a href="#">link</a>
IPO	International Project Office	
IPR	Indo-Pacific Region: Marine Biogeochemistry, Biodiversity, Sustainability Study Group	
IWC	International Whaling Commission	<a href="#">link</a>
MEASO	Marine Ecosystem Assessment of the Southern Ocean	<a href="#">link</a>
MEBM-PEG	Marine Ecosystem-based Management Progress Evaluation Group: tracking the global progress of EBM	<a href="#">link</a>
MEOPAR	Marine Environmental Observation, Prediction and Response Network	<a href="#">link</a>
NoCRISES	Negotiating Ocean Conflicts among Rivals for Sustainable and Equitable Solutions	<a href="#">link</a>
NOAA	National Oceanic and Atmospheric Administration	<a href="#">link</a>
NUTS&BOLTS	Importance of Physico-Chemical cycling of nutrients and carbon in Marine Transitional Zones	<a href="#">link</a>
OC-PC	Ocean Colour Based Plant Species Identification and Carbon Flux in the Indo-Pacific Oceans Study Group	<a href="#">link</a>
OFI	Ocean Frontier Institute	<a href="#">link</a>
PICES	North Pacific Marine Science Organization	<a href="#">link</a>

PolarRES	Polar Regions in the Earth System: the Role of Local and Regional Polar Processes in Changing the Polar Climate and the Global Climate System	<a href="#">link</a>
RACArctic	Resilience and Adaptive Capacity of Arctic Marine Ecosystems	<a href="#">link</a>
SCAR	Scientific Committee on Antarctic Research	<a href="#">link</a>
SCOR	Scientific Committee on Oceanic Research	<a href="#">link</a>
SIBER	Sustained Indian Ocean Biogeochemistry and Ecosystem Research	<a href="#">link</a>
SIOA	SOLAS-IMBeR Ocean Acidification	<a href="#">link</a>
SKAG	SCAR Krill Action Group	<a href="#">link</a>
SKED	The Study of Kuroshio Ecosystem Dynamics for Sustainable Fisheries	<a href="#">link</a>
SKLEC	State Key Laboratory of Estuarine and Coastal Research	<a href="#">link</a>
SOLAS	Surface Ocean – Lower Atmosphere Study	<a href="#">link</a>
SOLSTICE-WIO	Sustainable Oceans, Livelihoods and Food Security Through Increased Capacity in Ecosystem Research in the Western Indian Ocean	<a href="#">link</a>
SPIS	[IMBeR] Science Plan and Implementation Strategy 2016-2025	<a href="#">link</a>
SSC	Scientific Steering Committee	
SWIO	Southwestern Indian Ocean	
UNDOS	United Nations Decade of Ocean Science for Sustainable Development 2021-2030	<a href="#">link</a>
UNFCCC	United Nations Framework Convention on Climate Change	<a href="#">link</a>
WCRP	World Climate Research Programme	<a href="#">link</a>