

## **6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS**

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## 6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

### 6.1 Intergovernmental Oceanographic Commission (IOC)

*Arico, Sicre*



**SCOR 2019**  
**ANNUAL MEETING**

## REPORT OF THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC) of UNESCO

### I. Introduction: The UN Decade of Ocean Science for Sustainable Development

In December 2017, the United Nations General Assembly proclaimed the United Nations Decade of Ocean Science for Sustainable Development from 2021 to 2030 (hereafter, the Decade), building on the efforts of IOC Member States and the IOC Secretariat. The Decade is a once in a life-time opportunity to deliver a step-change in ocean science and to influence how countries invest, utilize, and participate in science and innovation to embrace societal goals and align research investment to contribute to common goals. The period from 2018 to 2020 is focusing on the preparation of the Decade Implementation Plan that will be submitted to the UN General Assembly for its consideration in 2020. This work is led by IOC, in consultation with Member States and all relevant stakeholders.

In July 2018, the IOC Executive Council decided to establish an Executive Planning Group (EPG) acting as an advisory body to the IOC on the preparation for the Decade. Its main tasks are to: (i) provide advice on the form and structure of the Decade including governance arrangements; (ii) support the drafting of the Implementation Plan for the Decade (to be finalized by 2020 for consideration by the UN General Assembly); and (iii) engage and consult relevant communities. Following a selection process led by the IOC Officers representing all five IOC regional groups, with due consideration to expertise, gender and geographical balance, 19 experts were invited to be a member of EPG. These experts met for the first time from 17 to 19 December 2018 at UNESCO Headquarters in Paris. The EPG provided guidance on the Decade's Implementation Plan formulation process including its structural and programmatic elements, as well as the consultations, engagement and communication strategies to unroll in 2019 and 2020.

A number of tasks have been assigned amongst EPG members including: the provision of inputs to the Roadmap (which serves as the basis for the Decade's Implementation Plan), the development of guidelines for the regional consultation workshops, the guidance for the organization of the Global Planning Meeting, the process for the development of a high level

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science plan, the definition of criteria for endorsement of Decade activities, the development of a business case for investing in ocean science, and the development of a model for the governance of the Decade implementation phase. Most of these works are in progress and are envisaged to be finalized by the end of the year.

Ocean scientists (interdisciplinary and specialized scientists) and the Innovation and Technology community (ocean science support infrastructures) are critical to engage as early as possible in the process. They will connect oceans science to societal needs. They will bring ocean science perspectives to the Decade and provide scientific technologies and services to the Decade (leading technological developments).

Several consultations and participation at the ocean science meetings have taken place. SCOR, IAPSO (International Association for the Physical Sciences of the Ocean), AGU (American Geophysical Union), PICES (North Pacific Marine Science Organization), ICES (International Council for the Exploration of the Sea), POGO (Partnership for Observation of the Global Oceans), IMBeR (Integrated Marine Biogeochemistry and Ecosystem Research Project), AMS (American Meteorological Society), EGU (European Geosciences Union), EMB (European Marine Board), Future Earth, AtlantOs and ICS (International Centre for Science and High Technology) and many other science networks active globally and regionally have been approached to communicate the aims and benefits of the Decade, but also to gather ideas and possible contributions, and to engage young scientists.

The engagement of the science community is also critical to the development of the Decade Science Plan. At its first meeting, the EPG deliberated that the Science Plan should be designed on the basis of a bottom-up process complementing the top-down guidance on the scoping of the Decade. A task team of the EPG was constituted to guide this exercise, and the IOC Secretariat was asked to elaborate a process for the collection of inputs from the active scientific community that will inform the Science Plan. Under the guidance of the dedicated EPG task team, the IOC Secretariat developed a questionnaire and invited relevant expert groups and scientific networks to fill it. As per EPG guidance, the questionnaire focused on the first three Strategic Objectives of the Decade, which pertain directly to the science aspects of the Decade. The initial results of the survey were presented at the Global Planning Meeting in Copenhagen (13–15 May 2019). While the approach followed with the questionnaire could be expanded to further expert groups, scientific networks and organizations, within a timeline coherent with the development of the overall Decade Implementation Plan, the EPG is currently reflecting on the main dimensions of a possible 'science action plan', taking into account the outputs of the 1<sup>st</sup> Global Planning Meeting on the Decade (see below).

The IOC convened such 1<sup>st</sup> Global Planning Meeting in Copenhagen from 13 to 15 May 2019, hosted by the National Museum of Denmark. This foundational meeting brought together 246 institutional representatives (including IOC Secretariat) working at the science-policy interface, as well as ocean businesses and philanthropic organizations committed to ocean sustainability, to start crafting science-based solutions and partnerships that the Decade will deliver. The aim of the meeting was to engage stakeholders and provide inputs to the development of the Implementation Plan of the Decade. The Global Planning Meeting was conceived as an integral part of the Decade design process, providing the first forum for international, interdisciplinary

and multi-stakeholder dialogues that will work in preparing and eventually implement the Decade.

The same framework will be replicated for the organization of the regional consultation workshops to facilitate the integration of regional outputs into the global planning process. Regional consultation workshops are an integral part of the Decade design process to achieve the engagement of various communities through a multi-stakeholder dialogue. These will build on the structure of the Global Planning Meeting with a focus on regional requirements and priorities as well as contributions to global activities. Working groups will be organized around the six societal outcomes that have been defined in the Decade Roadmap document ([IOC/EC-LI/2 Annex 3](#) and [Corr.](#)) in order to ensure that science delivered under the Decade is policy relevant. The first two regional workshops will focus on the Pacific Ocean and will be hosted by the Pacific Community (23–25 July 2019) and the Government of Japan (31 July–2 August 2019), respectively. Other workshops are foreseen in 2019 and early 2020, namely for the Indian Ocean, the Caribbean Sea, the North Atlantic (including Arctic) and South Atlantic, the Mediterranean, and South East Pacific region. Further consultations about the hosting of such meetings are underway with the Governments of France, Mexico, Canada, Brazil and Italy, as well as with the Permanent Commission for the South Pacific and the European Community.

It is anticipated that the draft Decade Implementation Plan will be finalized after the second global planning meeting in 2020, and will be circulated widely for comments prior to its finalization and transmission to the UN General Assembly. The 2<sup>nd</sup> UN Ocean Conference, co-hosted by Portugal and Kenya in Lisbon from 2 to 6 June 2020, with a focus on the progress from science to actions, will also provide a strategic opportunity to present the draft Decade Implementation Plan and forge partnerships around programmes and initiatives of relevance to the Decade.

## **II. Activities involving close cooperation and coordination between IOC and SCOR**

### **Harmful Algal Blooms**

The long-term focus of the IOC Harmful Algal Bloom (HAB) programme is on improved understanding of the factors controlling HAB events and thereby improving management and mitigation options. The scientific key questions have for more than a decade been addressed jointly with SCOR through research programmes. The current decadal IOC-SCOR research programme to meet societal needs in a changing world, entitled GlobalHAB, launched its science and implementation plan in 2017 ([www.globalhab.info](http://www.globalhab.info)). GlobalHAB is reported on in detail directly by the GlobalHAB SSC.

The IOC is coordinating and developing its work on HAB through the IOC Intergovernmental Panel on HABs (IPHAB). A number of Task Teams, working groups and activities are operating and reporting to the IPHAB. A core activity is the development of a ‘Global HAB Status Report’ with the aims of compiling an overview of HAB events and their societal impacts; providing a worldwide appraisal of the occurrence of toxin-producing microalgae; and assessing the status and probability of change in HAB frequencies, intensities, and range resulting from environmental changes at the local and global scale. The development of this report is intimately linked with the systematic compilation of HAB data in OBIS and the IOC Harmful Algal Event

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Data base HAEDAT and is funded by Flanders and cosponsored by the IAEA.

A key activity under IPHAB is on Ciguatera Fish Poisoning (CFP), which is the most extensive human illness caused by harmful algae. The IPHAB has initiated the development of a UN Coordinated Ciguatera Strategy involving the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), and the World Health Organization (WHO).

### **Time Series**

Since 2013 the establishment of an interdisciplinary IOC working group, the International Group for Marine Ecological Time Series (IGMETS), has offered the possibility to improve model projections and forecasts needed to understand open ocean and coastal changes. The collected information addresses new scientific questions and serves a well-established community of practice related to ship-based time series. The interdisciplinary character of IGMETS provides new scientific insights to improve model projections and forecasts needed to understand open ocean and coastal changes. IGMETS met on 7-9 November 2018 at IOC HQ to develop the scope its second report (read the first IGMETS report at <https://igmets.net/report>).

As from 2016, an affiliated group has worked specifically to investigate Climate Change and Global Trends of Phytoplankton in the ocean, in particular the coastal ocean (TrendsPO). The Group continues the comparative analysis and synthesis of long time series data sets compiled by SCOR WG137, and expands the focus not only to the continental shelf and open oceans, but also to estuarine and upstream freshwater ecosystems where perturbations from terrestrial, atmospheric, oceanic sources and human activities converge to cause changes that ramify across local and global scales.

### **De-oxygenation**

De-oxygenation is a global problem in coastal and open regions of the ocean, which has led to expanding areas of oxygen minimum zones and coastal hypoxia. In the coastal ocean, the number of reported dead zones has increased exponentially since the 1960s, with more than 600 systems catalogued now. The recent expansion of hypoxia in coastal ecosystems has been primarily attributed to global warming and enhanced nutrient input from land and atmosphere. The global extent and threat of ocean deoxygenation to human health and marine ecosystem services are just beginning to be appreciated; the related social and economic consequences have yet to be determined but are likely to be significant.

In order to raise awareness on the impacts of deoxygenation to marine life, in 2018 the IOC Global Ocean Oxygen Network (GO2NE) working group published a technical brief entitled 'The ocean is losing its breath'. IOC organized the annual meeting of the group on 1–2 September 2018 back to back with the international conference 'Ocean Deoxygenation: Drivers and Consequences: Past, present, future', in Kiel, Germany, 3–7 September 2018. The Conference concluded with the Kiel Declaration, which was signed by 502 experts as of 18 December 2018. The Secretariat also organized a joint GlobalHab/GO2NE workshop on 11–12 June 2019, who discussed the interaction of deoxygenation and harmful algae blooms. This workshop was followed by the 2019 GO2NE meeting, which focused on the workplan for the upcoming two years, including the GO2NE summer school in September 2019, which is

supported by SCOR, and the development of the Ocean Oxygen Data Portal. The IOC Secretariat further coordinated the input to the WMO Climate Change bulleting (published in February 2019) addressing deoxygenation in the ocean.

### **Multiple Stressors**

The IOC Executive Council at its 51<sup>st</sup> session in 2018 agreed to establish a new IOC working group focusing on multiple stressors. A draft policy brief introducing the issue of multiple stressors on marine ecosystems prepared in collaboration with members of SCOR WG149, the working title of which was 'Ocean under Stress: A changing ocean at all locations' was presented to the 30<sup>th</sup> Session of the IOC Assembly in June 2019. The final publication will be available during the fourth quarter of 2019.

### **Enhancing oceanography capacities in CCLME Western Africa countries (Eastern Boundary Upwelling Systems – EBUS)**

Climate change is increasing ocean temperature and is furthermore causing modifications in the dynamics of marine ecosystems at multiple scales and levels of organization. Eastern Boundary Upwelling Systems (EBUS), which are the most productive ecosystems in the world in terms of fisheries production, are likely to be affected. The overall aim of Phase III of this project is to improve the existing knowledge on the possible effects of climate change on the Canary Current Large Marine Ecosystem (CCLME) and to continue building regional science capacity in this regard. Changes in the productivity of this LME would have a direct impact on the national economies in the area, which are largely depending on fisheries resources.

This projects builds on previous results and scientific investments made in the CCLME, also taking advantage of relevant previous research and monitoring results gathered in the context of IOC- UNESCO regional (IOCAFRICA) and global programmes in relation to climate research, observations and data collection and exchange, namely the Global Ocean Observing Systems (GOOS) and International Oceanographic Data and Information Exchange/Ocean Biogeographic Information System (IODE/OBIS), as well as other relevant activities of IOC-UNESCO, in particular, ocean acidification, deoxygenation, and the effects of climate change on the oceans.

The foreseen Workshop I in the current phase of the project, focusing on “The effects of climate change on the productivity in the CCLME”, was held at the Centro Oceanográfico de Canarias of the IEO on 18-20 September 2018. This workshop was attended by 20 participants, including regional experts, from Cabo Verde, Guinea, Morocco, Senegal, Peru, France, Spain and Sweden, as well as by the IOC Secretariat from Paris and IOCAFRICA. Participants included experts from WCRP/CLIVAR Research focus on EBUS, SCOR WG155 on “EBUS: Diversity, coupled dynamics and sensitivity to climate change”, and relevant IOC networks – Global Ocean Oxygen Network (GO2NE), Global Ocean Acidification Observing Network (GOA-ON), IOC Working Group to Investigate Climate Change and Global Trends of Phytoplankton in the Oceans (TrendsPO), and the GlobalHAB Programme.

According to the discussions held during the workshop, a Research Agenda and Capacity Development Plan were elaborated, which will guide the further implementation of the project. The main goal of the Research Agenda is to address fundamental scientific knowledge gaps in the CCLME through regional cooperation in research activities, with a focus on total primary

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productivity and functional diversity, and on physical forcing; while the Capacity Development Plan aims to develop a common science capacity development agenda and related implementation strategy for the coastal nations in the CCLME region.

The project is linked with similar efforts on improving the scientific knowledge in the dynamics of the EBUS and to build the necessary scientific capacity to understand them further. One of such efforts is the WCRP CLIVAR “Research Focus EBUS”, which also encompasses the Canary Current system. IOC co-sponsored the ICTP-CLIVAR Summer School on Oceanic Eastern Boundary Upwelling Systems, held in Trieste on 15-19 July 2019. IOC has also partnered with SCOR WG155 on EBUS in the preparation of an ambitious Open Science Conference on EBUS to be held in Peru in 2021.

### **III. Other activities of actual or potential interest to SCOR Ocean acidification**

In view of the growing urgency and recognition of ocean acidification as one of the major stressors for the marine environment, improved observation and research are needed to help scientists and governments in implementing related mitigation and adaptation measures. IOC-UNESCO actively provided technical support to Member States to report towards the Sustainable Development Goal indicator 14.3.1, focusing on ocean acidification in the framework of sustainable development. The Commission provides the methodology guiding scientists and countries in terms of how to carry out measurements following the best practices established by the ocean acidification community. In this way, IOC and its networks, including the Global Ocean Acidification Observing Network (GOA-ON), directly contribute to the achievement of SDG Target 14.3.

During its 51<sup>st</sup> session, the IOC Executive Council welcomed the Methodology for the Sustainable Development Goal (SDG) Target Indicator 14.3.1 and recommended to the IOC secretary as the custodian agency for this indicator to propose its upgrade from Tier III to Tier II. In November 2018, this application was brought forward and the IAEG-SDG agreed on the upgrade from Tier III to Tier II. During an expert workshop organized by the Commission in October 2018, experts agreed on the outline and timeline for the production of an IOC manual focusing on the 14.3.1 methodology, to be published in the third quarter of 2019.

GOA-ON has now more than 632 members from 96 countries (in 2015 these were 150 scientists from 31 countries) and is constantly growing; currently 17 SIDS and 23 African countries are represented in GOA-ON. This is also thanks to IOC engagement and involvement in Ocean Acidification projects in the Caribbean, the Middle East and East Africa.

Work to develop a 14.3.1 data portal continued. A beta version of this portal is expected to be available in August 2019, facilitating ocean acidification collection and quality control. The IOC was further invited to submit a contribution on ocean acidification to the WMO annual Statement on the State of the Global Climate. This is only the second year that ocean acidification is included in the Statement. The IOC Secretariat also contributed to a Community White Paper for the upcoming OceanObs’19 conference, highlighting the 14.3.1 methodology. IOC co-organized the annual GOA-ON Executive Council meetings in 2018 (Sopot, Poland) and 2019 (Hangzhou, China), and further actively supported and participated in the 4<sup>th</sup> international

GOA- ON Workshop (14-17 April 2019, Hangzhou, China).

### **Nutrient's coastal Impacts research**

Nutrient over-enrichment of coastal ecosystems is a major environmental problem globally, contributing to problems such as harmful algal blooms, dead zone formation, and fishery decline. Yet, quantitative relationships between nutrient loading and ecosystem effects are not well defined. The IOC Nutrients and Coastal Impacts Research Programme (N-CIRP) is focussing on integrated coastal research and coastal eutrophication, and linking nutrient sources to coastal ecosystem effects and management in particular. As part of the implementation strategy for N-CIRP, IOC actively participates in a UN Environment led 'Global Partnership on Nutrient Management' (GPNM) with intergovernmental organizations, non-governmental organizations and governments. GPNM has an online information portal to enable GPNM partners to monitor progress on implementing activities related to the sustainable use of nutrients. IOC-UNESCO supports the development of the indicators for SDG 14.1, for which UN Environment is the custodian agency. A task force, which includes experts from IOC-UNESCO and GESAMP, the UN Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, supported by the Group on Earth Observation (GEO) Blue Planet, was established to provide the technical expertise during the course of the development of the methodology for the indicator. The core focus of IOC-UNESCO is to contribute to the development of the Index of Coastal Eutrophication (ICEP). Currently, IOC UNESCO together with UN Environment is soliciting for funding to finalize the Silica component of the model and for testing it.

### **Microplastics**

Plastics form a large proportion of marine litter, and the widespread occurrence of macroscopic plastic debris and the direct impact this can have both on marine fauna and legitimate uses of the environment, sometimes remote from industrial or urban sources, has grown rapidly. Lately the existence of micro-plastics and their potential impact has received increasing attention. The extent of the impact of plastic litter in the oceans is uncertain, despite the considerable scientific effort that has been expended in recent years.

GESAMP Working Group 40 on 'Sources, Fate and Effects of plastics and micro-plastics in the marine environment', led by IOC and UNEP, was initiated in 2012. The Working Group has recently published guidelines on how to monitor plastics in the ocean, This new set of publicly-available guidelines for monitoring plastics and microplastics in the oceans will help harmonize how scientists and others assess the scale of the marine plastic litter problem (read more at <http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic-litter-in-the-ocean>). The focus in 2019–2021 is on an overview of risks associated with marine plastic litter; environmental risk from nano- and microplastics; and human health risks associated with nano- and microplastics.

### **Blue Carbon**

The Blue Carbon Initiative, established in 2011 by the IOC, the International Union for the Conservation of Nature (IUCN) and Conservation International (CI), works to synthesize, scientific and technical knowledge, including policy mechanisms, for ensuring the conservation, restoration and sustainable use of coastal blue carbon ecosystems. The IOC is highly involved in the Blue Carbon Scientific Working Group, which provides the scientific foundation for the Blue Carbon Initiative by synthesizing current and emerging science on blue carbon assessment,



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conservation and management. Priority research activities coordinated by the Scientific Working Group are conducted in close partnership with the Initiative's Policy Working Group. IOC is further a coordinating member of the International Blue Carbon Partnership, a body that brings together governments, NGOs, IGOs and UN-Agencies.

IOC co-organized and co-sponsored the International Blue Carbon Initiative (BCI) annual meeting in China in August 2018. Furthermore, IOC supported three side events during the UNFCCC COP24, highlighting the potential of Blue Carbon Ecosystems as a Nature Based Solution to be applied in the NDCs to mitigate climate change, and also provided the coordinated input on blue carbon ecosystems to the WMO Climate Change Bulletin 2018. In collaboration with the Blue Carbon Partnership, these events gave the opportunity to connect high-level representatives and scientists to raise awareness for the central role of these ecosystems for carbon sequestration.

### **Integrated Ocean Carbon Research**

In 2018, the IOC Executive Council considered a note prepared by the IOC Secretariat on recent developments related to ocean carbon research and the landscape of ocean carbon research activities. Scientific considerations included the need for generating new knowledge on the role of ocean carbon in climate regulation and on the effects of climate change on ocean carbon, including carbon biology, thus responding to growing needs for such knowledge from relevant initiatives and processes, namely the IPCC (also taking into account the findings and knowledge gaps in the IPCC Special Report on Ocean and the Cryosphere, in due course) and scientific and technical work related to requests formulated by the UNFCCC and its Subsidiary Body on Scientific and Technical Advice (SBSTA).

The global ocean carbon research community is constituted by several initiatives carried out in the context of: the International Ocean Carbon Coordination Project (IOCCP); the Surface-Ocean Lower Atmosphere Study (SOLAS), the Integrated Marine Biosphere Research (IMBeR); the Global Carbon Project (GCP); WCRP's core project on Climate and Ocean Variability, Predictability and Change (CLIVAR), and numerous other relevant activities of IOC itself. Relevant national efforts on carbon research, as exemplified by the Ocean Carbon and Biogeochemistry programme under the US Carbon Cycle Science Program, contribute directly to such global efforts on ocean carbon research.

Historically IOC played a central role in federating the global ocean carbon research community through the SOCOVV workshop held in April 2007 at IOC's headquarters and follow-up meetings. IOC had supported the creation of IOCCP in the early 2000s, building on joint efforts of IOC during the previous two decades with SCOR and ICSU, including the CO<sub>2</sub> Advisory Panel of the Committee on Climate Change and the Ocean and the subsequent Joint SCOR-JGOFS-CCCO Advisory Panel on Ocean CO<sub>2</sub>. IOCCP was hosted at, and its secretariat supported by, IOC until 2012. IOCCP is co-sponsored by IOC and SCOR.

The IOC Executive Council concluded that these developments indicated the need to strengthen the IOC Ocean Science portfolio's focus related to ocean carbon, responding to the demand for such coordinating role by the scientific community. The IOC Executive Council noted that while

IOCCP tends to focus on ocean carbon observations, assisting in the development of new needed technology, and developing relevant capacity, there is a continuous need for an integrative platform on ocean carbon research, and a clear role for IOC therein.

The discontinuation in 2017 of the IMBeR and SOLAS carbon working groups that, based on the Joint SOLAS/IMBeR Carbon Implementation Plan, were charged with coordination and synthesis of ocean carbon research related to both ocean surface and ocean interior, had created the need for such a new federating initiative on ocean carbon research. This would contribute to inter alia better-coordinated ocean carbon cycle simulations in the context of CMIP6 and of the Global Carbon Project's efforts to establish annual global carbon budgets with reduced uncertainty for each iteration.

On the question of scope, a significant fraction of the individuals and programmes consulted was of the opinion that any new initiative would have to go beyond the inorganic component of the carbon cycle, and include other related biogeochemical properties such as nutrients, oxygen, and N<sub>2</sub>O, that is, consistently with the biogeochemical suite of Essential Ocean Variables developed through the GOOS Biogeochemistry Panel (provided by IOCCP). A smaller fraction of the individuals and programmes consulted was in favour of a more focused approach, mostly focused on inorganic carbon, that is, within the scope of the past SOLAS/IMBeR working groups.

The new focus on integrated ocean carbon research would deal with issues related to decadal variability, meso and sub-meso scale processes, scientific requirements for optimal observing system design, integrating ocean carbon biology considerations, and the interaction of the fluxes of heat and carbon fluxes and their storage. Such new initiative should also look into relevant new developments in ocean carbon research. For example, innovative work initiated in the context of SCOR Working Group 134 on the Microbial Pump in the Ocean in 2008 and leading to the publication of a number of established studies in 2011 have emphasized the importance of the microbial pump in the global carbon cycle and in related models; its relation with eutrophication levels in coastal areas; and the need to combine established knowledge and research on the biological pump with research on the microbial pump.

The Executive Council therefore decided to establish the IOC Working Group on Integrated Ocean Carbon Research, which will operate in cooperation with IOCCP, IMBeR, SOLAS, WCRP/CLIVAR and GCP. The first step of this initiative will be to convene an expert workshop under the auspices of IOC, involving 40 to 50 experts from different IOC regions, sub-disciplines (fluxes vs storage, for example), research types (observations vs models), as well as end-users (assessments, status reports). A first output of the initiative would be a synthesis report on ocean carbon: current knowledge, gaps, and related research and observation requirements. Following the successful launch of the initiative, individual programmes or specifically created task-teams would then concentrate on specific actions, depending on the alignment of certain actions with their respective terms of reference. The workshop will be held at the headquarters of IOC in Paris, France, on 28 to 30 October 2019.

## IV. Potential future IOC and SCOR cooperation

The IOC and SCOR have long successfully cooperated and thereby strengthened research and scientific programmes. The 20109 SCOR Working Group Proposals represent a wide-ranging array of relevant research projects, and the IOC Secretariat would like to share with SCOR its views on those proposals that more closely reflect the current priorities of IOC in the area of ocean science (provided to SCOR proposal monitors).

## 6.2 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

Duce

### **GESAMP WORKING GROUP 38**

#### **THE ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS**

Annual Report to SCOR by the Co-Chairs of Working Group 38, August, 2019

Robert Duce and Timothy Jickells

#### **History, early meetings and their results**

1 Working Group 38 was first formed in 2008 because of growing concern about the impact of atmospheric deposition of both natural and anthropogenic substances on ocean chemistry, biology, and biogeochemistry, as well as climate. It has held meetings at the University of Arizona, Tucson, Arizona in 2008; at IMO in London in 2010; in Malta in 2011; and at the University of East Anglia, Norwich, UK in 2013 and 2017. The 2013 workshop focused on nitrogen inputs from the atmosphere to the ocean and their impacts. Sponsors of those WG 38 efforts have included WMO, IMO, SCOR, SIDA, the European Commission Joint Research Centre, the University of Arizona, the International Environment Institute at the University of Malta, the University of East Anglia, and the U.S. National Science Foundation. Following the initial terms of reference and the meetings through 2013, twelve scientific papers have been published in the peer-reviewed scientific literature. These were as follows:

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- [2] Hunter, K.A., P.S. Liss, V. Surapipith, F. Dentener, R.A. Duce, M. Kanakidou, et al., “Impacts of anthropogenic SO<sub>x</sub>, NO<sub>x</sub> and NH<sub>3</sub> on acidification of coastal waters and shipping lanes”, Geophysical Research Letters, *38*, L13602, doi:10.1029/2011GL047720 (2011).

- [3] Kanakidou, M., Kanakidou, M., R. Duce, J. Prospero, A. Baker, et al., “Atmospheric fluxes of organic N and P to the ocean”, Global Biogeochemical Cycles, GB3026, doi:10.1029/2011GB004277 (2012).
- [4] Schulz, M., J.M. Prospero, A.R. Baker, F. Dentener, L. Ickes, P.S. Liss et al., “The atmospheric transport and deposition of mineral dust to the ocean - Implications for research needs”, Environmental Science and Technology, 46, doi:10.1021/es30073ul, 10,390-10,404 (2012).
- [5] Hagens, M., K.A. Hunter, Peter S. Liss, and Jack J. Middelburg, “Biogeochemical context impacts seawater pH changes resulting from atmospheric sulfur and nitrogen deposition”, Geophysical Research Letters, 41, doi:10.1002/2013GL058796 (2014).
- [6] Kim, T.-W., K. Lee, R.A. Duce and P.S. Liss, “Impact of atmospheric nitrogen deposition on phytoplankton productivity in the South China Sea”, Geophysical Research Letters, 41, 3156-3162, doi: 10.1002/2014GL059665 (2014).
- [7] Somes, C., A. Landolfi, W. Koeve, and A. Oschlies, “Limited impact of atmospheric nitrogen deposition on marine productivity due to biogeochemical feedbacks in a global ocean model”, Geophysical Research Letters, 43, 4500–4509, doi:10.1002/2016GL068335 (2016).
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- [9] Sharples, J., J.J. Middelburg, K. Fennel, and T.D. Jickells, “What proportion of riverine nutrients reaches the open ocean”, Global Biogeochemical Cycles, 31, 39–58, doi:10.1002/2016GB005483. (2017).
- [10] Jickells, T.D., E. Buitenhuis, K. Altieri, A.R. Baker, et al., “A re-evaluation of the magnitude and impacts of anthropogenic atmospheric nitrogen inputs on the ocean”, Biogeochemical Cycles, 31, 289–305, doi:10.1002/2016GB005586. (2017).
- [11] Baker, A.R., M. Kanakidou, K. E. Altieri, et al., “Observation- and model-based estimates of particulate dry nitrogen deposition to the oceans”, Atmospheric Chemistry and Physics, 17, 8189-8210, (2017).
- [12] Suntharalingam, P., L.M. Zamora, H.W. Bange, S. Bikkina, E. Buitenhuis, M. Kanakidou, J.-F. Lamarque, A. Landolfi, L. Resplandy, M.M. Sarin, S. Seitzinger and A. Singh, “Anthropogenic nitrogen inputs and impacts on oceanic N<sub>2</sub>O fluxes in the northern Indian Ocean: The need for an integrated observation and modelling approach”, Deep Sea Research II, In press (2019).

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2 Following the completion of the publication of the papers resulting from the 2013 workshop on the impacts of atmospheric nitrogen deposition to the ocean, WG 38 prepared a synthesis of the results from the scientific papers derived from that workshop. That report was reviewed by GESAMP and published by WMO in 2018 as GESAMP Reports and Studies No. 97, The Magnitude and Impacts of Anthropogenic Atmospheric Nitrogen Inputs to the Ocean. The primary conclusions of that report were presented in the 2018 WG 38 report to SCOR and will not be repeated here.

## **Current Activities of Working Group 38**

3 For the sixth year in a row WG 38 organized a session on atmospheric input of chemicals to the ocean for the 2019 European Geosciences Union meeting, held in Vienna, Austria in April – “Air-sea Exchanges: Impacts on Biogeochemistry and Climate”. A number of oral and poster papers at this session were presented by a combination of WG 38 members and other scientists.

4 Tim Jickells attended the International Nitrogen Management System (INMS) annual meeting in Edinburgh UK on 16-19 April 2018 to represent WG38 and supported by INMS. At the meeting he informally presented the work of WG 38 to relevant leaders of the INMS activity, particularly those leading initiatives in SE Asia, and he presented them with details of our synthesis report. He made clear the enthusiasm of WG38 to work with the INMS initiatives if they felt that would be useful, and we await their responses.

Tim Jickells then attended and participated in the 2<sup>nd</sup> East Asia Nitrogen Conference in Tsukuba, Japan from 19 to 22 November 2018, where he gave a keynote talk on the atmosphere/ocean aspects of the nitrogen cycle on behalf of WG 38. He also participated in a subsequent workshop in Tsukuba. We hope that this effort will increase our interactions with the INMS activity, and we hope to contribute to an INMS initiative on methods to quantify nitrogen deposition

5 WG38 proposed the following activity to be considered for the OceanObs'19 ocean observing community conference: “Ocean observations to estimate atmospheric nutrient and trace metal inputs to the oceans”. This has been adopted and is incorporated as part of a whitepaper that is in press in a special issue of Frontiers in Marine Science. Alex Baker is taking the lead on this effort by WG 38.

[13] Smith, S.R., G. Alory, A. Andersson, W. Asher, A. Baker, D. I. Berry, K. Drushka, D. Figurskey, E. Freeman, P. Holthus, T. Jickells, H. Kleta, E. C. Kent, N. Kolodziejczyk, M. Kramp, Z. Loh, P. Poli, U. Schuster, E. Steventon, S. Swart, O. Tarasova, L.P. De La Villéon, N. Vinogradova Shiffer, “Ship-based contributions to global ocean, weather, and climate observing systems, In press, Frontiers in Marine Science, Ocean Observation section (2019).

6 On behalf of WG 38 Alex Baker participated in the Workshop on Measurement-Model Fusion for Global Total Atmospheric Deposition held in Geneva, Switzerland in February 2019. He presented results from the GESAMP-supported paper recently published in Atmospheric Chemistry and Physics, “Observation- and model-based estimates of particulate dry nitrogen

deposition to the oceans”, publication [11] above.

7 At the meeting of GESAMP 42 at IOC in Paris in September, 2015, GESAMP approved two new workshops for WG 38. These two simultaneous workshops were related to the changing acid/base character of the global atmosphere and ocean and the impact of these changes on certain air/sea chemical exchange processes. Funding was obtained for these workshops from SCOR through the U.S. National Science Foundation, from WMO, and from IMO. SOLAS also sponsored these workshops. The workshops took place at the University of East Anglia (UEA) in Norwich, United Kingdom from February 27 through March 2, 2017. The topics of the two workshops were as follows:

Impact of Ocean Acidification on Fluxes of Atmospheric non-CO<sub>2</sub> Climate-Active Species

Changing Atmospheric Nutrient Oceanic Solubility

8 The workshops took the form of rather informal presentations from experts followed by very lengthy discussion sessions exploring multiple issues and feedbacks evident in these complex air-sea interaction issues. The invited scientists were selected for their expertise and interest in these areas, and also to provide a wide spectrum of expertise from modellers to experimentalists. 34 scientists from 16 countries and also from a wide range of career stages, from senior scientists through to graduate students, participated in the workshops. At the present time the following papers have been published, will shortly be submitted, or are still in preparation from the workshop discussions:

**Published:**

- [14] Kim, J.-M, K. Lee, Y.-S. Suh, and I.S. Han, “Phytoplankton do not produce carbon-rich organic matter in high CO<sub>2</sub> oceans”, Geophysical Research Letters, **45**, 4189–4197. <https://doi.org/10.1029/2017GL075865> (2018).
- [15] Kanakidou, M., S. Myriokefalitakis, and K. Tsigaridis, “Aerosols in atmospheric chemistry and biogeochemical cycles of nutrients, In press, Environmental Research Letters, **13**. <https://doi.org/10.1088/1748-9326/aabddb> (2018).
- [16] Myriokefalitakis, S., A. Ito, M. Kanakidou, A. Nenes, M.C. Krol, N.M. Mahowald, R.A. Scanza, D.S. Hamilton, M.S. Johnson, N. Meskhidze, J.F. Kok, C. Guieu, A.R. Baker, T.D. Jickells, M. Sarin, R. Shelley, A. Bowie, M.M.G. Perron, and R.A. Duce, “The GESAMP atmospheric iron deposition model intercomparison study”, Biogeosciences, **15**, 6659-6684. <https://doi.org/10.5194/bg-15-6659-2018> (2018).
- [17] Ito, A., S. Myriokefalitakis, M. Kanakidou, N.M. Mahowald, R.S. Scanza, D.S. Hamilton, A.R. Baker, T.D. Jickells, M. Sarin, S. Bikkina, Y. Gao, R.U. Shelley, C.S. Buck, W.M. Landing, A.R. Bowie, M.M.G. Perron, C. Guieu, N. Meskhidze, M.S. Johnson, Y. Feng, J.F. Kok, A. Nenes, and R.A. Duce, “Pyrogenic iron: The missing link to high iron solubility in aerosols”, Science Advances, **5**:eeau7671 (2019).

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## **To be submitted by early fall, 2019:**

- [18] Hopkins, F.E., P. Suntharalingam, M. Gehlen, O. Andrews, S.D. Archer, L. Bopp, E. Buitenhuis, I. Dadou, R.A. Duce, N. Goris, T.D. Jickells, M. Johnson, F. Keng, C.S. Law, K. Lee, P.S. Liss, M. Lizott, G. Malin, C. Murrell, H. Naik, A. Rees, J. Schwinger, and P. Williamson, “Changing ocean acidity as a modulator of atmospheric biogeochemistry and climate”, To be submitted to Proceedings of the National Academy of Sciences (2019).
- [19] Baker, A.R., M. Sarin, R.A. Duce, T.D. Jickells, M. Kanakidou, A. Nenes, S. Myriokefalitakis, A. Ito, D. Turner, N.M. Mahowald, R. Middag, C. Guieu, Y. Gao, P. Croot, R. Shelley, and M.M.G. Perron, "Changing Atmospheric Acidity and the Oceanic Solubility of Nutrients", To be submitted to Proceedings of the National Academy of Sciences (2019).

## **In preparation, for submission later in 2019:**

- [20] Peter Croot, lead author, “Controls and impacts of atmospheric nutrient solubility in the ocean”.
- [21] Peter Croot, lead author, “Impacts of the episodic atmospheric deposition on ocean biogeochemistry”.
- [22] Steve Archer, lead author, “A synthesis of the DMS response to ocean acidification observed in mesocosm experiments”. Dr. Archer also presented a paper on this topic at the AGU/TOS Ocean Sciences meeting in 2018.

**9** On June 28, 2019 a preliminary planning meeting was held for a possible WG 38 workshop in 2020 entitled “The Atmospheric Input of Chemicals to the Ocean – Management and Policy Implications”. This workshop would bring together appropriate players to discuss the management and policy implications of current knowledge about atmospheric inputs of nutrients and possibly other substances to the ocean and their interactions and impacts within the marine environment. The planning meeting was held in Norwich, United Kingdom, at the University of East Anglia, and it included Tim Jickells, Alex Baker, Peter Liss, Peter Kershaw, David Vousden, Michael Roberts, and Robert Duce. A tentative decision was made to hold such a workshop in the spring, 2020, assuming that the workshop is approved by GESAMP. The location is still to be determined. A more detailed description of the outcomes of this planning meeting and a formal proposal for this workshop is now being prepared and will be discussed with GESAMP at GESAMP 46 at the United Nations in New York in early September and with SCOR at the SCOR annual meeting in Toyama, Japan later in September.

## **Future Activities of Working Group 38**

**10** One goal of WG 38 for the next year is to complete the submission and publication of all papers resulting from the two 2017 workshops at the University of East Anglia:

Impact of Ocean Acidification on Fluxes of Atmospheric non-CO<sub>2</sub> Climate-Active Species and Changing Atmospheric Nutrient Oceanic Solubility

**11** A second goal for the next year will be to carry out the workshop described briefly in paragraph **9** above, assuming that this is approved by GESAMP and that appropriate funding can be obtained.

**6.3 North Pacific Marine Science Organization (PICES)**

*Batchelder, Yoo*

**SCOR and PICES Collaborative Activities**

**Report from PICES for the 2019 SCOR Annual Meeting  
September 22-25, 2019, Toyama, Japan  
Prepared by Hal Batchelder**

The North Pacific Marine Science Organization (PICES) is an intergovernmental scientific organization established by an international convention in 1992, in order to promote and coordinate marine scientific research in the North Pacific and adjacent seas. Our current member countries are Canada, Japan, People's Republic of China, Republic of Korea, Russian Federation and the United States of America. PICES' goals are to (1) advance scientific knowledge and capacity available for the member countries, including information on human activities affecting, and affected by marine ecosystems, and (2) provide a mechanism for collaboration among scientists in addressing timely and critical scientific questions about the North Pacific. In the 28 years since its establishment, PICES has become a major forum for the discussion and sharing of marine science in the North Pacific. Information on the Organization and its activities is available on the PICES website at <http://www.pices.int>.

SCOR and PICES have developed cooperative methods that have made it possible for an international non-governmental organization and a regional intergovernmental organization to share their strengths. Continuing and expanding collaboration between PICES and SCOR is based on the recognition that PICES can play an important role in bringing a North Pacific perspective to the global activities of SCOR, and that by participating in and implementing these activities in the region, PICES can advance its own scientific agenda. PICES contributes scientific expertise to SCOR-sponsored international large-scale ocean research projects (HABS [GlobalHAB], IMBeR, SOLAS, GACS [Global Alliance of Continuous Plankton Recorder Surveys]), to ocean carbon activities (IOCCP [International Ocean Carbon Coordination Project]) supported by SCOR, and to several SCOR Working Groups. SCOR working groups supported by PICES have included WG 125 (Global Comparisons of Zooplankton Time Series), WG 134 (The Microbial Carbon Pump in the Ocean), WG 137 (Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation), WG 146 (Radioactivity in the Ocean, 5 decades later), WG 149 (Changing Ocean Biological Systems (COBS): how will biota respond to a changing Ocean), WG 154 (Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS), and WG 155 (Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to



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climate change). In addition to the above, PICES and SCOR are both strong proponents of capacity building.

To discuss on-going and future collaborations, SCOR and PICES continue to irregularly exchange observers to the others annual/executive meetings. In recent years, SCOR was represented by Dr. Sinjae Yoo (Korea) at the PICES-2014 annual meeting in Yeosu, Korea, Dr. Sun Song, Vice-president of SCOR at the PICES-2015 annual meeting in Qingdao, China, and Edward Urban at the PICES-2016 meeting in San Diego, USA. Dr. Harold Batchelder (PICES Deputy Executive Secretary, liaison member of SCOR Capacity Building Committee) attended the 2013 SCOR Executive Committee Meeting (Wellington, New Zealand), the 2014 SCOR meeting (Bremen, Germany), the 2015 meeting in Goa, India, the 2016 meeting in Sopot, Poland, and the 2018 meeting in Plymouth, UK. A written report and PowerPoint file of PICES activities in 2017 was prepared by PICES and presented by Song Sun (China) on behalf of PICES at the 2017 SCOR meeting in Cape Town, South Africa. According to our records, SCOR was not represented at PICES-2017 in Vladivostok nor PICES-2018 in Yokohama, Japan. Sinjae Yoo will officially represent SCOR at the PICES-2019 annual meeting in Victoria, BC, Canada (16-27 Oct 2019).

This report provides an update on PICES-SCOR collaborations since the 2018 SCOR Meeting in Plymouth—a period that includes the PICES 27<sup>th</sup> Annual Meeting, which was held in Yokohama, Japan (Oct 24 – Nov 4 2018) as well as activities at the SOLAS Open Science Conference (21-25 April 2019, Sapporo, Hokkaido, Japan) and the Future Oceans2 IMBER Open Science Conference (17-21 June 2019 in Brest, France).

For the SOLAS Open Science Conference, PICES partially supported the travel costs of two Chinese participants, Lingyan Wang and Xue Ding. Our normal practice is to offer partial support to Early Career Scientists (ECS) that can enable them to leverage additional funds from local institutions or other sources. This has worked well for us historically and allows more students to participate than would otherwise if we funded the full expenses of individual ECS. For SOLAS, an Early-Career Scientists Day (ECSD) was organized on 21 April. This event brought together 25 doctoral students and postdoctoral researchers from 15 countries to network, discuss and share their respective research. After two opening lectures on “Making science cool” and “Writing about your research for a non-academic audience”, each ECS presented their research during 3-min talks followed by 2-min Q&A sessions, and EC peer evaluations. The best 3 talks were given awards during the conference banquet. The activities during the ECSD were made possible through funding provided by PICES. Feedback from the group suggests that the event was a terrific success. In total, PICES provided \$4,500 USD for two partial travel supports and the ECSD was considered well spent.

The IMBER Open Science Conference was extremely well attended with 750 participants from many research fields, 367 of which were ECS. Four young investigators (shown below in the photo) received travel support from PICES to attend IMBER—two from Canada, one from China and one from Japan. PICES provided \$4,500 USD to this event. Both the IMBER and SOLAS Conferences were written up in the Summer 2019 PICES Press Newsletter.



*Early career scientists receiving travel support from the North Pacific Marine Science Organization (PICES). Left to right: Andrés Beita-Jiménez (Canada), Irene D. Alabia (Japan), Xin Guo (China), and Patricia Angkiriwang (Canada).*

PICES is greatly appreciative of SCOR's long standing financial support, since it is difficult for PICES to fund participants from non-PICES countries to our annual meetings and sponsored international activities.

Examples of such sponsored international activities in the recent past are:

- (1) SCOR provided \$5,000 USD for travel support of country-in-transition participants to the PICES-ICES 6<sup>th</sup> Zooplankton Production Symposium "*New Challenges in a Changing Ocean*" that was held in May 2016 in Bergen, Norway.
- (2) travel support for the May 2017 3<sup>rd</sup> Early Career Scientist (ECS3) Conference "*Climate, Oceans and Society: Challenges and Opportunities*", in Busan, Korea. SCOR also provided \$2,500 USD to PICES to support travel of SCOR eligible developing nation early career scientists to attend the 3<sup>rd</sup> Early Career Scientist Conference.
- (3) SCOR provided \$5,000 USD for an international symposium "*Drivers of Dynamics of Small Pelagic Fish Resources (SPF)*" that was held March 6-11, 2017 in Victoria, British Columbia, Canada.

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- (4) SCOR provided \$2,500 USD for the PICES-2017 Annual Meeting that was held from 22 September – 1 October 2017 in Vladivostok, Russia. Plus, Ed Urban approved transfer of \$283 USD residual from the PICES/ICES ECS3 to PICES-2017.
- (5) SCOR provided \$3,000 USD to PICES to support international travel of early career scientists to attend the International Symposium on *Understanding Changes in Transitional Areas of the Pacific*, which was held in La Paz, Mexico, from 24-26 April 2018.
- (6) SCOR provided \$3,000 USD to PICES to support international travel of scientists from developing countries to attend the 4<sup>th</sup> Effects of Climate Change on the World's Oceans Symposium in Washington, DC, 2-9 June 2018.
- (7) SCOR provided \$5,200 USD to PICES on behalf of SOLAS to support international travel of scientists from developing countries to attend the 4<sup>th</sup> Effects of Climate Change on the World's Oceans Symposium (ECCWO-4) in Washington, DC, 2-9 June 2018.
- (1) Travelers and home countries supported to each of these events were detailed in the report presented by PICES at the SCOR meeting in Plymouth, UK.

For the PICES 2019 Annual Meeting in Victoria, BC in October, SCOR is providing substantial funding (\$10,000 USD) from the GlobalHAB program budget to support a 2.5-day Workshop (17-19 October 2019) titled “*GlobalHAB: Evaluating, Reducing and Mitigating the Cost of Harmful Algal Blooms: a Compendium of Case Studies*”, which is cosponsored by SCOR, ISSHA, NOWPAP, Greig Seafood Ltd., IOC UNESCO, GlobalHAB, and AXA XL Insurance).

**Workshop (W18) Description:** Over the last 2 decades, several reports have compiled what is known about the economic effects of harmful algal blooms. Most coastal regions have neither conducted economic analyses of HABs nor collected data that can be used to generate reliable quantitative estimates of net economic losses and economic impacts. Better estimates of the economic impacts of HABs will require coordination among HAB scientists and economists.

This is a 2.5-day international workshop to bring together expertise in the science of HABs and economics to review and analyze case studies for the study of economic impacts of HABs on fisheries and aquaculture. The workshop structure is:

**Day 1 (1/2 day): Overview of Economics and HABs, Analysis of U.S. west coast impacts.** *The discussion will be focused on types of economic assessment that will guide our discussions of case studies on workshop day 2.*

**Day 2 (full day): Case studies: examples of HAB impacts to wild fisheries, recreational fisheries and aquaculture worldwide.** *The discussions will be focused on what economic studies can be done in the future and where the data gaps are.*

**Day 3 (full day): Mitigation strategies, Value of Information.** *The discussions will be focused on the value of HAB forecasts. Wrap up and writing assignments.*

The output of this workshop will be a compendium of examples describing economic approaches used to estimate the costs of HABs and their mitigation, focusing on establishing connections between HAB scientists and economists. A shorter version of the compendium may be prepared for submission to a journal. In addition, the workshop will (1) propose priorities for research and effective management in the future, (2) develop partnerships between economists and HAB researchers to develop transdisciplinary projects, and (3) attract resources to the field.

### **LARGE-SCALE OCEAN RESEARCH PROJECTS CO-SPONSORED BY SCOR**

PICES contributes to SCOR-sponsored international large-scale ocean research projects, particularly IMBeR and SOLAS, by: (1) convening joint sessions/workshops with the projects at PICES Annual Meetings, (2) co-sponsoring symposia/workshops/summer schools, (3) assisting projects having North Pacific activities with meeting logistics, and (4) contributing to participation of early-career scientists from the North Pacific region in project activities.

#### ***Integrated Marine Biosphere Research (IMBeR)***

- Joint sessions/workshops at PICES Annual Meetings

Co-sponsorship of topic sessions and/or workshops by IMBeR has declined during the past few years, as IMBeR focused on redefining their strategic and implementation plan for the transition from IGBP to Future Earth (FE). In May 2016, PICES Science Board Chairman Thomas Therriault and Hal Batchelder of the PICES Secretariat met with Eileen Hofmann (former chair of IMBeR SSC), Einar Svendsen (Executive Officer, IMBeR), and Lisa Maddison (Deputy Executive Officer, IMBeR) in Bergen, Norway to discuss how to enhance collaborations between PICES and IMBeR.

- The PICES-2016 Annual Meeting held November 2-13, 2016, in San Diego, CA, USA had a theme of “*25 Years of PICES: Celebrating the Past, Imagining the Future*”. Gro van der Meeren (IMBeR Executive Officer) and Cisco Werner (IMBeR SSC Vice-Chair) represented the IMBeR International Project Office at PICES-2016, and both made presentations to PICES Science Board. They highlighted some of the areas of overlap and common interest including the ESSAS Regional Program, the Carbon Working Group, and the connections between the IMBeR Human Dimensions Working Group and the PICES FUTURE integrative science program.

#### Co-sponsorship of symposia/conferences/workshops

IMBeR co-sponsored (providing \$3,000 USD) the *4<sup>th</sup> Effects of Climate Change on the World's Oceans Symposium*, held from 2-9 June 2018 in Washington, DC. About 550 scientists participated and benefited from the information provided within 18 topic sessions spread across five days, and 11 workshops on the first weekend.

#### Capacity building activities

PICES approved financial support of \$7,000 CAD to IMBeR for cosponsorship of the IMBeR IMBIZO 5 that was held in Woods Hole, MA, USA from 2-6 October 2017. Support for IMBIZO 5 was provided to two scientists from Canada and one from China.

## IMBeR Regional Programs

IMBER has four long-standing regional programs, several of which migrated from SCOR/IGBP programs to IMBER when IGBP was disbanded. The four programs are CLIOTOP (*Climate Impacts on Oceanic Top Predators*), ESSAS (*Ecosystem Studies of Sub-arctic and Arctic Seas*), ICED (*Integrating Climate and Ecosystem Dynamics*), and SIBER (*Sustained Indian Ocean Biogeochemistry and Ecosystem Research*). Of these four, ESSAS has been the one with the greatest geographic overlap and involvement of scientists from the North Pacific Region (PICES).

- IMBeR Regional Program on *Ecosystem Studies of Sub-Arctic Seas* (ESSAS)
  - PICES and ESSAS share the goal of using a comparative approach in developing predictions of how climate variability and change affect, and will affect, the sustainability of goods and services obtained from Sub-Arctic seas.
  - A PICES/ESSAS special issue of *Progress in Oceanography* on “*Modeling and observational approaches to understanding marine ecosystem dynamics*” (Guest Editors: E. Curchitser, S.I. Ito, M. Kishi, M. Peck and K. Rose) was published electronically in late 2015 and in hard copy in early 2016.
  - ESSAS requested financial support from PICES to cosponsor the ESSAS Open Science Meeting (OSM) in Tromso, Norway in June 2017. PICES Science Board approved expenditure of \$14,000 CAD for early career scientist travel to the OSM. The ten supported ECS were reported to SCOR previously.

## ***Surface Ocean-Lower Atmosphere Study (SOLAS)***

### Joint sessions/workshops at PICES Annual Meetings

- We had no significant joint PICES-SOLAS activities in 2016 or 2017. This may be because of similar reasons as the IMBeR hiatus, as SOLAS was also proposing new initiatives to be associated with Future Earth (FE).

### Capacity building activities

In 2018, SOLAS organized a Summer School from 23 July to 4 August in Cargese, France. This was the 7<sup>th</sup> International SOLAS Summer School, and the first since 2013. Objective of the 7<sup>th</sup> SOLAS Summer School was to expose graduate students and young scientists to recent developments and methods in the study of biogeochemical and physical feedbacks between the ocean and atmosphere in a changing environment. PICES committed \$7,000 CAD to support travel and/or local costs for 2-3 students. The SOLAS International Project Office in Kiel, Germany identified two young scientists from Canada to be supported with PICES funding. Typically, for summer schools PICES prefers to distribute funding more broadly among the 6 PICES member nations, but the PICES funding was the only extramural funding available that could support scientists from Canada. PICES contributions to the SOLAS Open Science Conference (21-25 April 2019, Sapporo, Hokkaido, Japan) were described earlier in this

document.

## **HARMFUL ALGAL BLOOM ACTIVITIES SUPPORTED BY SCOR**

### Co-sponsored symposia/conferences/workshops

PICES partnered with GEOHAB (with ICES and NOAA as other sponsors) in organizing and funding the workshop on “*Harmful algal blooms in a changing world*” (March 18–22, 2013, Friday Harbor, WA, U.S.A.) to assess the state of knowledge on HABs and climate change, and to identify the most critical research needs that can realistically be addressed over the next 5–10 years. The findings were published in the peer-reviewed journal:

*Harmful Algae*. Wells, M.L., V. L. Trainer, T. J. Smayda, B.S.O. Karlson, C.G. Trick, R.M. Kudela, A. Ishikawa, S. Bernard, A. Wulff, D. M. Anderson, W.P. Cochlan. 2015, Harmful algal blooms and climate change: Learning from the past and present to forecast the future. *Harmful Algae*, 49 (2015), 68–9.

SCOR generously provided \$10,000 USD to support a 2.5-day Workshop at PICES-2019 (17-19 October 2019) titled “*GlobalHAB: Evaluating, Reducing and Mitigating the Cost of Harmful Algal Blooms: a Compendium of Case Studies*”. More details about this workshop and SCOR’s participation is in earlier text of this document.

Recent HAB updates from Vera Trainer (Member and former co-chair of PICES Section on HABs)

### Under GlobalHAB Theme 12. Climate Change

- **Economic Impacts of HABs workshop** – proposed for October 2019 in conjunction with the PICES Annual Meeting in Victoria, BC.
- **Special issue in *Harmful Algae*** (information from Chris Gobler). The submission deadline of 1 July 2018. Ca. 14 titles have been submitted. It is not clear how many papers will be submitted to the SI
- **Best-practices Manual** (information from Marina) – The first meeting was held in Napoli on 26 Feb.-1 March 2018. They discussed interactions with SCOR WG 149 (COBS). The idea is not to build a manual for all possible scenarios. This item has not been updated since last year’s annual meeting, so may be dated.

### **Climate Change and HABs: Special Issue of Harmful Algae (Draft – authors are in flux)**

- 1) The Future of HAB Science: Directions and Challenges (Authorship: HAB-Climate Change Symposium Organizers and Breakout Discussion Leads) Mark Wells
- 2) Projected Latitudinal Changes in Environmental Conditions influencing HABs (Potential Authorship: (Fei Chai, Enrique Curchitser (Temperate latitude), Phil Boyd (High latitude), Low latitude)
- 3) Modelling HABs in a changing climate (Potential Authorship: Kevin Flynn, Lead).
- 4) Cyanobacterial HABs and Climate Change in Freshwater, Brackish and Marine Waters (Potential Authorship: Angela Wulff, Petra Visser, Michele Burford, Hans Pearl)

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- 5) Fish-killing HABs and Climate change (Potential Authorship: Charles Trick, Gustaaf Hallegraeff, Allan Cembella)
- 6) Future observing systems (Potential Authorship: Raphe Kudela, Bengt Karlson, Stewart Bernard).
- 7) Macroalgae and Climate Change (Potential Authorship: Adriana Zingone, D. Liu).
- 8) Pelagic HABs and climate change (Vera Trainer, Stephanie Moore, Gustaaf Hallegraeff, William Cochlan)
- 9) Dinoflagellate cysts and climate change (Don Anderson et al.)

### **OCEAN CARBON ACTIVITIES SUPPORTED BY SCOR**

#### Communication/coordination

- PICES, through its Working Groups on *CO<sub>2</sub> in the North Pacific* (WG 13; 1998–2001) and *Biogeo-chemical Data Integration and Synthesis* (WG 17; 2002–2005), and now through the Section on Carbon and Climate (S-CC), has provided coordination for synthesis of ocean carbon research and the development of a network of ocean carbon observations in the North Pacific. The importance of ensuring effective two-way communication with other international scientific groups that have a responsibility for the coordination of ocean carbon research, such as the SCOR/IOC International Ocean Carbon Coordinated Project (IOCCP) and the SOLAS/IMBeR Carbon (SIC) Research Working Group, has been explicitly included in the terms of reference for S-CC. There are S-CC members on SIC's subgroups: Dr. Masao Ishii (Japan) is on the subgroup on *Interior Ocean Observations*, and Dr. Richard Feely is the lead of the subgroup on *Ocean Acidification-Global Context*. [NOTE: this paragraph not updated since 2017 report.]

#### Scientific Activities

- Ocean acidification has been proceeding for a century, at an accelerating rate, and its impacts are beginning to be felt in many corners of the North Pacific. A workshop on “*Acidification of the North Pacific Ocean: a basin-wide assessment*” was held on November 3, 2016 at the PICES Annual Meeting in San Diego, CA. It was well attended, and brought together scientists from all of the PICES countries to synthesize observations and projections of acidification processes and impacts in our respective countries' waters and adjacent international waters. The workshop was the culmination of a two-year long process of collation of relevant information, and synthesis of data collected in each of the countries of the North Pacific basin. The workshop proceedings will form the basis for subsequent assessments, with improved understanding of which ocean regions are most vulnerable to acidification impacts, and how additional resources might best be deployed to predict or detect changes likely to produce significant impacts. There were several topical presentations, as well as individual national updates and extensive discussion of the contents of the proposed assessment and strategies for completing it.
- During the past two years a group led by the co-chairs (James Christian (Canada) & Tsuneo Ono (Japan)) of the PICES Section on Carbon and Climate (S-CC), worked with other contributing authors to complete the document (it is being finalized for publication before the PICES Annual Meeting in October 2019). It will be PICES Special Publication No. 5,

and titled “*Ocean Acidification and Deoxygenation in the North Pacific Ocean*”. The first few pages of the contents of this special report can be found below in Appendix 1.

## SCOR WORKING GROUPS

PICES regularly provides comments on SCOR Working Group proposals and often recommends and funds an Associate Member for PICES-relevant groups. The support from PICES extends the expertise available within the group, increases the geographic coverage of the groups, and helps individual scientists from the North Pacific become more involved in SCOR activities, which benefits both organizations.

- PICES currently supports Associated Members for three SCOR Working Group:
  - WG 149 on *Changing Ocean Biological Systems: how will biota respond to a changing ocean?* (COBS) (Dr. Uta Passow, USA, Assoc. Member) – This WG was approved in late 2015, so should be completing its tasks in 2019.
  - WG 154 on *Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs (P-OBS)* (Dr. Sonia Batten, Canada, Assoc. Member)—This WG was approved in late 2017, and is holding its third meeting in September 2019.
  - WG 155 on *Eastern Boundary Upwelling Systems: Diversity, Coupled Dynamics and Sensitivity to Climate Change (EBUS)* (Dr. Ryan Rykaczewski (USA); Note also that Dr. Enrique Curchitser (USA) is a full member of EBUS and the Vice Chair of PICES.— This WG was also approved in late 2017, and met for the first time in Washington DC immediately prior to the ECCWO-4 Symposium. I am unsure if there has been a second meeting, as there is not information about other meetings on the website.
- The SCOR Working Group proposals for 2019 are being reviewed by PICES’ Standing Committees from the view point of their scientific interests and relevance to the PICES integrative science program, FUTURE. Results of the review by PICES and any recommendation regarding PICES sponsorship of an Associate Member will be provided at the SCOR Annual Meeting in Toyama.
- PICES provided partial support to Sonia Batten to participate in the first P-OBS meeting immediately prior to the AGU Ocean Sciences meeting in Portland, OR in February 2018, and partial support to Ryan Rykaczewski to participate in a 2-day meeting of EBUS immediately prior to the 4<sup>th</sup> Symposium on the Effects of Climate Change on the World’s Oceans, held in Washington, DC in early June 2018.

## CAPACITY BUILDING

SCOR and PICES have a history of cooperating in capacity building.

- SCOR provides travel support for scientists from countries with “economies in transition” to participate in SCOR-relevant sessions/workshops at PICES Annual Meetings, international symposia and capacity building events led/co-organized by PICES. For this reporting period, funding from the SCOR/NSF fund was provided/committed for the following event, and there is one other request pending with SCOR (see below):
  - \$5,000 USD (~6,650 CAD) for the PICES-2019 Annual Meeting “*Connecting Science and Communities in a Changing North Pacific*”, which will occur from 16-27 October 2019 in Victoria, BC, Canada. The scientists to be offered partial travel support from



## 6-24

SCOR are Samuel Akande (Nigeria; 1200 CAD), Basheer Ahamedd KK (India; 1000 CAD), Pengbin Wang (China; 1000 CAD), Maria Shulgina (Russia; 1000 CAD), Jianchao Li (China; 1000 CAD), Gloria S. Duran (Peru; 1000 CAD), and Baolan Wu (China; 450 CAD).

- SCOR and PICES share ideas on capacity building, and a PICES representative has participated on the SCOR Committee on Capacity Building. Dr. Harold Batchelder has served in this capacity since September 2012; beginning in 2017 he is one of several named liaisons to the SCOR Committee on Capacity Building.

### **Request PENDING for Consideration by SCOR**

**(PENDING WITH SCOR):** Travel support in the amount of \$5000 USD has been requested from SCOR for scientists from countries with “economies in transition” to attend sessions and workshops at the MSEAS-2020 Symposium that will be held 24-28 May 2020 in Yokohama, Japan.

APPENDIX 1: PICES Special Publication 5 – brief preview of contents and authorship. See NEXT PAGES.

6-26



PICES SPECIAL PUBLICATION 5

**Ocean Acidification and Deoxygenation  
in the North Pacific Ocean**







## Ocean Acidification and Deoxygenation in the North Pacific Ocean

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Tsuneo Ono (Japan)

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The views expressed in this volume are those of the  
participating scientists. Contributions were edited for  
brevity, relevance, language, and style and any errors that  
were introduced were done so inadvertently.

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### Feedback

Comments on this volume are welcome and can be sent via  
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Institute.



Fisheries and Oceans  
Canada



FRA

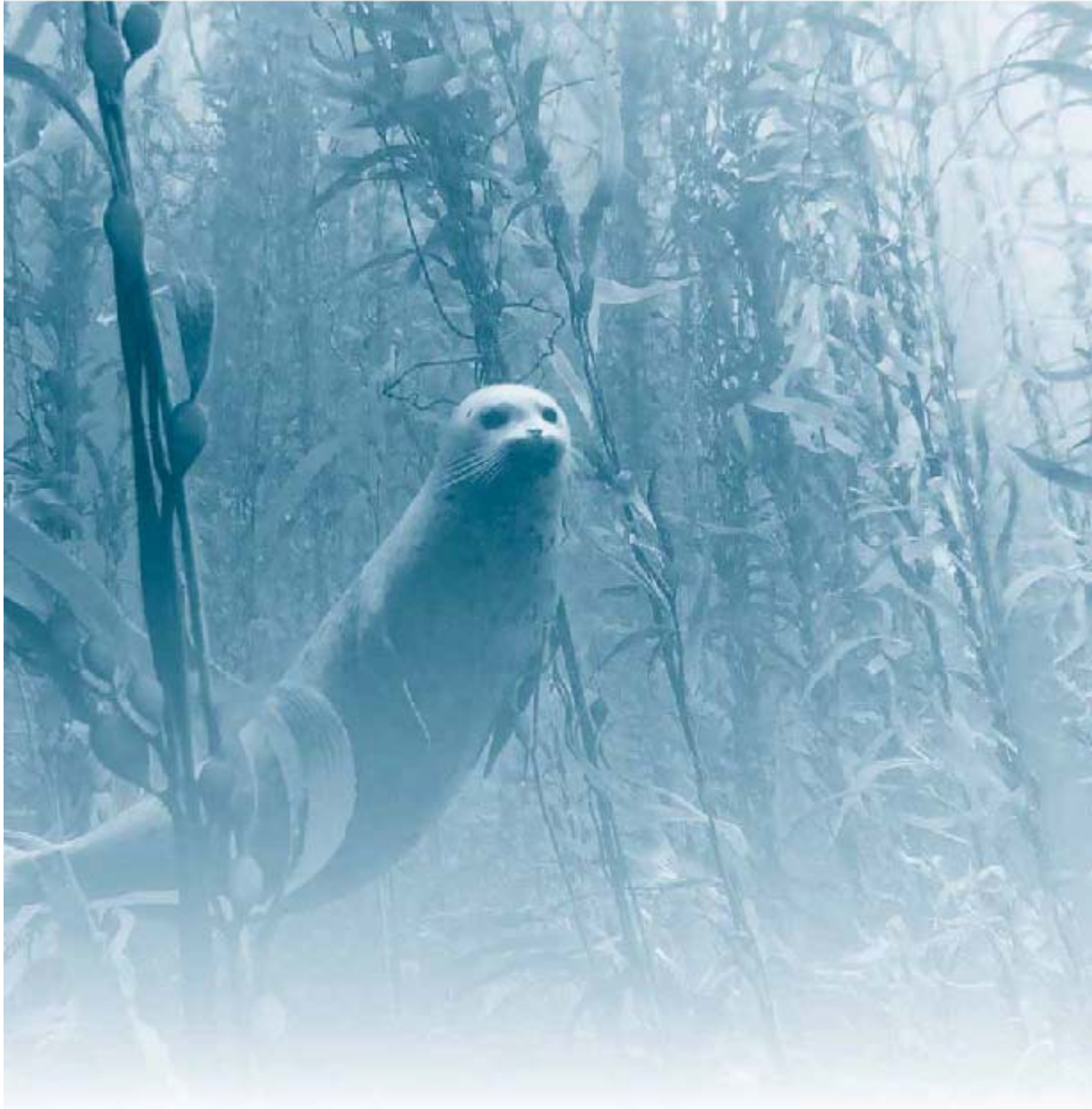


気象庁  
Japan Meteorological Agency



Front cover images: top: Moira Galbraith, bottom: Hiroya Yamano.





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PICES Special Publication

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Credit: NASA





## The FUTURE Science Program of PICES

FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) is an integrative Scientific Program undertaken by the member countries and affiliates of the North Pacific Marine Science Organization (PICES) to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders, and the public.

FUTURE evolved from research conducted by its predecessor, the PICES/GLOBEC Climate Change and Carrying Capacity program, which had the goal of increasing understanding of climate influences on marine ecosystems. FUTURE continues a focus on understanding climate impacts on marine ecosystems and places additional emphasis on coastal anthropogenic influences, ecosystem forecasting, and engaging a broad user community with interests in North Pacific ecological and climate information.

This PICES Special Publication on ocean acidification and ocean deoxygenation is an important contribution to FUTURE's principal objective of improving our knowledge and communication of the future of North Pacific ecosystems and the potential impacts of human activities on the North Pacific.

