

3.0 LARGE-SCALE OCEAN RESEARCH PROJECTS

- 3.1 Global Ecology and Oceanography of Harmful Algal Blooms Program, **p. 3-1** *Enevoldsen, Sun Song*

3.2 Integrated Marine Biogeochemistry and Ecosystem Research, **p. 3-6** *Burkhill*

3.3 GEOTRACES, **p. 3-32** *Naqvi*

3.4 Surface Ocean – Lower Atmosphere Study, **p. 3-60** *Sarma, Turner*

3.5 International Quiet Ocean Experiment, **p. 3-80** *Urban, Shapovalov*

3.6 Second International Indian Ocean Expedition, **p. 3-82** *Hood, D'Adamo, Burkhill*

3.1 Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)/GlobalHAB (joint with IOC)

Sun

Terms of Reference:

The Scientific Steering Committee of the GEOHAB Programme will

1. Coordinate and manage GEOHAB Core Research Projects (CRPs) in accordance with the GEOHAB Science and Implementation Plans.
2. Identify gaps in knowledge required to execute CRPs, and encourage targeted research activities to fill those gaps.
3. Review progress on CRPs over time and initiate new CRPs in priority research areas.
4. Foster framework activities to facilitate implementation of GEOHAB, including dissemination and information tools.
5. Establish appropriate data management activities to ensure access to, sharing of, and preservation of GEOHAB data, taking into account the data policies of the sponsors.
6. Promote comparative and interdisciplinary research on harmful algal blooms by providing coordination and communication services to national and regional research groups, encouraging explicit affiliation with GEOHAB via the endorsement process.
7. Collaborate, as appropriate, with intergovernmental organizations and their subgroups (e.g., ICES, PICES, FANSA, ANCA, WESTPAC/HAB, HANA, NOWPAP), as well as related research projects (e.g., GLOBEC, LOICZ, IMBER) and observational systems such as the Global Ocean Observing System and its regional alliances.
8. Report regularly to SCOR, the IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB), and the global HAB research community on the state of planning and accomplishments of GEOHAB, through annual reports and, as appropriate, the GEOHAB Web site, a GEOHAB Newsletter, *Harmful Algal News*, special sessions at scientific meetings, and other venues.
9. Interact with agency sponsors to stimulate the support of GEOHAB implementation through various mechanisms (e.g., direct support of GEOHAB initiatives and integration of the GEOHAB approach in national programs).

Acronyms

ANCA = IOC HAB working group for Central America and Caribbean Sea

FANSA = IOC HAB working group for South America

HANA = IOC HAB working group for North Africa

GLOBEC = Global Ocean Ecosystem Dynamics project

ICES = International Council for the Exploration of the Seas

IMBER = Integrated Marine Biogeochemistry and Ecosystem Research project

IOC = Intergovernmental Oceanographic Commission

LOICZ = Land-Ocean Interactions in the Coastal Zone project

NOWPAP = UNEP Northwest Pacific Action Plan

PICES = North Pacific Marine Sciences Organization

SCOR = Scientific Committee on Oceanic Research

WESTPAC/HAB = IOC SubCommission for the Western Pacific HAB working group

3-2

Chair:

Raphael M. Kudela
Ocean Sciences Department
University of California
Santa Cruz, CA 95064, USA
Email: kudela@ucsc.edu

Vice Chair:

Elisa Berdalet
Institut de Ciències del Mar (CMIMA,
CSIC)
Dept. Biologia Marina i Oceanografia
Pg. Marítim, 37-49
08003- Barcelona, Catalunya
SPAIN
E-mail: berdalet@icm.csic.es,
elisa.berdalet@icm.cat

Members:

Icarus Allen	UK
Stewart Bernard	SOUTH AFRICA
Paul Bienfang	USA
Michele Burford	AUSTRALIA
Liam Fernand	UK
Songhui Lu	CHINA-Beijing
Patricia Tester	USA
Gires Usup	MALAYSIA

Ex-officio Member: Gires Usup (IOC IPHAB)

IOC Staff: Henrik Enevoldsen

Executive Committee Reporter: Sun Song

The GEOHAB SSC is continuing work until their synthesis products are completed.



Global Ecology Algal Blooms (GEOHAB)

This document presents finished at the end of its continuation as the new

Raphael Kudela and Elisa respectively, in of the program, as well as research on harmful algal **sustained support of GlobalHAB.**

and Oceanography of Harmful Program Activities, 2014-2015

the last activities of the GEOHAB project that 2014, and the transition period along 2015 toward initiative GlobalHAB.

Berdalet, Chair and Vice-chair of GEOHAB, representation of all the SSC members along the life the whole scientific community engaged in the blooms, **express their deep gratitude to the SCOR to this programme and its continuation as**

1. Representation at IPHAB Meeting, April 2015.

GEOHAB was represented by the SSC Vice-Chair (Elisa Berdalet) at the XII IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB-XII) meeting held in Paris, on 28-30 April 2014. The Progress Report presented at the IPHAB meeting can be found at http://hab.unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15021.

Because the IPHAB meeting takes place once every two years, Berdalet presented an update of GEOHAB activities during the 2014-2015 period. The activities (and their corresponding science highlights) conducted until July 2014, were already in our 2014 report to SCOR. The activities performed since July 2014 are presented in the next sections of this document.

Berdalet acknowledged the decision of SCOR to accept to co-sponsor GlobalHAB, which was also appreciated by IOC IPHAB. With this funding, GlobalHAB will initiate the GlobalHAB SSC and foster the implementation of recommended workshops and activities agreed at the Final Open Science Meeting of GEOHAB (Paris, April 2013). **Berdalet emphasized the need for IPHAB member states to contribute additional funds to the implementation of GlobalHAB.** She briefly presented the main components of GlobalHAB, as they had been presented to SCOR in its 2014 General Meeting (Bremen, September 2014). Namely, the Terms of Reference, the

3-4

- **Decided** to establish with SCOR an IOC-SCOR GlobalHAB Scientific Steering Committee in accordance with the draft Terms of Reference, as approved by SCOR and attached to this Decision as Annex I;
- **Invited** other international scientific coordinating bodies to support GlobalHAB activities; and
- **Urged** Member States and their institutions to provide advice and resources to help implement GlobalHAB objectives.

2. Science Highlights

2.1. Summary for policy makers

This document, that constitutes one of the final products of GEOHAB, was led by Raphael Kudela, Elisa Berdalet, and Henrik Enevoldsen. The *Summary for Policy Makers* was delivered on June 2015 and disseminated by IOC (http://www.unesco.org/new/en/natural-sciences/ioc-oceans/single-view-oceans/news/new_publication_on_harmful_algal_blooms_for_policy_makers/#.VeXWJngdzS).

It can be download free at this link and it is also included in the Addendum of this document.

2.2. Co-sponsoring and participation at the Scientific Symposium on Harmful Algal Blooms and Climate Change

GEOHAB co-sponsored this symposium held in Göteborg, Sweden, on 19-22 May 2015; Raphael Kudela one of the conveners. Kudela and Berdalet also presented the oral communication "**From GEOHAB to GlobalHAB - International Research and Coordination of HABs Leading to Improved Societal Benefits**" at the symposium. Information about the symposium can be found at https://pices.int/meetings/international_symposia/2015/2015-HAB/organizers.aspx. Two publications with the symposium findings are in preparation.

2.3. Representation of GEOHAB at the 16th International Conference on Harmful Algae (ICHA) meeting in New Zealand (October 2014).

The venue allowed the final public outreach/meeting efforts for GEOHAB. The organizers of the conference facilitated a booth where posters synthesizing the activity of GEOHAB were exhibited, and GEOHAB distributed printed copies of the reports resulting from the programme, including the last published Synthesis Report. Members of the GEOHAB SSC provided information to many attendants of the conference who were interested about the future GlobalHAB programme.

3. Publications

GEOHAB Open Science Meeting Report

The SSC convened a synthesis GEOHAB Open Science Meeting at IOC Headquarters in Paris, France in April 2013. The SSC finalized the report and it was presented at the ICHA in New Zealand (October 2014). The Report can be freely downloaded from the GEOHAB web site (www.geohab.info).

Publication of a special issue

As part of the synthesis, the GEOHAB SSC, in coordination with the GEOHAB Core Research Projects (CRPs0, identified a series of publications targeting *Oceanography* magazine. The additional funds received in August 2015 (H. Enevoldsen) will allow the publication of 6 papers in the mentioned journal by Spring-Summer 2016.

3-6

3.2 Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) (joint with IGBP)

Burkill

Terms of Reference

- To develop the IMBER Science Plan and Implementation Strategy, in accordance with guidance from the sponsoring organisations.
- To oversee the development of IMBER in accordance with its Science Plan and Implementation Strategy.
- To collaborate, as appropriate, with related projects of the sponsors IGBP and SCOR, and other related programmes and organisations (e.g., IHDP, DIVERSITAS, IOC and the Global Ocean Observing System (GOOS), etc.)
- To establish appropriate data management policies to ensure access to, sharing of, and preservation of IMBER data, taking into account the policies of the sponsors.
- To report regularly to SCOR and IGBP on the state of planning and the accomplishments of IMBER.

The IMBER SSC, its subsidiary groups and International Project Office shall operate in accordance with the operating procedures for IGBP Projects and the requirements of the other co-sponsors.

Chair	Vice-Chairs		
Eileen E. Hofmann (F) Old Dominion University Center for Coastal Physical Oceanography 4111 Monarch Way Norfolk, VA 23508 USA Tel: +1 757 683 5334 hofmann@ccpo.odu.edu	Alida Bundy (F) Bedford Institute of Oceanography Ocean Ecosystem Science Division P.O. Box 1006 Dartmouth NS B2Y 4A2 CANADA Tel: + 902 426 8353 alida.bundy@dfo-mpo.gc.ca	Kenneth F. Drinkwater (M) Institute of Marine Research Department of Oceanography and Climate P.O. Box 1870 Nordnes 5817 Bergen Norway Tel: +47 976 75 592 ken.drinkwater@imr.no	Alberto R. Piola (M) Servicio de Hidrografía Naval Departamento Oceanografía Av. Montes de Oca, 2124 C1270ABV Buenos Aires Argentina Tel: +54 11 4301-0061 apiola@hidro.gov.ar

Members

Edward Allison, USA
Laurent Bopp, FRANCE
Claudio Campagna, ARGENTINA
Ratana Chuenpagdee, CANADA
Rubén Escribano, CHILE
Gerhard Herndl (M), AUSTRIA
Masao Ishii, JAPAN

Su Mei Liu (F), CHINA-Beijing
Eugene Murphy (M), UK
Katrin Rehdanz (F), GERMANY
Tatiana Rynearson (F), USA
Svein Sundby, NORWAY
Sinjae Yoo (M), KOREA

Executive Committee Reporter: Peter Burkill
Executive Officer: Einar Svendsen



Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Annual Report to SCOR

August 2015

A. *Introduction*

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER, www.imber.info) is an international global environmental change research project, co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and the International Geosphere-Biosphere Programme (IGBP, ending in 2015 after 30 years). The goal of IMBER science is to develop a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society. The 2005 IMBER Science Plan and Implementation Strategy (SPIS) outlined questions and approaches to address this goal. The SPIS was updated in 2010 when the Global Ocean Ecosystems Dynamics (GLOBEC) project ended and its activities were incorporated into IMBER. Having completed its first 10 years, IMBER is now planning its next scientific phase. A new SPIS that will form the basis for the next decade of IMBER research has been developed and will be submitted to SCOR for review and approval in Fall 2015. The current structure of IMBER (Fig. 1) provides the starting point for implementation of the SPIS.

IMBER's strong commitment to curiosity-driven science provides the foundation for its new 10-year research plan. However, the environmental issues facing society, particularly those relating to global environmental change, are issues that challenge natural and social sciences and humanities. Integration of the understanding provided by curiosity-driven natural science and the problem-driven, societally relevant science requires research that cross the interfaces between these disciplines (transdisciplinary research). A clear message from the 2014 IMBER Open Science Conference (OSC) and community consultation associated with development of the SPIS was that trans-disciplinary research must be part of any future research agenda. This is underscored by the science discoveries and highlights presented in the next section, most of which are drawn from publications subsequent to the OSC.

IMBER Implementation

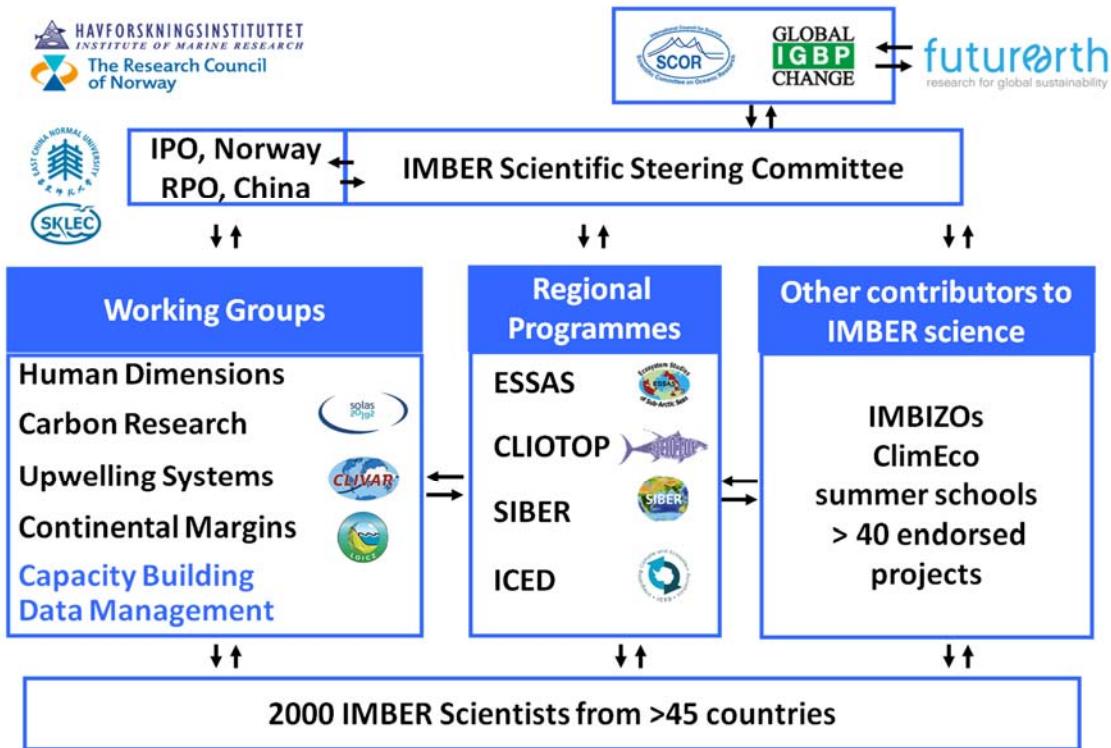


Fig. 1. Structure of IMBER.

B. Selected recent IMBER discoveries and highlights

- IMBER advanced understanding of climate effects on marine ecosystems in the Anthropocene
- IMBER advanced understanding of natural-human science interactions in marine systems
- IMBER is developing societal-ecological decision support frameworks for marine systems
- IMBER promoted and undertook capacity building and knowledge transfer activities
- IMBER research informs sustainable use of marine ecosystems

Selected recent discoveries and highlights from IMBER regional programmes, working groups and related research projects are:

From: Ecosystem Studies of Sub-Arctic Seas (ESSAS):

1. The Atlantic Multidecadal Oscillation (AMO), with a 60-80 year periodicity (Fig. 2), was shown to extend into the high latitudes and Arctic regions, as observed in temperature and

sea-ice data (*Drinkwater et al.*, 2014)

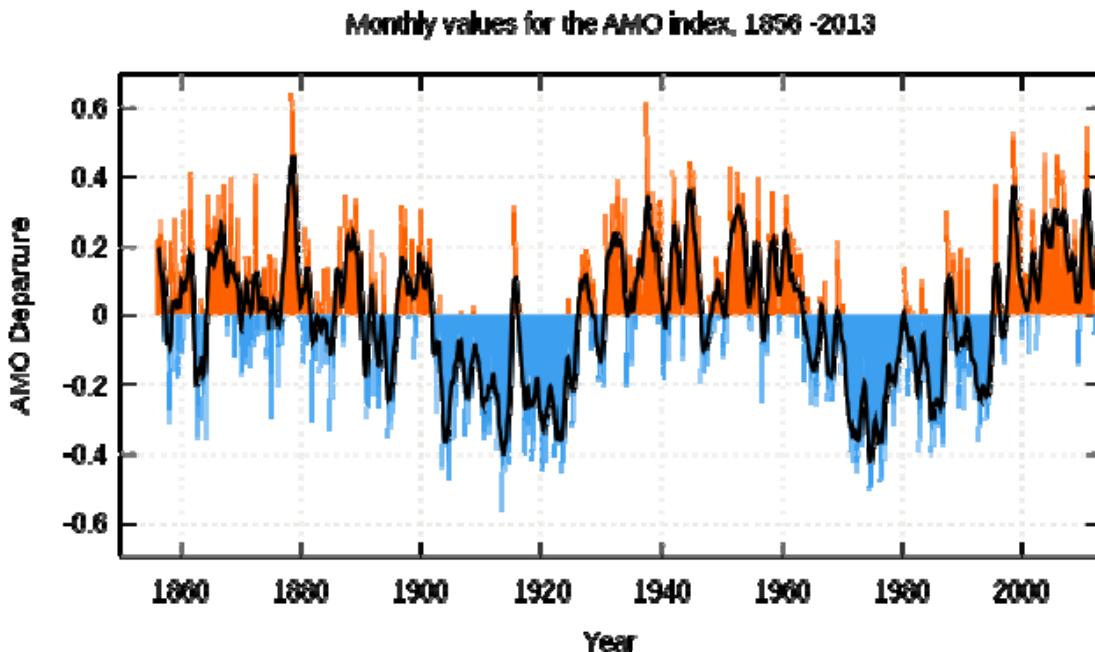


Fig. 2. 157 year development of the Atlantic Multidecadal Oscillation Index expressed as standardized anomalies and de-trended, i.e. excluding the anthropogenic signal.

(<http://www.esrl.noaa.gov/psd/>).

2. Contrary to the general perception of increased primary production in frontal regions, enhanced production is not observed in association with the Polar Front in the Barents Sea and the Arctic Front in the Norwegian Sea. The International Polar Year (IPY) project NESSAR (Norwegian component of the ESSAS) was the first to demonstrate that these frontal regions are primarily density compensating with strong interleaving between the warm, saline Atlantic waters and the cold, low saline Arctic waters. Turbulence near the fronts is relatively weak. Although mixing occurs through both double diffusion and current shear, it is not strong enough to mix nutrients into the surface layers during the stratified period. No secondary upwelling circulation was observed and, hence nutrients are low in the frontal region once the spring bloom is over (*Drinkwater and Tande, 2014*).
3. Circulation on the Bering Sea shelf, through the Bering Strait and on the Chukchi Sea shelf, is tightly coupled, with transport anomalies through the Strait driven by the longitudinal location of the Aleutian Low (*Danielson et al., 2014*).
4. Much of the diatom production on the Bering Sea shelf is consumed by protists in the microzooplankton, rather than by zooplankton such as copepods and krill, as previously believed. These microzooplankton are also important in the food web, supporting a large summer zooplankton biomass on the shelf, when they can be more abundant than phytoplankton (*Sherr et al., 2013; Stoecker, et al., 2014*).

3-10

From: Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED):

5. Antarctica's Ross Sea is projected to lose more than half its summer sea ice by 2050 and more than three quarters by 2100. This will be a dramatic change for the area, which is one of the few polar regions that has experienced an increase in summer sea ice coverage over the past few decades. This loss of sea ice has important implications for biological production of the Ross Sea (*Smith et al., 2014*).
6. Winter fast-ice trends over the past 100 years for the South Orkney Islands, Antarctica, demonstrate marked inter-annual variability and long-term changes. These findings indicate the need for caution in interpreting changing ice conditions based on shorter-term satellite series (*Murphy et al., 2014*).
7. Despite inhabiting one of the strongest currents in the world's oceans, Antarctic krill appear to be able to influence their distribution at large oceanic scales through behavior that facilitates maintenance of population centers (*Tarling and Thorpe, 2014*).
8. Due to warming, species richness may increase in Antarctic water masses as sub-Antarctic species increasingly encroach southwards (*Ward et al., 2014*).
9. Changes in penguin abundance and distribution can be used to understand the response of species to climate change and fisheries pressures, and to gauge of ecosystem health (*Waluda et al., 2014*).
10. Zooplankton faecal pellet production is a key control of the efficiency of deep carbon transfer in the Scotia Sea. This area contains the largest seasonal uptake of atmospheric carbon dioxide yet measured in the Southern Ocean (*Manno et al., 2015*).
11. Dissolution dominating calcification processes in polar pteropods are close to the point of Aragonite undersaturation (*Bednaršek et al., 2014*).
12. IMBER/ICED scientists contributed to a Southern Ocean biogeographic atlas, www.biodiversity.aq.

From: Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER):

13. The Indonesian Throughflow (ITF) is a chokepoint in the upper ocean thermohaline circulation that carries Pacific water through the strongly mixed Indonesian Sea and into the Indian Ocean. This suggests that most of the ITF nutrient supply goes into the thermocline waters, where it can support new production and impact Indian Ocean biogeochemical cycling (*Ayes et al., 2014*).

From: Climate Impacts on Ocean Top Predators (CLIOTOP):

14. From the 137-year long record of the El Niño-Southern Oscillation (ENSO), no significant trend can be detected, and the recent multi-decadal variability is similar to earlier decades. ENSO has not fundamentally changed over the period of large increase in atmospheric CO₂, and the potential of predicting the future states of the fisheries and ecosystems are quite limited. (*Harrison and Chiodi, 2015*)
15. Major uncertainties in modelling frameworks are broadly categorised into those associated with (i) deficient knowledge in the interactions of climate and ocean dynamics with marine

organisms and ecosystems; (ii) lack of observations to assess and advance modelling efforts and (iii) an inability to predict with confidence natural ecosystem variability and longer term changes as a result of external drivers (e.g. greenhouse gases, fishing effort) and the consequences for marine ecosystems. As a result of these uncertainties and intrinsic differences in the structure and parameterisation of models, users are faced with considerable challenges associated with making appropriate choices on which models to use. A key research direction is the development of management systems that are robust to this unavoidable uncertainty. (*Evan et al., 2015*)

From: SOLAS/IMBER Carbon (SIC) Working Group:

16. The Surface Ocean CO₂ Atlas (SOCAT, www.socat.info), compiled by the international marine carbon community, provides access to quality-controlled surface CO₂ data (Fig. 3). The first two versions were released in 2011 and 2013, respectively. Version 2 contains 10.1 million quality-controlled, surface ocean fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global oceans and coastal seas. Version 3 of the Atlas was released on 7 September 2015 (*Bakker et al., 2014; Pfeil et al., 2013; Sabine et al., 2013*).
17. Scientific applications of SOCAT include: 1) quantification of the ocean carbon sink and 2) ocean acidification and their temporal and spatial variation, 3) validation of ocean carbon models and coupled climate carbon models, and 4) provision of constraints for atmospheric inverse models used to estimate land carbon sink (*Landschützer et al., 2014; Lauvset et al., 2015; Rödenbeck et al., 2014; Séférian et al., 2014; Tjiputra et al., 2014*).
18. SOCAT synthesis products represent an impressive achievement in coordinating international researchers to deliver publicly accessible and uniformly quality-controlled data for marine carbon and ocean acidification research that can be used for research and to inform international policy and climate negotiations.

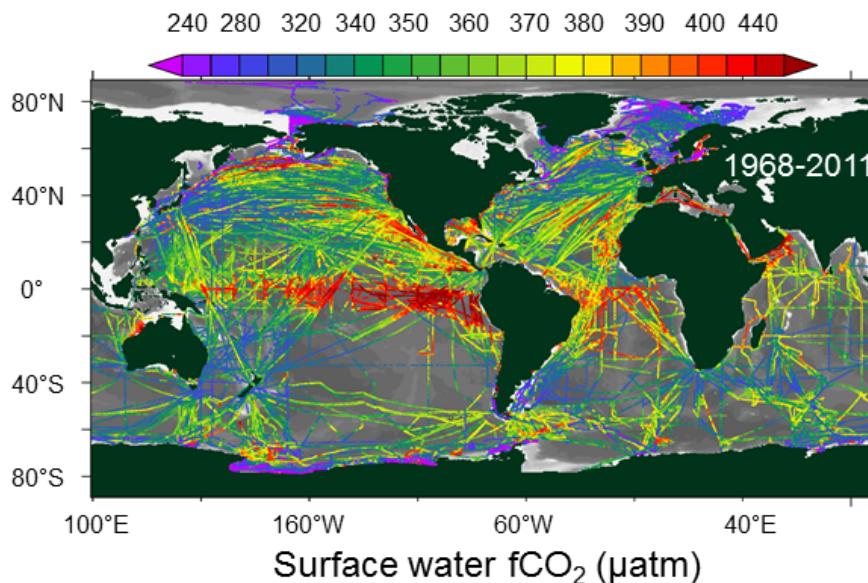


Fig. 3. The global distribution of surface water fCO₂ values in SOCAT version 2 for 1968 to 2011 (<http://www.socat.info/>; Bakker et al. (2014))

From: Capacity Building Task Team:

- 19.** IMBER is proactive in building and strengthening the scientific capacity of early to mid-career researchers, and scientists from developing countries. A major activity in facilitating capacity building is the biannual international, transdisciplinary ClimEco (Climate and Ecosystems) summer school. To date, more than 300 students and early career researchers, many from developing countries, have attended the four summer schools organized by IMBER (*Hofmann et al., submitted*).

From: Human Dimensions Working Group (HDWG):

- 20.** IMBER-ADApT (Assessment based on Description, Responses and Appraisal for a Typology) developed by the HDWG, is an integrated assessment framework built on knowledge learned from past responses to global change issues. It will enable decision makers, researchers, managers and local stakeholders to make more efficient decisions for marine sustainability, and to evaluate most effectively where resources should be allocated to reduce vulnerability and enhance resilience of coastal people and communities to global change (*Bundy et al., 2015*; <http://www.imber.info/index.php/eng/Science/Working-Groups/Human-Dimensions/IMBER-ADApT>).

From: Continental Margins Working Group:

- 21.** The quest for resources is driving exploration and exploitation on continental margins, including the Arctic margins. Disasters, such as the 2010 BP-Deepwater Horizon oil spill, are likely to occur with increasing frequency and exacerbate on-going threats, such as coastal hypoxia. The IMBER-LOICZ Continental Margins Working Group (CMWG) found that the prevailing Law of the Sea promotes exploitation, but with insufficient responsibility and accountability to stem unsustainable development on continental margins. Recommendations from CMWG activities focus on reforms based on better understanding of the social-ecological systems (*Levin et al., 2015*), assessment of risks associated with development, and effective governance (*Glavovic et al., 2015*).

From Endorsed projects:

GALATHEA

- 22.** Nutrient availability is considered to be a primary control on size structure of phytoplankton communities, with small cells being more competitive at low nutrient concentrations. However, research from the GALATHEA project indicates that temperature also appears to have a direct effect, with small cells dominating the community structure in warmer water. This temperature effect on cell size has implications for the ocean as a carbon sink because of the slower sinking rate of small cells (*Mousing et al., 2014*).
- 23.** Localised vertical mixing between 200 m and the depth of the deep chlorophyll maximum (DCM, approximately 130 m) stimulates phytoplankton activity and alters the distribution of

zooplankton. Eel larvae in the Sargasso Sea tend to be concentrated in areas of deep mixing. This deep localized mixing may be responsible for heterogeneity in plankton distributions. Research continues to better understand the processes leading to this vertical mixing (*Richardson et al., 2014*).

- 24.** It is expected that ocean warming will lead to increased bacterial activity and faster remineralisation of particulate organic carbon (POC) in the surface layers, which increase POC export to deep waters, potentially decreasing the strength of the biological pump. This temperature sensitivity of remineralisation in the global ocean has now been quantified and is an important input for modelling of the ocean carbon cycle (*Bendtsen et al., 2015*).

PERSEUS

- 25.** Changes in the structure and functioning of the Black Sea food web between 1960 and 2000 were investigated with four models developed to evaluate trophic transfers. These models showed new energy pathways resulting from changes in trophic components and the conversion of significant amounts of system production to detritus. This shift in the food web led to various ecosystem-wide changes (*Akoglu et al., 2014*).
- 26.** The project provided the first climatology of the seasonal thermocline slope and the upper-ocean heat storage rate in the Mediterranean Sea. This has Implication of sub-basin circulation patterns and the ocean heat storage. Climatologies of the mixed layer depth and temperature in the Mediterranean Sea was also updated (*Houpert et al., 2014*)
- 27.** Biogeochemical data of the surficial and sub-surficial sediments of the Adriatic Sea were processed using statistical Q factor data analysis. Four different biogeochemical facies were identified, indicating that the biogeochemical and sedimentary processes of the Adriatic Sea have changed slightly in the last century (*Spagnoli et al., 2014*)
- 28.** The connection between climate variability and anchovy spawning and recruitment in the Black Sea and other ecosystems, was studied using a two-way coupled lower trophic level and anchovy bioenergetics model. Temperature was the dominant factor influencing early life stages and the population dynamics of Black Sea anchovy through its effect on anchovy egg production and recruitment success. Each 2°C decrease in summer mean temperature resulted in a 12- to 19-day delay in egg production. This strong link between climate variability and anchovy spawning and recruitment could have important prediction potential for short-term anchovy stock estimations for fisheries management (*Guraslan et al., 2014*).
- 29.** Human activities, such as shipping, aquaculture, and the opening of the Suez Canal, have led to the introduction of nearly 1000 alien species into the Mediterranean Sea. The local taxonomic identity of the alien species is dependent on the dominant maritime activities/interventions and the related pathways of introduction. Further research is needed to better understand how biodiversity changes will affect Mediterranean Sea food webs, ecosystem functioning, and the provision of ecosystem services (*Katsanevakis et al., 2014*).
- 30.** Climate variation has increased surface temperature and stratification, producing a decrease in winter mixing. Oxygen and nutrient dynamics in the middle pycnocline have been decoupled. Nutrient concentrations in the upper layer decreased with the decrease in

3-14

anthropogenic eutrophication. Warm periods (series of warm winters) led to a decrease of oxygen in the Cold Intermediate Layer (CIL), an elevation of the hydrogen sulphide boundary and a decrease of nutrients in the surface layer. Cold periods (series of cold winters) lead to an increase of oxygen in the CIL, deepening of the hydrogen sulphide boundary and increase of nutrient in the surface layer (*Pakhomova et al., 2014*).

31. Biomass size distribution, light absorption properties and carbon and nitrogen uptake rates were analysed in phytoplankton assemblages along coast–offshore gradients in the Alboran Sea. Surface nitrate concentration was $>1 \mu\text{M}$ at the coastal stations and less than the detection limit at the offshore stations. Phytoplankton community biomass was dominated by diatoms at the coastal sites; dinoflagellates and picoplankton contributed <30 and 7%, respectively (*Mercado et al., 2014*).
32. Studies of nutrients and phytoplankton during a deep convection episode showed that nutrient supplies were equivalent to the annual river discharge and that these events counterbalance decreased surface silicate to nitrate ratio. New hypotheses were proposed to explain triggering of the intense spring bloom (*Severin et al., 2014*).
33. An overview of the pressures impacting the Southern European Seas (SES) and their roles in altering the environmental status was undertaken. Additional knowledge and improved understanding is needed to undertake a scientific Good Environmental Status (GES) evaluation. Some of the indicators for the *Marine Strategy Framework Directive* (MSFD) are almost impossible to evaluate for operational purposes (e.g. those related to biodiversity, food web structure, marine litter and microplastics, underwater noise and energy). Additional targeted scientific priorities were identified for the SES to help reduce uncertainties and gaps in data and knowledge (*Crise et al., 2015*)
34. The swarms of Portuguese Man-of-War (*Physalia physalis*) that appeared in summer 2010 in the Mediterranean Sea had dramatic consequences, including the region's first recorded human fatality attributed to a jellyfish sting. Analyses of the meteorological and oceanographic conditions of the Northeast Atlantic Ocean in the months prior to the appearance of *P. physalis* and simulation of the probable drift of Atlantic populations into the Mediterranean basin suggested that the swarms resulted from an unusual combination of meteorological and oceanographic conditions the previous winter, and was not a permanent invasion due to favourable climatic changes (*Prieto, et al., 2015*).
35. Trawls in the coastal areas of the Eastern Mediterranean and Black Sea found up to 1211 items of litter per km^2 . Plastics were the most abundant (mostly bags and bottles) litter, up to 95% of the total, in all study areas. More than half of marine litter items were of medium size: $10 \times 10 \text{ cm}$, $<20 \times 20 \text{ cm}$. The results are presented in a recent report, supporting the *Marine Strategy Framework Directive* (MSFD) implementation, as well as efforts to discourage plastic carrier bag use (*Ioakeimidis et al., 2015*).
36. A visual census of marine litter on the seafloor of the Saronikos Gulf (Greece) was combined with environmental education in a novel two-day research cruise, in which schoolchildren actively participated in using a Remote Operated Vehicle (ROV). Marine litter proved to be

an ideal theme to enhance the environmental awareness of schoolchildren (*Ioakeimidis et al., in press*).

- 37.** The first observation-based acidification trends in the water masses of the Atlantic basin over the past two decades were presented and compared with climate model results. Observations and model output confirm that pH changes in surface layers are dominated by the anthropogenic component. In mode and intermediate waters, the anthropogenic and natural components are of the same order of magnitude and sign (about -0.002 yr^{-1}). Large changes in the natural component of newly formed mode and intermediate waters are associated with latitudinal shifts of these water masses caused by the Southern Annular Mode in the South Atlantic and by changes in the rates of water mass formation in the North Atlantic (*Aida et al., 2015*).

CARBOCHANGE

- 38.** Identifying the magnitude of a trend and the point in time when this signal emerges from the background noise of natural variability is essential for the detection of climate change. Even strong trends, in both the physical climate and carbon cycle system, can be masked by variability over decadal timescales in areas with high natural variability. Because natural variability, unlike the trend, is affected by the seasonal cycle, observational data must be interpreted with caution. Intra-annual variability may obscure the representativeness of irregularly sampled seasonal measurements taken over a year and, thus, the interpretation of any observed trends (*Keller et al., 2014*).
- 39.** Global CO₂ emissions from fossil-fuel combustion and cement production will increase by 2.5% (1.3–3.5%) to $10.1 \pm 0.6 \text{ GtC}$ in 2014, 65% above 1990 emissions. The cumulative emissions of CO₂ (from 1870–2014) will reach about $545 \pm 55 \text{ GtC}$ (*Le Quéré et al., 2014*).
- 40.** It has been argued that controlling only the Earth's temperature (e.g. the 2°C target) may not be sufficient to control the other impacts of climate change. Six target variables (air temperature, sea-level rise, aragonite, primary production levels, soil, and carbon loss) were analysed under different limits using a state-of-the-art cutting-edge Earth system model. The results showed that allowable carbon emissions were considerably reduced, suggesting that mitigation efforts focused solely focus on a temperature target will not limit the risk arising from human-induced emissions (*Steinacher et al., 2013*).
- 41.** By 2100, under the high CO₂ emission scenario RCP8.5, pH reductions exceeding -0.2 (-0.3) units are projected to be about 23% (~15 %) for waters of North Atlantic deep-sea canyons and ~8% (3 %) waters over seamounts, including seamounts proposed as sites for marine protected areas. The spatial pattern of impacts reflects the depth of the pH perturbation and does not scale linearly with atmospheric CO₂ concentration. Impacts may cause negative changes of the same magnitude, or exceeding the current target of 10% of preservation of marine biomes set by the Convention on Biological Diversity, implying that ocean acidification may offset benefits from conservation/management strategies that rely on regulation of resource exploitation (*Gehlen et al., 2014*)

3-16

Too Big To Ignore (TBTI, <http://toobigtoignore.net/>)

42. To address the marginalization of small-scale fisheries in policy and governance, an Information System (ISSF, <http://issf.toobigtoignore.net/>), containing information such as fishing area, gear type, targeted species and catch fate, has been developed. As of March 2015, ISSF contained 1,740 records contributed by 400 individuals from 140 countries. This extensive and comprehensive information system makes possible for the first time the development of evidence-based descriptions of the existence and importance of small-scale fisheries around the world (Jentoft and Chuenpagdee, 2015).

C. Activities of IMBER Regional Programmes

Ecosystem Studies of Sub-Arctic Seas (ESSAS) Regional Programme

The ESSAS programme (www.imr.no/essas) focuses on the impacts of climate change on sub-Arctic and Arctic marine ecosystems and their sustainability. The recent expansion of ESSAS research interests into the Arctic resulted in modifying the name to Ecosystem Studies of Sub-Arctic and Arctic Seas, which retains the programme acronym. Comparative ecosystem studies are an important part of ESSAS research and this provides a basis for interactions with other IMBER regional programmes.

ESSAS held an annual science meeting (in conjunction with its Science Steering Committee (SSC) meeting) at the University of Washington in Seattle, WA, USA on 15-17 June 2015. The theme of the symposium was “The Role of Ice in the Sea”. Session themes included:

- Humans, Ice and the Sea in the Subarctic and Arctic Past
- The Role of Sea Ice in the Arctic and Subarctic
- Ecological Roles of Glaciers in the Sea
- Socio-economics of Management for Resilience

An ESSAS-related special issue of the journal *Progress in Oceanography* on “Modelling and observational approaches to understanding marine ecosystem dynamics” will be published in 2015. In addition, 11 papers describing results from the Norway-USA Climate Change and Marine Ecosystems Workshop will be submitted to *Elementa: Science of the Anthropocene* before the end of 2015.

RACArctic (Resilience and Adaptive Capacity of Arctic marine systems under changing climate), a joint Japan-USA-Norway activity, was recently awarded 500k Euros from the Belmont Forum to synthesise information from regional studies.

Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Regional Programme

The ICED programme aims to better understand the climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles, and the development of sustainable management procedures. See www.iced.ac.uk/index.htm.

Highlights from ICED science over the past year are described in section B. In addition, ICED scientists provided input for the IPCC AR5 chapter on polar regions. Several studies focused on assessments of changes in Antarctic ecosystems are ongoing. Also, end-to-end models that include carbon are being developed to provide scenario projections. An ICED community paper on scenarios is being developed. ICED will strengthen the science areas as outlined in the new IMBER Science Plan, and will work to establish a strong role for ICED within CCAMLR, SCAR and Future Earth.

ICED has engaged stakeholders through a partnership with the World Wildlife Federation (WWF) to hold a workshop on krill and its fishery. The WWF provided links to fisheries and NGOs. The Marine Stewardship Council certification of the krill fishery also encourages interaction between the various stakeholders.

A joint AnT-ERA / AntClim21 / ICED session on ‘Impact of climate change on Antarctic biota’ was convened at the SCAR Open Science Conference in Auckland, New Zealand on 28 August–3 September 2014.

Revision of the online fieldwork map tool is underway, and a Southern Ocean wiki, led by the ‘Sentinel’ programme is being developed.

CLimate Impacts on Oceanic TOp Predators (CLIOTOP) Regional Programme

CLIOTOP aims to organise large-scale comparative efforts to elucidate key processes involved in the impact of both climate variability (at various scales) and fishing on the structure and function of open ocean pelagic ecosystems and their top predator species. The ultimate objective is to develop a reliable predictive capability for the dynamics of top predator populations and oceanic ecosystems combining the effects of fishing and climate.

www.imber.info/CLIOTOP.html.

A special issue of *Deep-Sea Research II* (26 papers) was published following the 2nd CLIOTOP symposium. Meetings organized by CLIOTOP Working Groups have generated a large amount of scientific results as indicated by the publications listed on the IMBER website at (<http://imber.info/Science/Regional-Programmes/CLIOTOP>).

CLIOTOP has been ongoing for almost 10 years, and is now assessing its scientific objectives and structure in terms of the new IMBER SPIS. Currently, CLIOTOP research is done through working groups, several of which will soon be concluded. The CLIOTOP SSC is now discussing a new structure for a proposed CLIOTOP phase III, for the next five years. As a start towards this process, the IMBER SSC at its meeting in June 2015 supported the continuation of CLIOTOP as a regional programme, gave a mandate to modify the programme structure, and recognized the need for flexibility in how limited resources are allocated.

CLIOTOP organised a workshop on “Variability in the movement patterns of marine predator populations: physiological, behavioural and environmental drivers” as part of the Bio-logging 5 Symposium on 22-26 September 2014 in Strasbourg, France.

CLIOTOP also participated in the Euro BASIN workshop on ‘Futures of the North East Atlantic Ocean by 2040 - a Stakeholder Consultative Workshop’ in November 2014.

3-18

Several sessions proposed for the ICES/PICES 3rd International Symposium on Climate Change Effects on Marine Ecosystems in Santos City, Brazil, March 2015 were initiated by CLIOTOP.

The 3rd CLIOTOP Symposium will be held from 14 to 18 September 2015 in San Sebastian, Spain. The title of the symposium is ‘The Future of Oceanic Animals in a Changing Ocean.’

Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) Regional Programme

SIBER is a basin-wide research initiative sponsored by IMBER and the Indian Ocean GOOS (IOGOOS) Programme, with close ties to CLIVAR’s Indian Ocean Panel (IOP). It focuses on understanding climate change and anthropogenic forcing on biogeochemical cycles and ecosystems in the Indian Ocean, to predict the impacts of climate change, eutrophication and harvesting (www.imber.info/index.php/Science/Regional-Programmes/SIBER and www.incois.gov.in/Incois/siber).

SIBER’s project office is hosted at INCOIS in Hyderabad, India and recently a regional office (headed by Louis Wicks) was established in Perth, Australia.

SIBER has actively supported the deployment of (new) biogeochemical sensors in the Indian Ocean. SIBER activities in the past year have been in support of the second International Indian Ocean Expedition (IIOE-2), which will be launched at the International Indian Ocean Expedition Symposium in Goa, India, 30 November-4 December 2015. The Symposium will coincide with the 50th anniversary of the National Institute of Oceanography in Goa. Data collected on IIOE-2 cruises will be submitted to national repositories, in accordance with the IOC data-sharing policy regulations.

The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) has emerged as a major SIBER activity. This is a 5-year process study under the IIOE-2 in the Eastern Indian Ocean, focusing on upwelling.

SIBER has strong collaborations with various regional organizations (e.g., Indian Ocean Panel of CLIVAR and IOGOOS). A positive result is that this collaboration provides a model for CLIVAR-IMBER collaboration.

D. Activities of IMBER Working Groups and Task Team

SOLAS-IMBER Carbon (SIC!) Working Group

IMBER currently has three joint SOLAS-IMBER carbon (SIC!) working groups that consider carbon in the surface ocean systems (SOS), carbon in the interior ocean (IOC) and ocean acidification (SIOA).

Surface Ocean Systems (SIC!-SOS)

The main goal of this group is the continued development of the Surface Ocean Carbon Atlas (SOCAT).

Interior Ocean Carbon (SIC!-IOC)

This working group co-ordinates international research on interior ocean changes in carbon and biogeochemistry, undertakes synthesis activities, and aims to develop sustainable observing systems, including the addition of oxygen sensors to the international ARGO float programme (ARGO-O₂). Recent activities focused on the analysis of carbon data from hydrographic surveys to determine the change in the ocean's anthropogenic CO₂ content since the 1990s. This analysis is now in the final stages (paper draft completed) and the synthesis project should be completed by early 2016. This group also contributed to the planning of the upcoming joint GO-SHIP/Argo/IOC meeting in Galway on the topic of "Sustained ocean observing for the next decade" <http://www.gaic2015.org>, assisted in the development of essential ocean variables (EOV), led by IOC/IOC (see <http://www.ioccp.org/foo>), and also assisted in the development of global dataset of ocean interior variables (GLODAPv2, led by CarboChange).

SOLAS-IMBER Ocean Acidification (SIOA)

The SIOA working group coordinates international efforts and synthesis activities for ocean acidification research. Within a single decade ocean acidification has gone from a research area of limited interest to one that is now considered to be a priority for ecology and environmental sciences. This rapid expansion has made it difficult for experts to share information and train new scientists from different countries.

The Ocean Acidification International Coordination Centre (OA-ICC), initiated and mainly driven by the SIOA, is in its final year of funding (2013-2015), and a proposal has been submitted to IAEA in Monaco for three additional years of support. The Centre aims to foster scientific collaboration at the international level, promote best practices, improve observational capacities and databases, and facilitate communication and outreach. The OA-ICC is supervised by a science coordinator (SIOA's current chair). The OA-ICC advisory board includes all SIOA members and is chaired by a SIOA member. The OA-ICC produced several key products that have become fundamental building blocks for the ocean acidification research community and ocean acidification science users, including the OA-ICC web site, www.iaea.org/ocean-acidification; OA-ICC news stream at news-oceanacidification-icc.org; OA-ICC bibliographic database, <http://tinyurl.com/oaicc-biblio>; OA-ICC data compilation at <http://tinyurl.com/oaicc-data> (now including data from almost 600 publications); an SIOA / IOC / CARBOCHANGE comparison study of the seven publicly available software packages that compute marine carbonate chemistry was published in *Biogeosciences Discussions*; and the OA-ICC slide set *Things you should know about ocean acidification*, produced for scientists to facilitate making presentations on ocean acidification to non-scientists https://www.iaea.org/ocean-acidification/download/Resources/OA_slides-generalaudience_17feb2013.pdf.

The 4th Ocean in a High-CO₂ World Symposium will be held in Hobart, Australia on 3-6 May 2016. SIOA organised several side events at the IPCC *Our Common Future Under Climate Change* conference in Paris in July 2015, and produced a variety of outreach material. Continental Margins Working Group (CMWG)

The CMWG is co-sponsored by IMBER and Future Earth Coasts (previous LOICZ). As human activities dominate key global processes in the Anthropocene, there is an urgent need to secure sustainability by implementing transformative governance strategies to safeguard Earth's life-support systems for long-term human well-being. Nowhere is this endeavour in greater demand

3-20

than at the ocean-land interface – the continental margins, which are experiencing pressures from:

- Population growth, development intensification and rising demands for energy-intensive resources;
- Ecosystem degradation and loss;
- Rising CO₂ concentrations, climate change and alteration of marine biogeochemistry and ecosystems; and
- Ecosystem tipping points and rapid and irreversible changes in social-ecological systems and societal responses.

The CMWG published a synthesis paper in *Current Opinion in Environmental Sustainability* that outlines the threats to continental margin systems and potential consequences if mitigation actions are not initiated.

The CMWG is currently being restructured with a new IMBER co-chair (K Limburg) and membership. The CMWG is discussing the focus for this next phase of research. This may be regional, with particular focus on Arctic issues and regional seas. New members will be chosen for their expertise to undertake the work of the CMWG.

Data Management Committee (DMC)

The Data Management Cookbook ([http://imber.info/index.php/Science/Working-Groups/Data Management/Cookbook](http://imber.info/index.php/Science/Working-Groups/DataManagement/Cookbook)) remains an important and significant product of the DMC. Data management workshops have been organised at the IMBIZOs and the OSC. At IMBIZO IV the DMC will provide advice and guidance on all data-related issues. The SSC discussed if a separate committee is still needed for data management. The consensus was that continuation of DMC would be only with a revised focus and mandate (e.g. social science data use), which will require membership with different expertise. It is noted that even managing just a meta-database requires a dedicated data liaison person. Making use of international *in situ* data organizing activities, e.g. “Data kind.org” might be an approach for submitting metadata that identifies IMBER data. A plan for the future is needed if DMC shall continue, however the DMC has earlier recommended: to fully integrate data management activities in all IMBER project-wide events; to ensure that endorsed projects are prepared to comply with IMBER DM policies; and to organise a meeting of data scientists of IMBER-endorsed projects and regional programmes.

Capacity Building Task Team (CBTT)

The CBTT objectives are to enhance marine research capabilities in less developed countries, enhance research capabilities globally in relevant IMBER activities, and strengthen graduate education in ocean sciences. The IMBER SSC believes that the CBTT has completed its mandate and will disband this group. Capacity building will continue as it is now included in all regional programmes and working groups, and through activities, such as the summer schools and IMBIZOs.

The CBTT has produced a synthesis document describing the IMBER capacity building activities during the past ten years. It is anticipated that this document will be published later in 2015. This will be the legacy of the CBTT.

Human Dimensions Working Group (HDWG)

The HDWG focuses on the interactions between human and ocean systems, and aims to create an integrated and interactive natural-social science marine research community within IMBER. One of its major achievements has been the development of the I(MBER)-ADApT decision support tool (see section B).

I-ADApT has been published and is now being tested using the 23 case studies submitted thus far. The case studies developed as part of the Human-Ocean-Human workshop held at IMBIZO III are being collated into an I-ADApT synthesis book, which affords the ability to include information that is not as quantitative or synthesized to the level that is needed for a peer-reviewed publication. The HDWG wants to ensure that the information underlying the case studies is preserved.

On a longer term the intention is to develop a database of global case studies as an open-access web site to help decision makers, researchers and stakeholders decide how to respond when faced with difficult choices and trade-offs. There is an open invitation and template to supply case studies to the I-ADApT system. Because of the complex interactions and feedbacks between humans and the ocean, the case study template includes questions about the natural, social and governing systems, the stressors that affect them, their response and an appraisal of that response.

IMBER-CLIVAR Upwelling Working Group

Interest from CLIVAR in biophysical interactions and dynamics in upwelling regions resulted in formation of a joint working group on upwelling. A workshop held at the *Climate Change in the Oceans* conference in Santos, Brazil in March 2015 identified priority research areas for the working group. An Upwelling Workshop will be held at IMBIZO IV and participants will also be asked to suggest research topics that can be pursued in a 3-5 year timeframe. The 10 current working group members represent most of the global upwelling systems.

E. Other IMBER activities

ClimEco Summer Schools

IMBER ClimEco Summer Schools are held every two years and are a successful capacity building mechanism for engaging students and early-career scientists. The ClimEco4 Summer School titled, '*Delineating the issues of climate change and impacts to marine ecosystems: Bridging the gap between research, assessment, policy and management*', was held in early August 2014, at East China Normal University, Shanghai, China. It focused on indicators that inform about the impact of global change on marine ecosystems and the human populations that depend on them, and on how to combine them so that they can be used to inform policy and decision-making. Sixty-four participants from 30 countries were selected from almost 170 applications received. SCOR provided support for two students from developing countries.

Topics covered in lectures included an overview of climate change impacts on marine ecosystems from a biophysical and human perspective, information about indicators, models, analysis, linking indicators to a regulatory or management perspective, and bridging the gap between research and information that is practically useful for management. Practical sessions

3-22

each afternoon enabled participants to try out the methods and techniques covered in lectures. Several participants provided datasets so groups could select indicators and use them to evaluate the state of a system or species. Students presented their results at the end of the course. The event received excellent reviews from the participants.

Planning is now underway for ClimEco5, which will be held at the University of Rio Grande do Norte in Natal, Brazil in early August 2016. The focus of this summer school will be on '*Towards more resilient oceans: Predicting, managing and mitigating future changes in the ocean and their impacts on human societies*'. Advertising and fund-raising for the summer school will begin in Fall 2015.

IMBIZO IV

The IMBIZO IV will be held in Trieste, Italy on 26-30 October 2015. The IMBIZO has been expanded to four concurrent workshops and several integration sessions. Funding has been secured from several sponsors, including SCOR, to support students and early career researchers. The planning and preparation for the IMBIZOs is a major effort for the IPO.

Development of the new IMBER Science Plan and Implementation Strategy (SPIS)

The new SPIS is based on a position paper that was discussed at the IMBER Open Science Conference (OSC) in June 2014. The current version includes a new vision and research goal for IMBER, and is developed around three Grand Challenges (GC) and four Innovation Challenges (IC). Specific research questions relating to the GCs and ICs are intended to provide the basis for implementation of research programs. The SPIS will be submitted to SCOR and Future Earth (FE) in October 2015 for joint review.

IMBER will maintain its focus on fundamental biogeochemistry and ecosystem research, but will expand to include aspects of sustainable oceans, human well-being, biodiversity conservation, and making science relevant to society. Another issue is to ensure that IMBER science is available in a form that can be used to influence decision-making that will safeguard marine ecosystems and their dependent human societies. Achieving this will require the involvement of a diverse science community that is drawn from a range of different disciplines, including quantitative global change social science, international relations, and ocean geopolitics. IMBER will also engage in activities that enhance integration among and between IMBER's regional programmes, working groups and endorsed projects.

IMBER contributions to IGBP synthesis and celebration at AGU

IMBER submitted a manuscript to the IGBP synthesis special issue of *Anthropocene*. Minor comments were received from reviewers, which are now being addressed. A revised manuscript will be submitted in late September. It is anticipated that this special issue will be published in late 2015.

A final IGBP celebration event will be held at the Fall Meeting of the American Geophysical Union in San Francisco on 14-18 December 2015. IMBER is co-convening a session at the meeting on 'Observing Open Ocean Biogeochemistry with Profiling Floats', and a session on 'Trajectories of change in the Southern Ocean'.

IMBER and Future Earth (FE)

At its June 2015 meeting, the IMBER SCC decided to go forward with a request to become a core project of FE. The positive and negative aspects of this transition were discussed by the SSC. The primary negative aspects are the current lack of FE funding for core projects, the apparent lack of marine focus in FE, and the strong FE focus on social science and policy. The lack of focus on the marine environment in the FE provides an opportunity for IMBER to take the lead in developing the ocean part of FE. A transition statement, based on the new SPIS, will be submitted to FE in Fall 2015.

A potential new Integrated Marine Science Network

Martin Visbeck (Future Ocean, GEOMAR, Kiel, Germany) proposed the establishment of a network of marine-related core projects (IMBER, SOLAS, LOICZ, PAGES, IOCCP, CLIVAR) sponsored by SCOR, WCRP, GOOS and FE, to improve collaboration and communication, and to make marine science a stronger force in FE. In general, IMBER supports this proposal, but has emphasized that this must be a distinct group, not part of FE. The coordination and administration of the network is still under discussion, as well as topics or regions that would be of interest to all the projects.

Status of the International Project Office (IPO, Norway) and the Regional Project Office (RPO, China)

The IPO will continue to be hosted by the Institute of Marine Research (IMR) in Bergen, Norway until April 2017. In February 2015, Einar Svendsen (oceanographer from IMR) was appointed as Executive Officer of IMBER. In spring 2015, the IPO was relocated within IMR to be closer to the management team of the *Hjort Centre for Marine Ecosystem Dynamics*, sponsored by the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, the University of Bergen and Uni Research. This has increased interaction with a broader research community, and allows easy exchange of information on activities and publications. Discussions with the Norwegian Research Council and the leadership of IMR have been initiated to secure funding for a second 5-year period.

The IMBER Regional Project Office (RPO) was established under a Memorandum of Understanding between IMBER and its host institution, the East China Normal University in Shanghai, China, in 2010. The initial three-year support was renewed for an additional three years (2013-2016). The RPO is essential for engagement of the research community in the Asia-Pacific region. It also provides excellent support and assistance to the IPO.

Dr. Yi Xu replaced Dr. Liuming Hu as the Deputy Executive Officer of the RPO in December 2014. She is the IMBER liaison for the Continental Margins Working Group and submitted a first-stage funding proposal to the Asia-Pacific Network (APN) to hold a CMWG workshop in Shanghai, China in 2016. Securing support for the RPO after 2016 is a priority and the process for doing this needs to be initiated.

F. IMBER SSC member nominations

There are currently 15 IMBER SSC members. New members appointed in early 2015 are Masao Ishii (Japan), Ruben Escribano (Chile), and Svein Sundby (Norway). Four new SSC members will be appointed this year, and one current member (Bundy) will be extended for one year, as was done for some SSC members last year, to even out the distribution of new members.

3-24

Rynearson is eligible for appointment for a second term. In February 2015, IMBER solicited the research community for nominations for their replacements with the following expertise, identified by the IMBER Executive Committee:

- physical-biological interactions, and ecosystem functioning and dynamics
- fisheries as related to (sustainable) ecosystem-based management
- food web dynamics and diversity, and top predator interactions
- integrated studies of social, ecological and biogeochemical marine systems
- economics of marine resources

Twenty-five nominations were received. The Executive Committee ranked the nominations, and a short-list of eight nominees was tabled for discussion at the SSC meeting. It was recommended that in addition to expertise, fund raising and networking skills are also important. The agreed-upon nominees were put forward to SCOR and IGBP for approval.

Eileen Hofmann will end her term as Chair at the end of 2015. There was no call for nominations with regard to the Chair. Rather, the Executive Committee identified individuals who are/have been involved with IMBER. The Executive Committee suggested Carol Robinson (University of East Anglia, UK and former IMBER SSC member) as a possible candidate for Chair. Hofmann contacted Robinson and she agreed to be nominated. Hofmann will remain as *ex officio* Past Chair for one year.

G. IMBER cooperation

IMBER has been closely collaborating for many years with SOLAS (see SIC!) and LOICZ (see CMWG) and recently with CLIVAR, and with projects and other organizations.

a. Too Big To Ignore (TBTI)

IMBER is a partner of the TBTI project. TBTI has reached its midpoint and now includes over 200 scientists from 45 countries. TBTI is conducting a global analysis, based on information systems, to better understand small-scale fisheries (SSF). IMBER information that might relate to SSF can be added at <http://issf.toobigtoignore.net>, and this can be used for case studies for I-ADApT. There will be collaboration at IMBIZO IV. It is suggested that a transdisciplinary cluster might provide topics for the ClimEco5 summer school.

b. Ocean Carbon Biogeochemistry (OCB)

OCB continues to actively support IMBER by advertising its activities and events, and by providing financial support for activities. This year OCB is providing travel support for five participants from the USA to attend IMBIZO IV. There are plans to hold a half-day session on IMBER science at the 2016 OCB summer workshop.

c. GEOTRACES

Deals with biogeochemical cycles and large scale distribution of trace elements and isotopes, featuring a worldwide set of sampling transects across ocean basins.

d. WCRP

CLIVAR, a core project of WCRP and its Indian Ocean panel work closely with SIBER. CLIVAR will hold an OSC on 19-23 September 2016 in Qingdao, China and several

IMBER-related sessions will be convened as this conference. IMBER and CLIVAR are forming a Joint Upwelling WG.

e. *GOOS/Copernicus*

SIBER has strong connections with IO-GOOS, and IMR is involved with EURO-GOOS through Copernicus (European Programme to establish European capacity for Earth Observation). GOOS uses a system of global and regional models of different parts of the world ocean, which consider primarily ocean physics but with some primary production included. Increased alignment with GOOS will help IMBER deal with the challenge of ocean data.

f. *ICES*

ICES science issues are similar to those considered by IMBER, but are limited to the North Atlantic and adjacent seas, and more increasingly into the Arctic. In addition to the science, ICES gives environmental and fisheries advice to member countries, which is turning into ecosystem-based management advice. The IMBER IPO will have an information booth at the ICES Annual Science Conference in Copenhagen, Denmark in September 2015

g. *IOC*

IOC activities and focus are consistent with those of IMBER. However, implementation of activities differs. IOC is advanced in observations and tsunami warnings and designed the essential ocean variables. The IMBER IPO was represented at the last IOC assembly and used this opportunity to explore funding opportunities. IOC agreed to support two participants from developing countries to attend the Upwelling workshop at IMBIZO IV and to support participants for the CLIOTOP Symposium.

h. *Hjort Centre*

The Hjort Centre on Ecosystem Dynamics is co-located with IMBER at IMR. There are many overlaps and strong collaboration is developing.

i. *PICES*

IMBER and PICES have a long-term successful collaboration and partnership. This has ensured that representatives from both communities are able to attend project activities, such as summer schools and science meetings.

j. *CARBOCHANGE*

This is an IMBER-endorsed project that ended in 2015. Results are given in Section B.

H. Selected IMBER Publications

IMBER-related activities have produced more than 1,000 refereed research papers since its implementation; about 150 papers were published in 2014-2015.

Publications related to recent discoveries and highlights

Akoglu, E., et al. 2014. An indicator-based evaluation of Black Sea food web dynamics during 1960–2000. *Journal of Marine Systems* 134, 113–125.
<http://dx.doi.org/10.1016/j.jmarsys.2014.02.010>

Aida F. Ríos, Laure Resplandy, Maribel I. García-Ibáñez, Noelia M. Fajar, Anton Velo, Xose A. Padín, Rik Wanninkhof, Reiner Steinfeldt, Gabriel Rosón, and Fiz F. Pérez (2015).

3-26

- Decadal acidification in the water masses of the Atlantic Ocean PNAS 2015 112 (32) 9950-9955; published ahead of print July 27, 2015, doi:10.1073/pnas.1504613112
- Ayers J.M., Strutton P.G., Coles V.J., Hood R.R. and Matear R.J. 2014. Indonesian throughflow nutrient fluxes and their potential impact on Indian Ocean productivity. *Geophysical Research Letters* 41. doi:10.1002/2014GL060593
- Bakker DCE et al. (2014): An update to the Surface Ocean CO₂ Atlas (SOCAT version 2). *Earth System Science Data* 6, 69-90. doi:10.5194/essd-6-69-2014;
- Bednaršek N, Tarling GA, Bakker DCE, Fielding S, Feely RA (2014) Dissolution dominating calcification process in polar pteropods close to the point of aragonite undersaturation. *PLOS One* 9(10): e109183 doi: 0.1371/journal.pone.0109183
- Bendtsen, J., Hilligsoe, K.M., Hansen, J, Richardson, K. 2015. Analysis of remineralisation, lability, temperature sensitivity and structural composition of organic matter from the upper ocean. *Progress in Oceanography* 130:125-145.
- Bundy A., Chuenpagdee R., Cooley S., Defeo O., Glaeser B., Guillotreau P., Isaacs M., Mitsutaku M. and Perry, R. I. (2015), A decision support tool for response to global change in marine systems: the IMBER-ADApT Framework. *Fish and Fisheries*. doi: 10.1111/faf.12110.
- Crise A., et al., A MSFD complementary approach for the assessment of pressures, knowledge and data gaps in Southern European Seas: the PERSEUS experience. *Mar. Poll. Bull.* : 95(1), 15 June 2015, pp. 28–39
- Danielson, S.L., Weingartner, T.J., Hedstrom, K.S., Aagaard, K., Woodgate, R., Curchitser, E., Stabeno, P.J., 2014. Coupled wind-forced controls of the Bering–Chukchi shelf circulation and the Bering Strait throughflow: Ekman transport, continental shelf waves, and variations of the Pacific–Arctic sea surface height gradient. *Progress in Oceanography* 125, 40-61.
- Drinkwater, K.F., M. Miles, I. Medhaug, O.H. Otterå, T. Kristiansen, S. Sundby, and Y. Gao. 2014. The Atlantic Multidecadal Oscillation: its manifestations and impacts with special emphasis on the Atlantic region north of 60°N. *Journal of Marine Systems* 133: 117-130.)
- Drinkwater, K. and K. Tande (Eds.). 2014. Biophysical studies of the Polar Front in the Barents Sea and the Arctic Front in the Norwegian Sea: Results from the NESSAR Project. *Journal of Marine Systems* 130: 131-133.
- Evans K., Jaclyn N. Brown, Alex Sen Gupta, Simon J. Nicol, Simon Hoyle, Richard Matear, Haritz Arrizabalaga, 2015. When 1+1 can be >2: Uncertainties compound when simulating climate, fisheries and marine ecosystems. Deep Sea Research Part II: Topical Studies in Oceanography. Volume 113, Pages 1-322 (March 2015). In: Impacts of climate on marine top predators. Edited by Alistair J Hobday, Haritz Arrizabalaga, Karen Evans, Simon Nicol, Jock W Young and Kevin C Wen.
- Gehlen M, Séférian R, Jones DOB, Roy T, Roth R, Barry J, Bopp L, Doney SC, Dunne JP, Heinze C, Joos F, Orr JC, Resplandy L, Segschneider J & Tjiputra J (2014) Projected pH reductions by 2100 might put deep North Atlantic biodiversity at risk. *Biogeosciences* 11: 6955-6967. doi: 10.5194/bg-11-6955-2014.
- Glavovic, B.C., Limburg, K., Liu, K.-K., Emeis, K.-C., Thomas, H., Kremer, H., Avril, B., Zhang, J., Mulholland, M.R., Glaser, M., Swaney, D.P. (2015) Living on the Margin in the Anthropocene: Engagement arenas for sustainability research and action at the ocean-land interface. *Current Opinion in Environmental Sustainability*, (In press).

- Guraslan, C., Fach, B.A., Oguz, T. 2014. Modeling the impact of climate variability on Black Sea anchovy recruitment and production. *Fish. Oceanogr.* 23:5, 436–457. doi:10.1111/fog.12080
- Hofmann, Eileen, Alida Bundy, Ken Drinkwater, Alberto Piola, Bernard Avril, Carol Robinson, Eugene Murphy, Lisa Maddison, Einar Svendsen, Julie Hall, Yi Xu (submitted). IMBER – Research for Marine Sustainability: Synthesis and the Way Forward. Submitted to The Anthropocene.
- Harrison D.E and A.M. Chioldi, 2015. Multi-decadal variability and trends in the El Niño-Southern Oscillation and tropical Pacific fisheries implications. Deep Sea Research Part II: Topical Studies in Oceanography. Volume 113, Pages 1-322 (March 2015). In: Impacts of climate on marine top predators. Edited by Alistair J Hobday, Haritz Arrizabalaga, Karen Evans, Simon Nicol, Jock W Young and Kevin C We
- Houptet L., P. Testor, X. Durrieu de Madron, S. Somot, F. D Ortenzio, C. Estournel, H. Lavigne, 2014. Seasonal cycle of the mixed layer, the seasonal thermocline and the upper-ocean heat storage rate in the Mediterranean Sea derived from observations. *Progress in Oceanography* (in press). doi:10.1016/j.pocean.2014.11.004.
- Ioakeimidis C., C. Zeri, H. Kaberi, M. Galatchi, K. Antoniadis, N. Streftaris, F. Galgani, E. Papathanassiou, G. Papatheodorou (2015). A comparative study of marine litter on the seafloor of coastal areas in the Eastern Mediterranean and Black Seas. *Marine Pollution Bulletin* 89 (1–2), pp. 296–304
<http://www.sciencedirect.com/science/article/pii/S0025326X14006535>
- Ioakeimidis C, Papatheodorou G., Fermeli G., Streftaris N., Papathanassiou E., 2015. Use of ROV for assessing marine litter on the seafloor of Saronikos Gulf (Greece); a way to fill data gaps and deliver environmental education. Springer Plus (in press)
- Jentoft S. and R. Chuenpagdee (eds. 2015). Interactive Governance for small scale fisheries (book). MARE Publication Series 13
- Katsanevakis S., Coll M., Piroddi C., Steenbeek J., Ben Rais Lasram F., Zenetos A., Cardoso A.C., 2014. Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. *Frontiers in Marine Science* 1:32. doi: 10.3389/fmars.2014.00032
- Keller KM, Joos F & Raible CC (2014) Time of emergence of trends in ocean biogeochemistry. *Biogeosciences* 11: 3647-3659. doi: 10.5194/bg-11-3647-2014
- Landschützer P et al. (2014): Recent variability of the global ocean carbon sink. *Global Biogeochemical Cycles* 28, 1-23. doi:10.1002/2014GB004853
- Lauvset SK et al. (2015): Trends and drivers in global surface ocean pH over the past 3 decades, *Biogeosciences* 12, 1285-1298. doi:10.5194/bg-12-1285-2015;
- Levin, L.A., Liu, K.-K., Emeis, K.-C., Breitburg, D.L., Cloern, J., Deutsch, C., Giani, M., Goffart, A., Hofmann, E.E., Lachkar, Z., Limburg, K., Liu, S.-M., Montes, E., Naqvi, W., Ragueneau, O., Rabouille, C., Sarkar, S.K., Swaney, D.P., Wassman, P., Wishner, K.F. (2015) Comparative biogeochemistry-ecosystem-human interactions on dynamic continental margins. *Journal of Marine Systems*, 141, 3-17.
<http://dx.doi.org/10.1016/j.jmarsys.2014.04.016>.
- Le Quéré C, Moriarty R, Andrew RM, Peters GP, Ciais P, Friedlingstein P, Jones SD, Sitch S, Tans P, Arneth A, Boden TA, Bopp L, Bozec Y, Canadell JG, Chevallier F, Cosca CE, Harris I, Hoppema M, Houghton RA, House JI, Jain A, Johannessen T, Kato E, Keeling RF, Kitidis V, Klein Goldewijk K, Koven C, Landa CS, Landschützer P, Lenton A, Lima ID, Marland G, Mathis JT, Metzl N, Nojiri Y, Olsen A, Ono T, Peters W, Pfeil B, Poulter

3-28

- B, Raupach MR, Regnier P, Rödenbeck C, Saito S, Salisbury JE, Schuster U, Schwinger J, Séférian R, Segschneider J, Steinhoff T, Stocker BD, Sutton AJ, Takahashi T, Tilbrook B, van der Werf GR, Viovy N, Wang YP, Wanninkhof R, Wiltshire A & Zeng N (2014) Global carbon budget 2014. *Earth System Science Data Discussions* 7: 521-610. doi: 10.5194/essdd-7-521-2014.
- Manno, C., G. Stowasser, P. Enderlein, S. Fielding, and G. A. Tarling. The contribution of zooplankton faecal pellets to deep-carbon transport in the Scotia Sea (Southern Ocean). 2015. *Biogeosciences*, 12, 1955-1965, 2015
ww.biogeosciences.net/12/1955/2015/doi:10.5194/bg-12-1955-2015
- Mercado J.M., Sala I., Salles S., Cortés D., Ramírez T., Liger E., Yebra L., Bautista B. (2014) Effects of community composition and size structure on light absorption and nutrient uptake of phytoplankton in contrasting areas of the Alboran Sea. *Marine Ecology Progress Series*, 499, 47-64.
- Mouling, E.A., Ellegaard, M., Richardson, K. 2014. [Global patterns in phytoplankton community size structure-evidence for a direct temperature effect](#). *Mar. Ecol. Prog. Ser.* 497: 25-38.
- Murphy, E. J., A. Clarke, N. J. Abram, and J. Turner (2014), Variability of sea-ice in the northern Weddell Sea during the 20th century, *J. Geophys. Res. Oceans*, 119, 4549–4572, doi:10.1002/2013JC009511
- Pakhomova S., E. Vinogradova, E. Yakushev, A. Zatsepin, G. Shtereva, V. Chasovnikov, O. Podymov (2014). Interannual variability of the Black Sea oxygen and nutrients regime: The role of climatic and anthropogenic forcing. *Journal of Estuarine, Coastal and Shelf Science* 140: 134 -145.
- Prieto L., Macías D., Peliz A. & Ruiz J., 2015. Portuguese Man-of-War (*Physalia physalis*) in the Mediterranean: A permanent invasion or a casual appearance? *Nature, Scientific Reports* 5, Article number: 11545 doi:10.1038/srep11545
- Richardson, K., Bendtsen, J., Christensen, J.T., Adjou, M., Lyngsgaard, M.M., Hilligsøe, K.M., Pedersen, J.B., Vang, T., Nielsen, M.H. 2014. [Localised mixing and heterogeneity in the plankton food web in a frontal region of the Sargasso Sea: implications for eel early life history?](#) *Mar. Ecol. Prog. Ser.* 504: 91-107.77.
- Rödenbeck C et al. (2014): Interannual sea-air CO₂ flux variability from an observation-driven ocean mixed-layer scheme. *Biogeosciences* 11, 4599-4613. doi:10.5194/bg-11-4599-2014;
- Séférian R et al. (2014): Detecting the anthropogenic influences on recent changes in ocean carbon uptake *Geophysical Research Letters* 41, 1-10. doi: 10.1002/2014GL061223;
- Severin T., P. Conan, X. Durrieu de Madron, L. Houpert, M.J. Oliver, L. Oriola, J. Caparros, J.F. Ghiglione, M. Pujo-Pay, 2014: Impact of open-ocean convection on nutrients, phytoplankton biomass and activity, *Deep Sea Research Part I*, doi: 10.1016/j.dsr.2014.07.015.
- Spagnoli F., Dinelli E., Giordano P., Marcaccio M., Zaffagnini F., Frascari F., 2014. Sedimentological, biogeochemical and mineralogical facies of Northern and Central Western Adriatic Sea. *Journal of Marine Systems* 139: 183–203.
- Stoecker, D.K., Weigel, A., Goes, J.I., 2014. Microzooplankton grazing in the Eastern Bering Sea in summer. *Deep Sea Research Part II: Topical Studies in Oceanography* 109, 145-156

- Tarling GA, Thorpe SE (2014) Instantaneous movement of krill swarms in the Antarctic Circumpolar Current. *Limnology & Oceanography* 59(3):872–886 doi:10.4319/lo.2014.59.3.0872
- Tjiputra JF et al. (2014): Long-term surface pCO₂ trends from observations and models. *Tellus B* 66, 23083. doi:10.3402/tellusb.v66.23083; further publications listed on www.socat.info).
- Walker O. Smith Jr., Michael S. Dinniman, Eileen E. Hofmann and John M. Klinck (2014) The effects of changing winds and temperatures on the oceanography of the Ross Sea in the 21st century. *Geophysical Research Letters*. doi: 10.1002/2014GL059311
- Waluda CM, Dunn MJ, Curtis ML, Fretwell PT (2014) Assessing penguin colony size and distribution using digital mapping and satellite remote sensing. *Polar Biol* 37:1849–1855
- Ward P, Tarling GA, Thorpe SE (2014) Mesozooplankton in the Southern Ocean: spatial and temporal patterns from Discovery Investigations Prog. Oceangr. 120:305-319

Communication and Outreach

IMBER's main communication tool is the project website (www.imber.info), which has an average of about 250 visitors each day. A new IMBER website is being developed that will be hosted at IMR. Software changes by the internet service provider in France were such that the existing IMBER website could no longer be supported. This transition has caused disruptions in availability of the IMBER website. Once the new site at IMR is launched, it will have a new, more regularly updated, news section, and the community will be encouraged to regularly send news items or articles to be featured on the website. The new IMBER website will also be accessible from a range of devices such as mobile phones and iPads.

The *IMBER Update Newsletter*, www.imber.info/index.php/News/Newsletters, is emailed to ~2000 scientists three times each year, and re-directed through multiple channels to about 10,000 researchers:

- **Issue n°28** - June 2015, included articles about a new ESSAS Arctic project, Canadian research in the North, a generic concept for the vertical behaviour of fish eggs in the world oceans, observing changes in the surface ocean carbon, and a world-wide evaluation of the use of ecosystem drivers of stock production in tactical fisheries management.
- **Issue n°27** - September 2014, included articles about science highlights from the IMBER Future Oceans Open Science Conference in Bergen. This included the following:
 - Predicting Fish from Physics: Strengths, weaknesses and ways forward;
 - Mesopelagic fishes in the California Current: ecosystem role, climate change impacts and the need for global observations of marine fish populations;
 - From watching to acting: adaptation in marine systems;
 - *Trichodesmium* Growth Rates: Modelling the Fundamental Niche;
 - *Phaeocystis pouchetii* bloom from the perspective of heterotrophic bacteria;
 - Should we shift towards collaborative management? Case study of the Asturian (northern Spain) gooseneck barnacle fishery;
 - Time of emergence of trends in ocean biogeochemistry;
 - Recent climatic changes enhance ongoing ocean acidification in the California Current System;
 - Diving depth of elephant seals influences mercury bioaccumulation in the north Pacific.

3-30

Other IMBER-related activities that were included featured GLODAPv2, a new and updated global ocean carbon data product, and The 2014 Community Event of the Surface Ocean CO₂ Atlas.

An electronic IMBER *eNews Bulletin* is published monthly, which provides information about IMBER and IMBER-relevant activities and events. Calls for funding proposals, job opportunities, workshop and conference announcements are also included.

The IMBER contact database is continuously updated with information for about 2,300 marine researchers.

Finally, the IPO and RPO staff and several IMBER researchers have presented more than a dozen IMBER poster and oral presentations at many national and international meetings.

I. Support from SCOR

IMBER greatly appreciates the ongoing support received from SCOR, and the additional support for specific IMBER activities provided or managed by SCOR from other funding sources. In addition, IMBER welcomes the advice, assistance and information received from the SCOR President and secretariat, especially its Executive Director, Ed Urban, and Financial Officer, Liz Gross.

Funding request

We are requesting funding to support students and researchers from developing countries to attend the ClimEco5 summer school that will be held at the University of Rio Grande, Natal, Brazil in early August 2016.

Amount requested: 7,500 USD

J. Strategic development

IMBER is in the last year of its initial 10-year science plan. The IMBER science community has clearly indicated a desire for the project to continue. The enthusiasm and support shown at the June 2014 OSC indicated that there is a strong community of researchers engaged in IMBER science. The new Science Plan and Implementation Strategy will provide guidance for marine research for the next phase of IMBER.

At the same time, the organizational structure for international global environmental change research is changing. The IGBP, which co-sponsors IMBER with SCOR, will end in December 2015 and the core projects currently sponsored by the IGBP have been invited to become core projects under Future Earth.

IMBER has a history of connecting natural and social sciences and promoting integration across disciplines and communities. Many of IMBER's coordination and networking activities match the integrated approaches desired by FE. As a result, IMBER is well placed to take the lead in developing marine-focused efforts under FE. The transition to a combined SCOR-FE core project should not require modifications to IMBER science goals or implementation strategy.

As with SCOR, the new SPIS will form the basis for a request to FE to incorporate IMBER as core project. The request will include a description of what IMBER can bring to FE in terms of science and as an international network of researchers. The request will also include what IMBER expects from FE, such as support for SSC meetings and integrated activities, funding at the same level as provided by SCOR, and specific assistance with fund raising, outreach, communication and engagement of stakeholders. It is anticipated that the formal IMBER request to FE will be made in Fall 2015.

K. Budget

The SCOR omnibus grant from the National Science Foundation, which provides support for IMBER, was recently renewed for three years. NASA agreed to provide a one-year supplemental funding to the existing grant that supports activities of the HDWG, ESSAS and the SIOA. A three-year proposal to support NASA-relevant research in IMBER will be submitted in 2016. The limited funding available for IMBER activities has necessitated a reduction in the support provided to IMBER working groups and regional programmes.

3-32

3.3 GEOTRACES

Naqvi

Terms of Reference:

- Organize national and international planning workshops as well as special sessions at international conferences to obtain community input on the design and implementation of GEOTRACES.
- Establish priorities for research on the sources, sinks, internal cycling, transport, speciation and fate of TEIs, and develop this information into an International Science Plan.
- Promote intercalibration of analytical methods, and the development of standard reference materials.
- Identify new instrumentation and related infrastructure that will help achieve GEOTRACES objectives.
- Define a policy for data management and sample archival.
- Forge scientific linkages with other research programs holding overlapping interests to create synergies where possible and avoid duplication of efforts. To the extent practical, this will involve cross-membership between the GEOTRACES Planning Group and the Planning Groups and Science Steering Committees of other programs.
- Interact with SCOR Working Groups that share common interests including, but not limited to, SCOR/IMAGES WG 123 on Reconstruction of Past Ocean Circulation (PACE) and SCOR/IMAGES WG 124 on Analyzing the Links Between Present Oceanic Processes and Paleo-Records (LINKS).

Co-Chairs:

Ed Boyle
Dept. of Earth, Atmospheric, and
Planetary Sciences
Massachusetts Institute of Technology
77 Massachusetts Ave
Cambridge, MA 02139-4307, USA
E-mail: eaboyle@mit.edu

Reiner Schlitzer
Alfred Wegener Institute
Columbusstrasse
D-27568 Bremerhaven, GERMANY
E-mail: Reiner.Schlitzer@awi.de

Other Members

Andrew Bowie	AUSTRALIA	Oliver Marchal	USA
Luidmila Demina	RUSSIA	Hajime Obata	JAPAN
Jordi Garcia-Orellana	SPAIN	Katherina Pahnke	GERMANY
Vanessa Hatje	BRAZIL	Micha Rijkenberg	NETHERLANDS
Tung-Yuan Ho	CHINA-Taipei	Alakendra Roychoudhury	S. AFRICA
Phoebe Lam	USA	Géraldine Sarthou	FRANCE
Maeve Lohan	UK	David Turner	SWEDEN
Maria Maldonado	CANADA	Angela Wagner	BRAZIL
		Liping Zhou	CHINA-Beijing

Executive Committee Reporter: Wajih Naqvi

**GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2014/2015
June 2015**

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs

Ed Boyle, USA
Reiner Schlitzer, Germany

Members

Andrew Bowie, Australia
Ludmila L. Demina, Russia
Jordi Garcia-Orellana, Spain
Vanessa Hatje, Brazil
Tung-Yuan Ho, China-Taipei
Phoebe Lam, USA
Maeve Lohan, UK

Maria T (Maite) Maldonado, Canada
Olivier Marchal, USA
Hajime Obata, Japan
Katharina Pahnke, Germany
Micha Rijkenberg, Netherlands
Alakendra Roychoudhury, South Africa
Géraldine Sarthou, France
David Turner, Sweden
Angela Wagener, Brazil
Liping Zhou, China-Beijing

The SSC membership (listed above) contains representatives of 14 different countries with diverse expertise, including marine biogeochemistry of carbon and nutrients; trace elements and isotopes as proxies for past climate conditions; land-sea fluxes of trace elements/sediment-water interactions; trace element effects on organisms; hydrothermal fluxes of trace elements; tracers of ocean circulation; tracers of contaminant transport; controls on distribution and speciation of trace elements; and ocean modelling.

2. Progress on implementation of the project

After the very successful release of the first Intermediate Data Product in February 2014, GEOTRACES sustains a very favourable implementation. Its cruise field programme has completed 55 GEOTRACES cruises with 747 section stations completed and about 550 papers published.

2.1 Status of GEOTRACES field programme

The field programme continues to progress very successfully. Overall 66 cruises associated with GEOTRACES (this includes 11 International Polar Year- IPY cruises) have been completed. With one section cruise already completed in the Pacific Ocean (by Japanese scientists) since the last reporting period, the main field effort this year is currently focused on the completion of the GEOTRACES research Arctic Programme with 4 section cruises (from Canada, U.S. and Germany) to be held from July to October 2015.

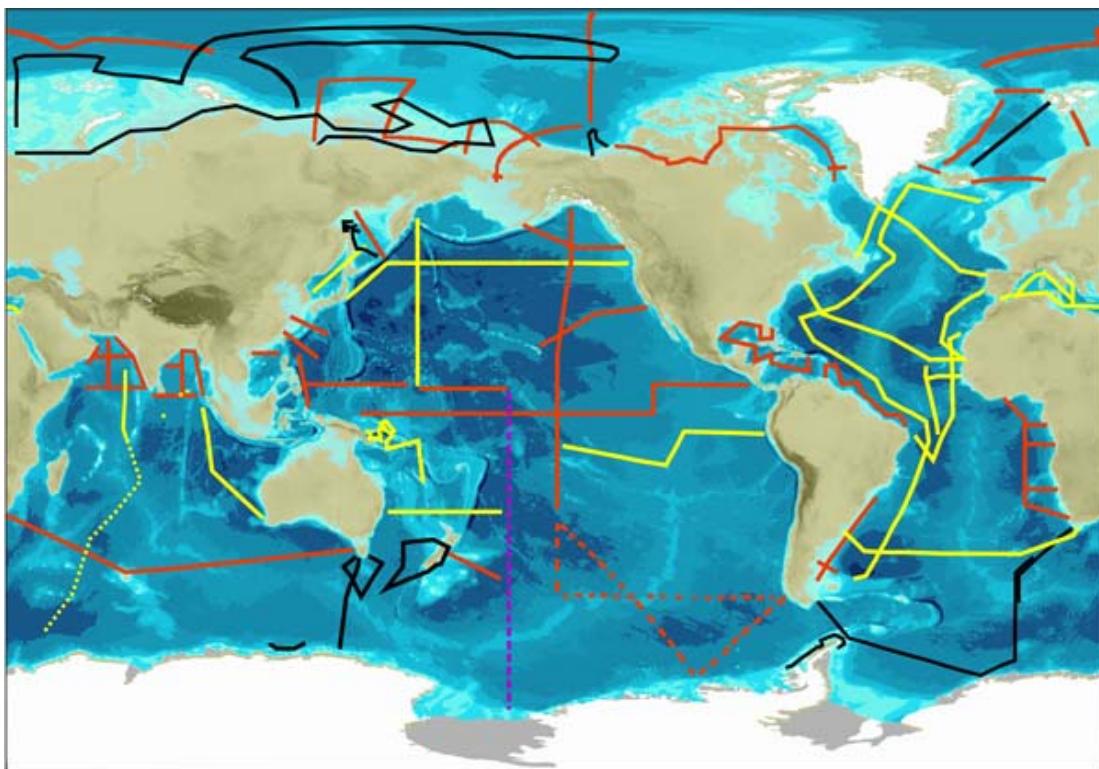


Figure 1: Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey (dotted purple, completed during the past year). In red: Planned Sections. An updated version of this map can be found on the GEOTRACES home page <<http://www.geotraces.org>>.

2.2 GEOTRACES Intermediate Data Product 2014

A corrected and updated version of the GEOTRACES Intermediate Data Product 2014 (IDP2014) was made available on May 2015. The new version (version 2) of the digital data is available in two new formats (Excel and netCDF). As a result, the IDP2014 is available now in four formats (ASCII, Excel, netCDF, and ODV, <http://www.bodc.ac.uk/geotraces/data/idp2014/>). A special thanks to Reiner Schlitzer for producing this new version of the IDP2014.

In addition, a DOI has been assigned to the IDP2014 which should be cited as follows:

Mawji, E., et al., The GEOTRACES Intermediate Data Product 2014, Mar. Chem. (2015), <http://dx.doi.org/10.1016/j.marchem.2015.04.005>.

GEOTRACES Intermediate Data Product 2014 survey

In order to help improve future Intermediate Data Products, GEOTRACES designed a survey to collect feedback from users of the IDP2014. The survey collected 262 responses, from which only 16% of the respondents were data contributors. Results from the survey can be grouped on: (1)

completion of the product and suggestions for improvement; (2) use of data; (3) and dissemination. Results from each of these categories are described below:

- Completion of the product and suggestions for improvement

Results from the survey proved that the product was very successfully received by the community in that 97% of respondents did not notice errors or inaccuracies, 89% did not find any missing data or information and only 11% suggested other organization or packaging. When asking about other formats for the data to be released, 16% suggested other formats mostly netCDF, Excel and Matlab. NetCDF and Excel have already been included in version 2 of the IDP2014.

- Use of data

When inquiring about the use of data, “comparison with other data” is the use listed most frequently followed by teaching (and outreach). Other uses reported are data synthesis and modelling.

- Dissemination

76% of the respondents were aware of the IDP2014 prior to the survey (the survey served as an effective means of dissemination for the other respondents). When asked about how users learned about the IDP2014, GEOTRACES media (website and mailing list) was listed first (total of 44% of the respondents), followed by the GEOTRACES 2014 Ocean Sciences Town Hall and SCOR Booth (24% of the respondents). Word of mouth was listed in third position.

The fact that 24% of the respondents identified the 2014 Ocean Sciences Town Hall and SCOR Booth proves the worth of the time and expenditure of the SCOR Booth at Ocean Sciences. GEOTRACES is very grateful to SCOR for this opportunity.

2.3 GEOTRACES Publications

The GEOTRACES publications database (<http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>) includes 548 GEOTRACES publications available from the beginning of the project. The following three new Special Issues have been published this year and four more are in preparation:

Progress in Oceanography (Volume 133, Pages 1-78, April 2015)

GEOTRACES Synthesis and Modeling: The role of particles in the marine biogeochemical cycles of trace elements and their isotopes

Edited by Catherine Jeandel, Olivier Marchal, Phoebe J. Lam and Robert F. Anderson

<http://www.sciencedirect.com/science/journal/00796611/133>

Deep Sea Research Part II: Topical Studies in Oceanography (Volume 116, Pages 1-342, June 2015)

GEOTRACES GA-03 - The U.S. GEOTRACES North Atlantic Transect

Edited by Edward A. Boyle, Robert F. Anderson, Gregory A. Cutter, Rana Fine, William J Jenkins and Mak Saito

<http://www.sciencedirect.com/science/journal/09670645>

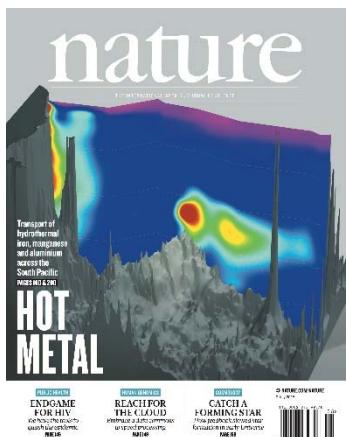
Marine Chemistry (Volume 173, Pages 1-342, July 2015)

SCOR WG 139: Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean

Edited by Sylvia Sander, Kristen Buck and Maeve Lohan

<http://www.sciencedirect.com/science/journal/03044203/173>

GEOTRACES findings featured on the cover of Nature



The work of Joseph Resing et al. (2015, see reference below) was featured on the cover of *Nature* (Volume 523 Number 7559, Thursday 9 July 2015). The cover shows an eGEOTRACES 3D scene view of dissolved iron across the South Pacific Ocean.

Reference:

Resing, J., Sedwick, P. N., German, C. R., Jenkins, W. J., Moffett, J. W., Sohst, B. M., & Tagliabue, A. (2015). Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. *Nature*, 523(7559), 200–203. doi:[10.1038/nature14577](https://doi.org/10.1038/nature14577).

2.4 GEOTRACES Science highlights

Below is a selection of recent GEOTRACES science discoveries. Owing to the large amounts of publications related to GEOTRACES, our criteria this year was to extract those published in the journal *Nature*:

Dissolved Iron Sources in the North Atlantic Ocean Quantified

The relative importance of four different dissolved iron (Fe) sources in the North Atlantic Ocean have been precisely determined for the first time, thanks to GEOTRACES.

Using a novel method based on the stable isotopic composition of dissolved Fe, Conway and John (2014, see reference below) have "fingerprinted" different sources of Fe along a section in the North Atlantic Ocean (GEOTRACES [GA03 section](#)). This has allowed the scientists to determine precisely the relative contribution of these sources to the North Atlantic Ocean. They found that the dominant sources were Saharan dust, which contributes 71-87% of dissolved iron, followed by North American margin sediments (10-19%). Smaller contributions were observed from the African margins (1-4%) and hydrothermal venting at the Mid-Atlantic Ridge (2-6%).

Since Fe is an essential marine micronutrient for phytoplankton, the scarcity of dissolved Fe in surface waters limits biological productivity over much of the oceans. Thus, changes in Fe inputs from different dissolved Fe sources have important implications for patterns of marine productivity

and the global carbon cycle. This study therefore represents a significant contribution to our understanding of how dissolved Fe may influence past and future global change.

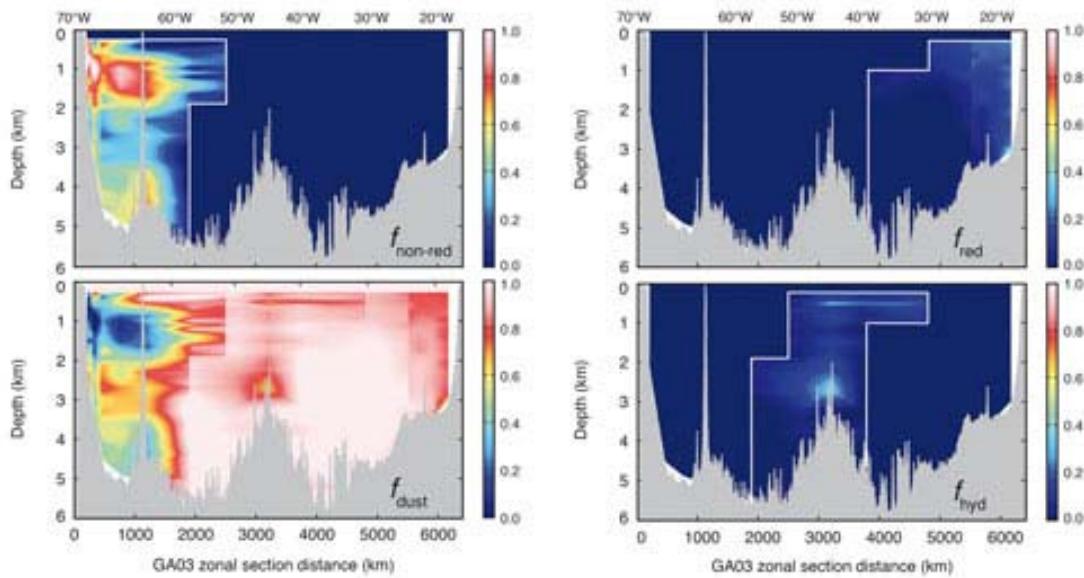


Figure 2: The figure shows the fraction of the seawater-dissolved Fe across the GA03 North Atlantic section that originates from each of four distinct sources : 1. Fe from oxygenated sediments on the North American margin ($f_{\text{non-red}}$); 2. Fe released by dissolution of atmospheric dust (f_{dust}); 3. Fe from reducing sedimentary porewaters on the West African Margin (f_{red}); and 4. Fe from hydrothermal venting on the Mid-Atlantic Ridge (f_{hyd}).

Reference:

Conway, T. M., & John, S. G. (2014). Quantification of dissolved iron sources to the North Atlantic Ocean. *Nature*, 511(7508), 212–215. doi:[10.1038/nature13482](https://doi.org/10.1038/nature13482).

Field Data Constrain Ocean Mercury Budget

Thanks to recent measurements during several oceanographic expeditions, among them GEOTRACES cruises, estimates of the total amount and spatial distribution of anthropogenic mercury in the global ocean have been substantially improved.

Global budgets of total mercury suggest that there has been a tripling of the surface water mercury content and a ~150% increase in the amount of mercury in thermocline waters above preindustrial levels.

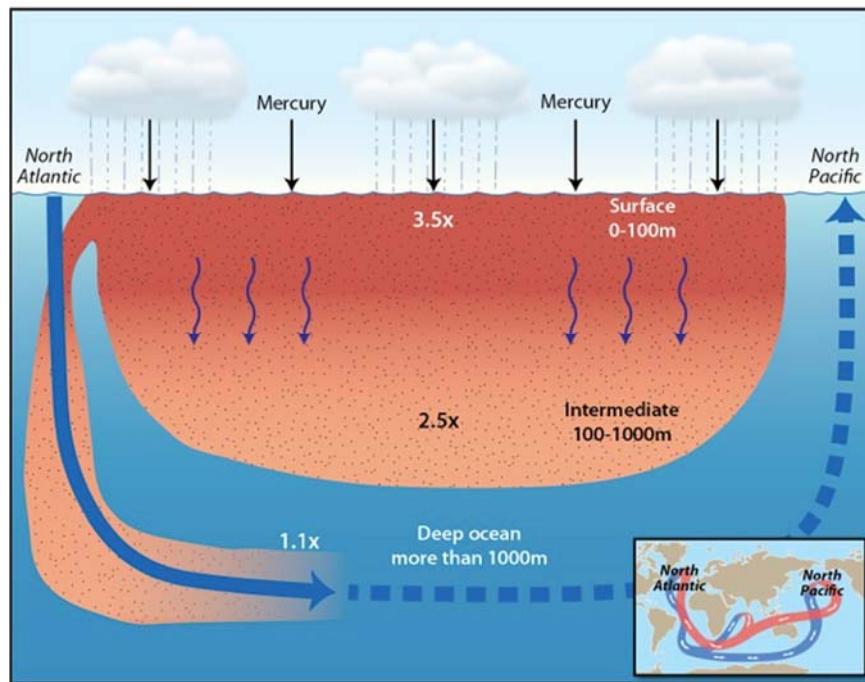


Figure 3: GEOTRACES researchers led by Carl Lamborg found that anthropogenic mercury (primarily atmospheric emissions produced by coal burning and cement production, as well as gold mining) have caused ocean waters down to 100 meters depth to be enriched in the toxic element up to 3.5 times the background level resulting from the natural breakdown, or weathering, of rocks on land. Once in the ocean, mercury adheres to organic particles and sinks or is consumed by progressively larger marine animals. One result is that intermediate levels of the ocean (between 100 and 1,000 meters depth) are also enriched in mercury up to 2.5 times the natural background rate. Even the deepest parts of the ocean have not escaped unscathed. Researchers found signs of pollution-derived mercury in the North Atlantic at depths below 1,000 meters, but those levels decreased as sampling efforts moved away from the North Atlantic basin. This is likely because pollution mercury has not yet moved with deep ocean currents throughout the global ocean, a process that can take as long as 1,000 years (extracted from WHOI's press release). Artwork: Jack Cook, WHOI.

Reference:

- Lamborg, C. H., Hammerschmidt, C. R., Bowman, K. L., Swarr, G. J., Munson, K. M., Ohnemus, D. C., Lam P.J., Heimbürger L-E., Rijkenberg M., Saito, M. A. (2014). A global ocean inventory of anthropogenic mercury based on water column measurements. *Nature*, 512(7512), 65–68. doi:[10.1038/nature13563](https://doi.org/10.1038/nature13563)

Seasonal Iron Supply in the Southern Ocean is Dominated by Winter Mixing

An international team of researchers analysed the available dissolved iron data taken from all previous studies of the Southern Ocean, together with satellite images of the area, to quantify the amount of iron supplied to the surface waters of the Southern Ocean. They found that, in contrast to the processes that supply so-called macronutrients in the tropics, seasonal iron supply is dominated by winter mixing, with little iron input afterwards. This is because the vertical profile of iron is distinct from other nutrients, with subsurface reserves located much deeper in the water column and therefore only accessible by the deeper mixing that occurs in winter. This means that after this input pulse, intense iron recycling by the 'ferrous wheel' is necessary to sustain biological activity. This unique aspect of iron cycling is yet to be explained but places important constraints on how climate models represent the iron distribution and how changes in ocean physics impact iron limitation.

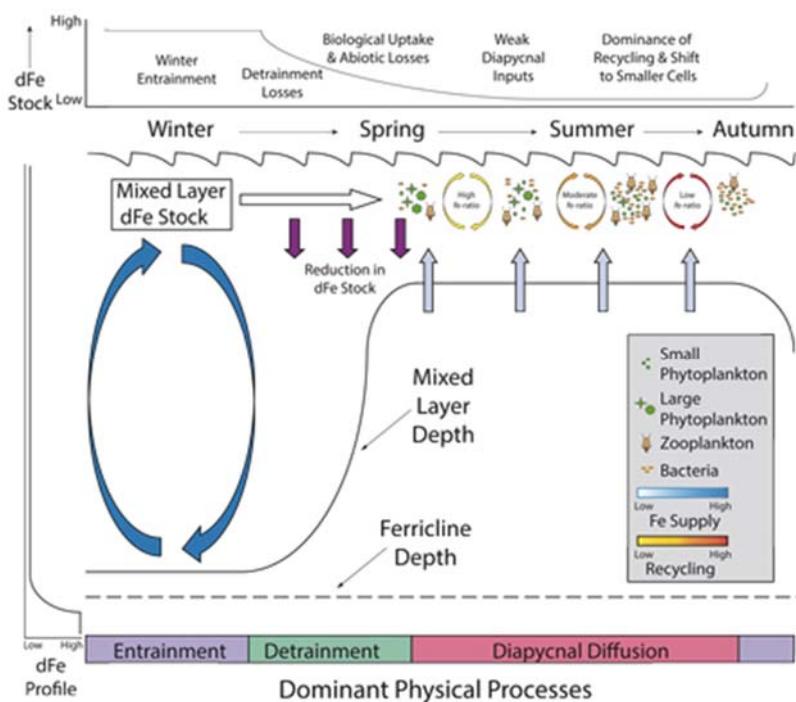


Figure 4: This diagram represents the seasonal variability in Southern Ocean iron (Fe) cycling.

Reference:

Tagliabue, A., Sallée, J.-B., Bowie, A. R., Lévy, M., Swart, S., & Boyd, P. W. (2014). Surface-water iron supplies in the Southern Ocean sustained by deep winter mixing. *Nature Geoscience*, 7(4), 314–320. doi:[10.1038/ngeo2101](https://doi.org/10.1038/ngeo2101)

3-40

What Controls the Copper Isotopic Composition in Oceanic Waters?

Takano and co-workers (2014, see reference below) strongly suggest that the isotopic composition of dissolved copper ($\delta^{65}\text{Cu}$) in surface seawater is mainly controlled by supply from rivers, the atmosphere and deep seawater. This is the conclusion of a study involving six vertical profiles of copper (Cu) concentration and isotopes measured in the Indian (1) and North Pacific (5) oceans. The finding contradicts previous interpretations suggesting a strong role of the biological activity in $\delta^{65}\text{Cu}$ fractionation.

At depth, $\delta^{65}\text{Cu}$ values are becoming heavier with the age of deep seawater, likely due to preferential scavenging of the light isotope (^{63}Cu). The authors built a box-model to quantify the oceanic budgets of both Cu concentrations and $\delta^{65}\text{Cu}$. Imbalance in this model suggests that Cu fluxes from continental shelf sediment might affect Cu distribution in the open ocean.

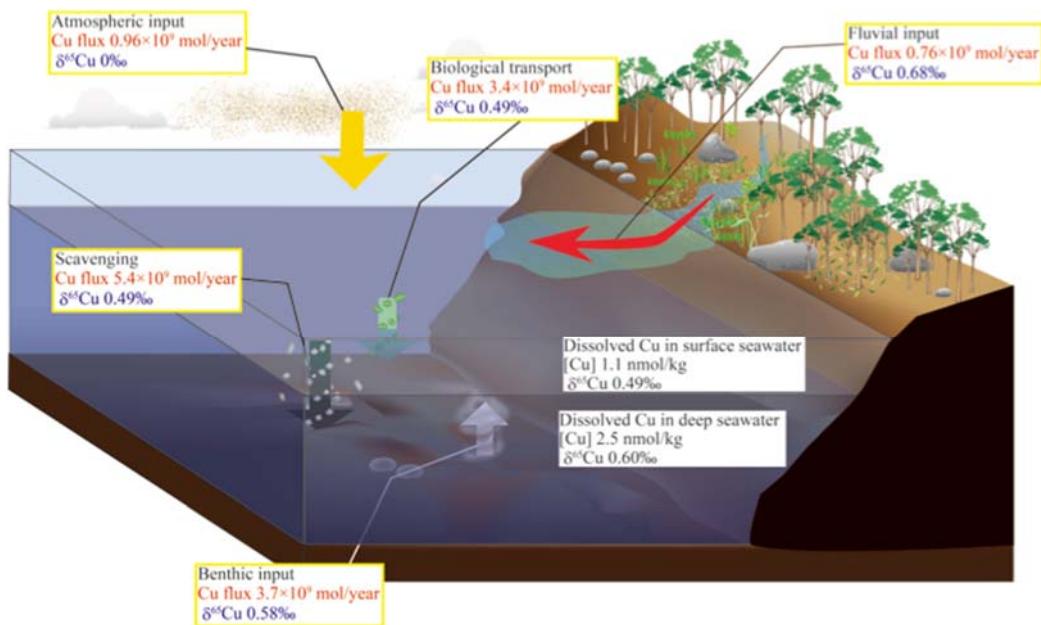


Figure 5: A box-model of Cu in the ocean based on both Cu concentration and isotopic composition.

Reference:

Takano, S., Tanimizu, M., Hirata, T., & Sohrin, Y. (2014). Isotopic constraints on biogeochemical cycling of copper in the ocean. *Nature Communications*, 5, 5663. doi:[10.1038/ncomms6663](https://doi.org/10.1038/ncomms6663)

Shallow Methylmercury Production in The Marginal Sea Ice Zone of the Central Arctic Ocean

Understanding persistent high levels of mercury in Arctic biota has been an elusive goal for nearly two decades. Little is known about where exactly inorganic Hg inputs into the Arctic generate the toxic methylmercury (MeHg) form that bioaccumulates in biota. Lars-Eric Heimbürger and colleagues (2015, see reference below) present the first full-depth high-resolution profiles (> 5200 m-depth) of total mercury (tHg) and MeHg in the central Arctic Ocean (79–90°N). MeHg maxima occur in the pycnocline waters, although noticeably shallower than in the other oceans (150 m in the Arctic versus roughly 1000 m in the Atlantic). These shallow maxima are probably due to the accumulation of settling biogenic particles slowed down by the strong density barrier of the arctic pycnocline which, in turn, will favor their microbial degradation and MeHg production. The shallow MeHg maxima likely result in enhanced biological uptake at the base of the marine food web, yielding elevated MeHg levels in Arctic wildlife. For this study the authors developed a new double isotope-dilution MeHg detection method with exceptional precision and low detection limit. These new findings will guide future Arctic Hg research, notably the international Arctic GEOTRACES multi-ship survey planned for summer 2015 by American, Canadian and German teams.

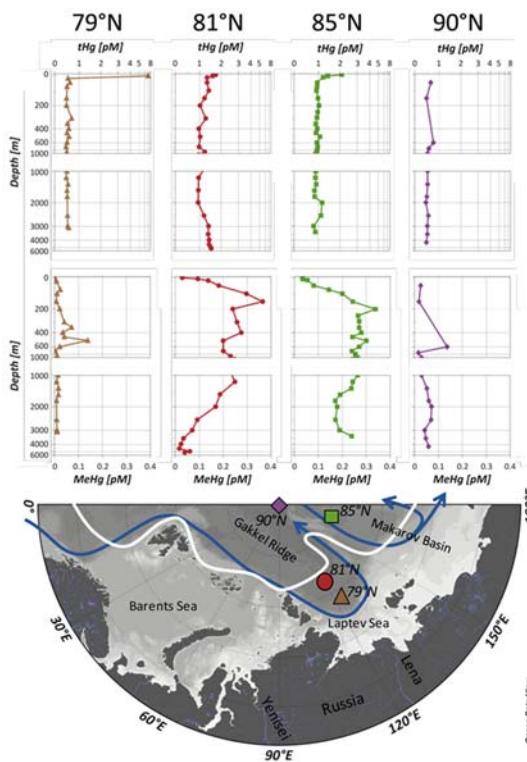


Figure 6: Total mercury (tHg) and methylmercury (MeHg) profiles in picomoles per litre (pM) at the coastally influenced open-water Laptev Sea station (PS78/280:79°N; brown triangles), the open-water Amundsen Basin station at the sea ice edge (PS78/273:81°N; red dots), the > 75% sea ice-covered Makarov Basin station (PS78/245:85°N; green squares), and the permanently sea ice-covered North Pole station (PS78/218:90°N, purple diamonds). The white line indicates the sea ice extent during the time of sampling. The blue line shows the general oceanic circulation of intermediate and Atlantic waters, after Rudels, 2012.

3-42

References:

Heimbürger, L.-E., Sonke, J. E., Cossa, D., Point, D., Lagane, C., Laffont, L., Galfond, B.T., Nicolaus, M., Rabe, B., van der Loeff, M. R. (2015). Shallow methylmercury production in the marginal sea ice zone of the central Arctic Ocean. *Sci. Rep.*, 5. DOI: [10.1038/srep10318](https://doi.org/10.1038/srep10318).

Rudels, B. Arctic Ocean circulation and variability - advection and external forcing encounter constraints and local processes. *Ocean. Sci.* 8 261–286 (2012).

Unexpected Magnitude of the Hydrothermal Iron Inputs in the Deep Pacific

Data from the U.S. GEOTRACES Eastern Pacific Zonal Transect (EPZT, [GP16](#)) demonstrate that lateral transport of hydrothermal iron, manganese and aluminium extends up to 4,000 km west of the southern East Pacific Rise, therefore crossing a significant part of the deep Pacific Ocean. Dissolved iron behaves more conservatively than expected, and the resulting flux is more than four times what was assumed before. Results from a coupled ocean circulation/biogeochemical model demonstrate that this hydrothermal iron input may sustain a large fraction of the Southern Ocean export production.

Nature decided to largely promote this work by reporting a GEOTRACES 3D view of the bottom Pacific showing the hydrothermal vent as a cover (see above).

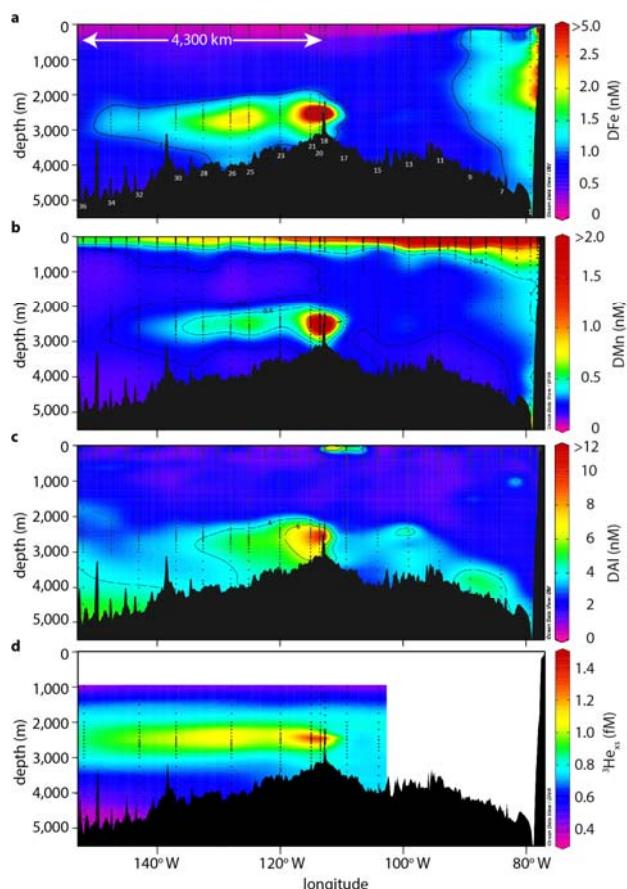


Figure 7: The top three panels show concentrations of dissolved iron, manganese and aluminium measured during the voyage. The bottom panel shows concentration of a form of helium that marks the water as coming from a hydrothermal vent, and its decreasing concentration away from the ridge reflects mixing rather than a chemical reaction. Credit: J. Resing / Univ. of Washington.

Reference:

Resing, J. A., Sedwick, P. N., German, C. R., Jenkins, W. J., Moffett, J. W., Sohst, B. M., & Tagliabue, A. (2015). Basin-scale transport of hydrothermal dissolved metals across the South Pacific Ocean. *Nature*, 523(7559), 200–203. doi:[10.1038/nature14577](https://doi.org/10.1038/nature14577).

Coupling Rare Earth Elements Concentrations, Neodymium And Radium Isotopes: A Powerful Tool to Decode Environmental Processes

For the first time, neodymium (Nd) isotopic compositions have been measured together with dissolved and colloidal Rare Earth Elements (REE) concentrations in the Amazon estuary salinity gradient, as part of the GEOTRACES process study AMANDES (Chief scientist: Catherine Jeandel). The sharp drop of REE concentrations in the low-salinity area (already observed in several estuaries) is clearly driven by the coagulation of colloidal material. While dissolved REE concentrations increase again at mid-salinities, Nd isotopic ratios allow tracing that these REE are released by lithogenic material, weathered and transported by the river to the Atlantic Ocean. The original coupling with radium (Ra) isotopes demonstrates that these dissolution processes are occurring within three weeks in the Amazon plume.

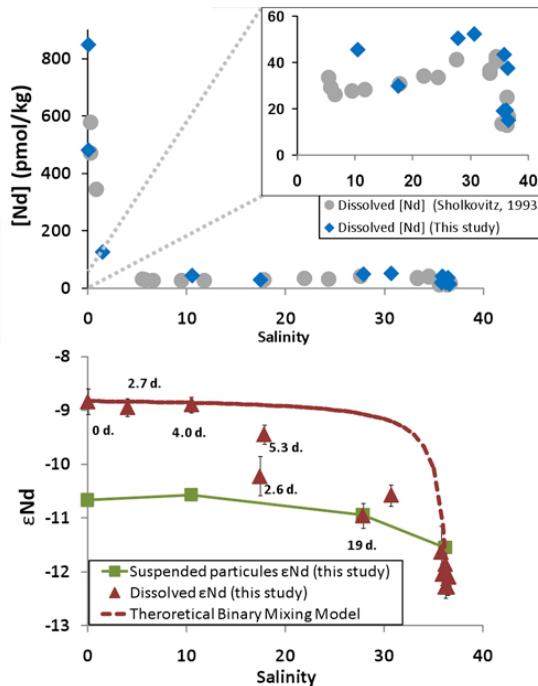


Figure 8: Nd concentrations and isotopic composition in the Amazon River estuary.

Upper panel: Amazon estuary [Nd] from Sholkovitz' 1993 study (grey circles) and this study (Blue diamonds) are reported against the salinity gradient. We observe the non conservative mixing between the Amazon river and the Atlantic waters. The sharp drop in [Nd] in the low salinity region is attributed to the coagulation of colloids, the main REE carriers within river. This drop in concentrations is followed by an increase with salinity before reaching typical low Nd levels of marine waters.

Lower panel: Amazon estuary dissolved (Red triangles), particulate (Green squares) ϵ_{Nd} and apparent radium ages (in days) values are reported against the salinity gradient. A simple two-endmember (Amazon and Atlantic dissolved Nd) mixing model (red dashed line) is not sufficient to explain ϵ_{Nd} variation within the salinity gradient. The dissolved Nd phase rapidly (19 days) homogenizes with a third source, the suspended sediments.

Reference:

Rousseau, T. C. C., Sonke, J. E., Chmeleff, J., Beek, P. van, Souhaut, M., Boaventura, G., Seyler, P., Jeandel, C. (2015). Rapid neodymium release to marine waters from lithogenic sediments in the Amazon estuary. *Nature Communications*, 6, 7592. doi:[10.1038/ncomms8592](https://doi.org/10.1038/ncomms8592).

3-44

3. Activities

3.1 GEOTRACES Intercalibration Activities

After the preceding and very busy year reviewing all intercalibration results for the first IDP release, the Standards and Intercalibration (S&I) Committee had a far less stressful, but productive, year. In addition, three new members joined the committee: Karen Casciotti (Stanford University, California, USA) covering N and C isotopes, Walter Geibert (Alfred Wegner Institute, Germany) handling radionuclides, and Tina van de Flierdt (Imperial College, London, UK) covering radiogenic isotopes such as neodymium. Both Karen and Tina were elemental coordinators in the initial 2008-2009 phase of the GEOTRACES Intercalibration programme and cruises, while Walter stood in for Michael van der Loeff for one meeting during the same phase of the programme. Thus, the new members of the committee are experienced with the processes of intercalibration and evaluating results from cruises.

The major accomplishment of the Committee in this period was completion and posting of the newest (Version 2.0) “Sampling and sample handling protocols for GEOTRACES cruises” cookbook on the GEOTRACES website, <http://www.geotrades.org/images/stories/documents/intercalibration/Cookbook.pdf>. This version has many updates for the various TEIs throughout the document and also includes a new section on artificial radionuclides that did not make it into the original version. Additionally, the hydrography requirements and methods were updated to be fully compliant with the GO-SHIP programme protocols. More significantly, the specifications for meeting intercalibration criteria were tightened up, changing the recommendations to requirements. The Committee decided that the cookbook will be updated every two years, so the next update will be in 2017 unless something critical needs to be updated/modified before this. To complement the cookbook, two Intercalibration Procedure documents, one for cruises with crossover stations and one for those without them, were created to help investigators undertake intercalibration before the S&I Committee sees the results (<http://www.geotrades.org/science/intercalibration/89-intercalibration-documents>). Both documents are only two pages long and should facilitate intercalibration between the relevant investigators largely independent of the Committee.

The Committee met in Galway, Ireland in January 2015 at the National University of Ireland and hosted by Peter Croot. In attendance were Per Andersson attending his last S&I meeting, Peter Croot, Greg Cutter, Walter Geibert, and Maeve Lohan; Karen Casciotti participated via conference software/internet connection. Topics discussed included calibration and reference materials for GEOTRACES TEIs; the latest compilation of TEI acceptability criteria to achieve intercalibration (e.g., nutrients within 2%); updates on recent intercalibration efforts including mercury, ligands (SCOR Working Group 139), cobalt, silicon isotopes, and particles; status of data from post-2014 IDP cruises; data review procedures for the next IDP; and timelines for reviews and plans for the Committee’s next meeting. With respect to the latter, the Committee would like to meet in June 2016 and Karen Casciotti offered to host the meeting at Stanford University. Finally, to better track the status of cruises, relevant investigators, and intercalibration status for each TEI, the Committee began a spreadsheet with all the relevant information. This document will be shared with the Data Management Committee to better coordinate and inform collaborations for ensuring a timely and accurate IDP.

For the next year, 2015-2016, the major activities of the S&I Committee will be contacting cruise investigators to ensure that they are conducting their intercalibrations via the established procedures and submitting their results to the Committee, and reviewing these results for the next IDP. With respect to the latter, the Committee will work much more closely with the Data Management Committee to ensure the timely and accurate incorporation of cruise data into the 2017 IDP. The Committee also will continue to identify suitable dissolved and particulate reference materials for the diverse suite of TEIs examined in GEOTRACES and monitor on-going intercalibration activities (e.g., chemical speciation). Finally, Lars-Eric Heimbürger at University of Bremen (Germany) will join the Committee as its newest member, with expertise in mercury and other contamination-prone trace elements.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), whose headquarters is located in Liverpool. The GEOTRACES Data Manager is based at the BODC Southampton, UK office. Regular communication is maintained between the two sites so that support and assistance can be offered to the GEOTRACES Data Manager when required.

GDAC is responsible for the entirety of the GEOTRACES data activities from inception to completion. This takes into account the following components:

- interaction between PIs and national data centres in order to encourage regular and timely data and metadata submissions
- maintaining and modifying GDAC webpages to include updated ocean basin maps (http://www.bodc.ac.uk/geotraces/cruises/section_maps/) and upcoming cruises on the programme page (<http://www.bodc.ac.uk/geotraces/cruises/programme/>)
- liaising with the Data Management Committee and Standards and Inter-calibration Committee to ensure that issues and questions relating to GEOTRACES and its progression as a project can be discussed, and deadlines can be met accordingly.
- input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies
- Collation of data and metadata for the 2017 Intermediate Data Product

GDAC, until recently, has been staff by a single person. This was Edward Mawji up until February 2015, at which point Abigail Bull took his place as the GEOTRACES Data Manager. BODC has provided extra resources to the GEOTRACES Project in order to aid and provide support to Abigail, primarily with the data processing. When the GEOTRACES Project expects to experience busy periods (i.e., in the lead up to the 2017 IDP) this extra resource will be invaluable. This data management report will highlight tasks that have been the focal point of GDAC since this Abigail Bull became the Data Manager in February 2015.

3-46

Working with the IPO

A sound working mechanism has been established between the GEOTRACES IPO and GDAC, even with the changeover of staff members at BODC. The IPO has been particularly useful in providing guidance to the new GEOTRACES Manager so the GEOTRACES project can continue to run efficiently. When there is a change in staff there is often a period of time dedicated to learning and development – the IPO has provided unending support in this matter and has made the new GEOTRACES Project Manager feel welcome. The IPO has also helped GDAC stay up to date with new cruises, as well as serving reminders of when certain people should be contacted in order to extract various information at relevant times.

Meetings attended

Various visits have been made since stepping into the GEOTRACES Data Manager role. These are essential for building good relationships with national data centres. The meetings attended including the following:

- Visit to the IPO Office in Toulouse, where Abigail met with Elena Masferrer Dadas and Catherine Jeandel. The GEOTRACES Project as a whole was discussed, as well as ways in which the IPO could support Abigail in her new role. Meeting significant GEOTRACES Project participants in person has solidified working relationships. This meeting also presented an opportunity to ask questions and clarify any outstanding issues. Also present was Catherine Schmechtig (Data Manager at French data centre - LEFE Cyber) The formats and submission of French data were discussed, along with retrieval of outstanding cruise reports for French cruises. This proved beneficial, as there is now a strong working relationship and communication method between the French data centre and GDAC.
- Meeting with Reiner Schlitzer in Bremen, Germany. The aim was to meet Reiner before the DMC/SSC meeting in July 2015, and to discuss various data-related items. These included version 2 of the 2014 IDP, the possibility of an interactive map on the GDAC website, IDP parameter codes, and preparation techniques for the 2017 IDP. The meeting was extremely useful in regards to identifying priorities for the project, as well as ascertaining items which should be discussed at the DMC meeting in order to clarify unanswered questions.
- Regular meetings with Alessandro Taglibue (DMC co-chair) in Liverpool – these one-to-one meetings have provided guidance and support to Abigail as the new GEOTRACES Data Manager. Data discussions as well as GDAC DMC items have been addressed in these informal meetings.
- Meeting with Cyndy Chandler (BCO-DMO) in Liverpool – discussion centred around BCO-DMO (the U.S. data centre) and what it can do to assist GDAC in its responsibilities. Further discussions regarding this will take place between 8 and 10 July, when Abigail and Graham Allen (Head of BODC) visited BCO-DMO at Woods Hole, MA, USA.

Data overview

The data management of the GEOTRACES Project is a large undertaking, with a total of 66 cruises (including all cruise legs) associated with the project (this takes into account all section cruises,

process studies and “compliant” data). More than 800 scientists have taken part in GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/section/process study cruise.

2014/2015 has been a successful period, where contact has been made with PIs owing data to GDAC: submissions of data and metadata are becoming more forthcoming. It has been recognised that a way of encouraging PIs to submit their data to GDAC more readily is to use inclusion of a PI’s data in the 2017 IDP as an incentive.

Summary of completed GEOTRACES cruises to date:

Section cruises	IPY cruises	Process studies	Compliant data
27 cruises (including all legs) with 19 sections	11	21 (including all legs) with 17 sections	5

In addition, 2 intercalibration cruises have been completed.

Since Abigail Bull started as GEOTRACES Data Manager, one process study cruise has taken place: NBP1409 (GPpr08 Leg2 - PHANTASTIC II cruise)). The PHANTASTIC I cruise NBP1310 02 (GPpr08 Leg1) took place in December 2013–January 2014. This cruise has recently been approved as a GEOTRACES Process Study and so it is new to the GDAC programme page (<http://www.bodc.ac.uk/geotraces/cruises/programme/>). The SSB (Shelf Seas Biogeochemistry) GEOTRACES cruise is on its way to completion, with leg 3 (DY033 – GApr04 leg3) still to take place between 11 July and 3 August 2015. DY018 (GApr04 Leg1) and DY029 (GApr04 Leg2) are already complete. One section cruise, KH14-6 (GP19), undertaken by Japan in the Western South Pacific and Antarctic Sea, took place at the beginning of 2015.

Summary of forthcoming GEOTRACES cruises to take place in 2015/2016:

This year the International GEOTRACES Arctic research programme focuses on field effort from the United States, Canada and Germany. Three Arctic cruises have been planned and funded and will take place between July and October 2015. German cruise M121 (GA08) is scheduled in the SE Atlantic with planned cruise dates of 21 November–27 December 2015.

In summary

The collection and processing of data to be included in the 2017 IDP will be a priority over the coming year. GDAC continues to receive data and metadata from completed cruise. In order to encourage more timely submission, the incentive of having data in the 2017 IDP as well as the recognition that results from such inclusion, will be more formally advertised.

3.3 GEOTRACES International Project Office

The GEOTRACES International Project Office (IPO) is based at the Laboratoire d’Etudes en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. The IPO is staffed by a

3-48

single person, the IPO Executive Officer, Elena Masferrer Dudas. She works under the scientific supervision of Catherine Jeandel (CNRS, LEGOS, France).

The IPO is responsible for assisting the Scientific Steering Committee (SSC) in implementing the GEOTRACES Science Plan and implementation plans of the programme; organising and staffing meetings of the SSC, working groups and task teams; liaising with the sponsors and other relevant organisations; seeking and managing programme finances; representing the project at international meetings; maintaining the project website and Facebook and Twitter pages; maintaining the project mailing lists; preparing GEOTRACES science highlights and the bimonthly GEOTRACES eNewsletter; maintaining the GEOTRACES publications database and the GEOTRACES Scientists Analytical Expertise Database; assisting the GDAC in securing information about upcoming cruises; and interacting with GEOTRACES national committees and groups, as well as other international projects.

Outreach effort

Outreach has been the top priority for the GEOTRACES IPO this year. Firstly, several actions have been undertaken to publicize the Intermediate Data Product 2014 (e.g. presentations in international conferences or other international programmes conferences, sending announcements to other international programmes mailing lists). Secondly, the IPO is collecting GEOTRACES outreach materials and activities developed during the five years of the programme and promoting them to be used not only through the GEOTRACES Community but also to other communities. For this, the IPO has developed an Outreach website:

- **GEOTRACES Outreach website**

An important effort has been made by the IPO to create a website devoted to outreach. This public website displays all the GEOTRACES outreach materials and activities:

<http://www.geotraces.org/outreach>

Example of materials available on the website are: cruise blogs, webinars, cartoons, videos, podcasts, textbooks, brochures, posters, publicity documents, etc.

Thirdly, the IPO has helped GEOTRACES national programmes in developing and promoting their outreach initiatives, as for example:

- **GEOTRACES Webinar series**: Ben Twining (U.S. GEOTRACES) has developed a webinar series devoted to GEOTRACES in collaboration with the Centers for Ocean Sciences Education Excellence (COSEE). The webinar hosted by the COSEE-Ocean Systems office at University of Maine is available here:
<http://www.geotraces.org/outreach/other-outreach-materials/webinars>

- **Toulouse Knowledge Festival (La Novela) and sharing science with prisoners (Association the stars shine for all)**: During the French GEOVIDE cruise, Catherine Jeandel (IPO science director, France) set up a project with the Seysses Prison (Toulouse, France). During 6 months (April-October 2014), GEOVIDE scientists communicated with prisoners (via their teachers). They did this before the cruise, during the cruise (thanks to a cruise blog) and after the cruise. The project ended with a session at the Toulouse Knowledge

Festival (called La Novela) in October 2014 where a video was projected followed by a debate. For further information:

<http://www.geotraces.org/outreach/other-outreach-materials/videos/1079-geovideo-sharing-oceanography-with-prisoners>

In addition, we would like to highlight the following tasks:

- **Major GEOTRACES website overhaul:** One important task this year was to overhaul the GEOTRACES website. While keeping the same structure to facilitate access to information, the website now has a dynamic new design that provides more visibility to GEOTRACES products, including outreach activities. At the same time, the link within the GDAC website and the IPO website has strengthened. Special thanks to Olivier Boebion (Obs. Oceano. Villefranche sur Mer) and Paule Dossi (DOoWEB) for their technical assistance and advice in upgrading the website.
- **Twitter account:** Since February 2015, GEOTRACES has a Twitter account that counts 111 followers at the time this report is written. This is in complement to the GEOTRACES Facebook page, which has 235 followers (and with 1453 people reached on a post).
- **International Conferences:** With the aim of publicising GEOTRACES towards other communities, two abstracts have been submitted and accepted to international conferences presenting the GEOTRACES Programme:
 - « GEOTRACES highlights in the Indian Ocean and plans for the future », oral presentation, presented by L. Demina⁴ (26th IUGG General Assembly, IAPSO Symposium, special session on *the 50th Anniversary of the Indian Ocean Expedition*, Prague, 22 June- 02 July 2015)
 - « Highlights from the GEOTRACES International Programme », poster, to be presented by G. Henderson on Monday 17 August at 17h (Goldschmidt 2015, Prague, August 16-21, 2015)
- **Working with GDAC:** A very nice working relation has been established between the IPO and the new GEOTRACES Data Manager, Abigail Bull. On March 2015, the IPO organized a meeting in Toulouse for Abigail Bull to meet not only the IPO staff, but also the French Data Manager Catherine Schmechtig.
- **Intermediate Data Product 2014 Survey:**
The GEOTRACES IPO has assisted DMC co-chairs and the SCOR Executive Director in disseminating the IDP2014 Survey and analysing and presenting the results.
- **Some statistics:**
80 highlights published (24 since last reporting period)
15 eNewsletter published (bimonthly newsletter)
120 researchers included in the GEOTRACES Researchers Analytical Expertise Database
548 peer-reviewed papers included in the GEOTRACES Publication Database

3-50

3.4 GEOTRACES Workshops

First GEOTRACES Brazil Workshop, 21-22 March 2015, Santos, Brazil.

As a result of the Latin America workshop held in 2012 (12-15 November 2012, Rio de Janeiro, a network of researchers has been established and a core community is being structured in Brazil. The *Final Statement* resulting from this workshop is available on the GEOTRACES site:

http://geotrades.org/images/stories/documents/workshops/2015_Brazil/2015_Workshop_GEOTRACES_BRASIL_final_statement_08_05.pdf

Forthcoming:

Coupled meeting and workshop to discuss and synthesise findings from the GEOTRACES programme:

*The biological and climatic impacts of ocean trace-element chemistry, 7–8 December 2015, The Royal Society, London, UK.

For further information: <https://royalsociety.org/events/2015/12/ocean-chemistry/>

A Royal Society Scientific Discussion Meeting to present new results and discoveries about the role of ocean in trace-element cycling in the Earth system. Speakers from eight countries will discuss the oceanic cycles of trace elements, their role in ocean biology, their use to assess past and present ocean processes, and the influence of human activity on ocean trace-element chemistry. The meeting is open to all, with registration at the above website. There is no charge to attend.

*Quantifying fluxes and processes of trace-metal cycling at ocean boundaries, 9–10 December 2015, Chicheley Hall, Buckinghamshire, UK.

For further information: <https://royalsociety.org/events/2015/12/ocean-chemistry/>

This is a workshop-format meeting to synthesise knowledge about the fluxes of trace elements at the four ocean boundaries: from continents across the shelf; from marine sediments; from mid-ocean-ridges; and from the atmosphere. Keynote talks will describe recent advances in data and understanding for each interface. Discussion groups and posters will enable a full exploration of the state of knowledge for each interface, identify areas of uncertainty, and consider possible future research. The programme is presently being finalised. This workshop has a limited number of places and is by invitation or application only.

3.5 Special sessions at international conferences featuring GEOTRACES findings

Several special sessions with relevance to GEOTRACES were featured or planned in major international conferences including the following:

2014 Asia Oceania Geosciences Society 11th Annual Meeting (AOGS 2014), 28 July to 1 August 2014, Sapporo, Hokkaido, Japan.

For further information: <http://www.asiaoceania.org/aogs2014/public.asp?page=home.htm>

*OS01: Trace elements and their isotopes in the ocean: GEOTRACES activities in Asia and Oceania

Convenors : Dr. Yoshiki Sohrin (Kyoto University, Japan), Dr. Tung-Yuan Ho (Academia Sinica, Taiwan), Dr. Pinghe Cai (Xiamen University, China), Prof. Man Sik Choi (Chungnam National University, Korea, South).

24th Earth Sciences meeting, 27-31 October 2014, Pau, France.

For further information: <http://rst2014-pau.sciencesconf.org>

*Session 8.5: Advances in mercury biogeochemistry. Organizers: Jeroen Sonke (GET, Toulouse) and David Amouroux (LCABIE, IPREM, Pau).

*Session 8.7 : Biogeochemical cycling of contaminants in the Arctic. Organizers: Lars-Eric Heimburger (GET, Toulouse, France) and Aurélien Dommergues (LGGE, Grenoble, France).

American Geophysical Union Fall 2014 Meeting, 15-19 December 2014, San Francisco, California, USA.

For further information: <http://fallmeeting.agu.org/2014/>

GEOTRACES sessions:

*Trace Element and Isotope Cycling in the Coastal Environment – 40 Years of Innovations. Convenors: Greg Cutter and Pete Sedwick

*Trace metals and isotopes in the Eastern Tropical South Pacific: Results of the 2013 U.S. GEOTRACES Zonal Transect and complimentary studies. Convenors: Jim Moffett, Chris German and Martin Frank

GEOTRACES-related sessions:

*Productivity Proxies: New Developments and Records. Convenors: Fatima Abrantes, Bob Anderson and Heather Stoll

*Biogeochemical cycling of silicon in coastal transition zones. Convenors: Claudia Ehlert, Patricia Grasse, Daniel J Conley and Mark A Brzezinski

*The Biogeochemical Cycling of Mercury in the Coastal and Open Ocean. Convenors: Robert P Mason and Arthur Russell Flegal

*Past Ocean Dynamics

Convenors: Joerg Albert Lippold, Luke Skinner and Sam Jaccard

3-52

ASLO 2015, Aquatic Sciences Meeting, 22-27 February 2015, Granada, Spain.
For further information: <http://www.aslo.org/meetings/index.html>

*142 - Chemical Oceanography/GEOTRACES

Convenor: Andrea Kochinsky, Jacobs University Bremen.

*037 - The Molecular Ecology of Metal-Microbe Interactions in the Ocean Environment.

Convenors: Robert Strzepek, The Australian National University; Maite Maldonado, The University of British Columbia; and Yeala Shaked, The Hebrew University in Jerusalem.

*014 - Atmospheric Deposition Effects in Aquatic Ecosystems

Convenors: Francesc Peters, Institut de Ciències del Mar (CSIC), Barak Herut, National Institute of Oceanography, Adina Paytan, Institute of Marine Sciences, Cecile Guieu, Laboratoire d'oceanographie de Villefranche, Ana M Aguilar-Islas, University of Alaska Fairbanks, Clifton Buck, Skidaway Institute of Oceanography and Simon Usher, University of Plymouth.

3rd International Symposium on the Effects of Climate Change on the World's Oceans, 23-27 March 2015, Santos, Brazil.

For further information: http://www.pices.int/meetings/international_symposia/2015/2015-Climate-Change/scope.aspx

*S3. Changing Ocean Chemistry: From Trace Elements and Isotopes to Radiochemistry and Organic Chemicals of Environmental Concern

Co-chairs: Angelica Peña (Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada) and Geraldine Sarthou (LEMAR, IUEM, Brest, France)

12th International Conference on Mercury as a Global Pollutant, 14-19 June 2015, Jeju, Korea.

For further information: <http://mercury2015.com/main/>

*17. Integrating marine observational studies and model development

Conveners: Anne Laerke Soerensen & Lars-Eric Heimbürger

*Conference Workshop: GEOTRACES Intercalibration exercises for Hg species in seawater discussion forum

Conveners: Lars-Eric Heimbürger

Forthcoming:

Goldschmidt 2015, 16-21 August 2015, Prague, Czech Republic.

For further information: <http://goldschmidt.info/2015/index>

** Theme 2: Ocean Geochemistry. Present Conditions and Past Variation: fluxes, reservoirs and processes

Co-ordinators: Geraldine Sarthou (Brest University, France) and Andrew Bowie

(University of Tasmania).

Team members: Katherine Barbeau (Scripps, USA), Kristen Buck (Univ South Florida, USA), Zanna Chase (Institute for Marine and Antarctic Studies, Australia), Rob Middag (Univ Otago, New Zealand), James Moffett (Univ. Southern Carolina, USA)

*02a: Trace Metals in the Ocean: Distributions, Isotopic Variation and Speciation.

Session Convenors: Katherine Barbeau (UC San Diego, Scripps Institution of Oceanography, USA), Andrew Bowie (University of Tasmania), Kristen Buck (University of South Florida, College of Marine Science, USA), Rob Middag (Univ Otago, New Zealand), Christopher Pearce (National Oceanography Centre), Phil Pogge von Strandmann (Earth Sciences, University College London, UK), Géraldine Sarthou (LEMAR CNRS, Brest, France).

*02b: Radionuclides in the Ocean

Session Convenors: Bob Anderson (Lamont-Doherty Earth Observatory, USA), Ken Buesseler (Woods Hole Oceanographic Institution, USA), Pere Masque (Universitat Autònoma de Barcelona)

*02c: Past Changes in Ocean Biogeochemistry and Circulation and their Interaction with Climate

Session Convenors: Zanna Chase (Institute for Marine and Antarctic Studies, Australia), Martin Frank (GEOMAR Helmholtz centre for ocean research Kiel, Germany), Norbert Frank (University of Heidelberg, Germany), Katharina Pahnke (ICBM and MPI for Marine Microbiology, Germany), Laetitia Pichevin (University of Edinburgh, UK), Laura Robinson (University of Bristol, UK), Tina van de Flierdt (Imperial College London, UK), Kazuyo Tachikawa (Cerege, CNRS, France)

*02d: What are the unifying principles common to all three Oxygen Minimum Zones (OMZs)?

Session Convenors: Jim Moffett (Univ. Southern Carolina, USA), Aurélien Paulmier (LEGOS, France)

*02e: Air-Sea Exchange, the Biological Pump, and Ocean Acidification

Session Convenors: Steve Emerson (University of Washington, USA), Doug Wallace (Dalhousie University, Canada)

*02f: Biogeochemistry of Arctic and Antarctic sea ice systems

Session Convenors: Jun Nishioka (Univ. Hokkaido, Japan), Delphine Lannuzel (University of Tasmania, Australia)

*02g: Advances in marine N, P and Si biogeochemistry

Session Convenors: Damien Cardinal (University Pierre and Marie Curie, LOCEAN, Paris), Albert Colman (University of Chicago, USA), Masha Prokopenko (University of Southern California, USA), Christian März (Newcastle University, UK)

3-54

*02s: Goldschmidt 25th Anniversary

The 25th anniversary talk is an overview of the progress and breakthroughs made in this theme over the last 25 years. Invited speaker: Catherine Jeandel

22nd International Society for Environmental Biogeochemistry (ISEB) Symposium Dynamics of Biogeochemical Systems: Processes and Modeling, 28 September-2 October 2015, Piran, Slovenia.

For further information : <http://www.iseb22.ijs.si>

*Marine and coastal environments – Special session: GMOS and GEOTRACES

American Geophysical Union Fall 2015 Meeting, 14-18 December 2015, San Francisco, California, USA.

For further information: <http://osm.agu.org/2016/>

*GC067: Trace Metal Cycling in the Environment – 40 Years of Advancements
Session ID#: 8771

Convenors: Priya Ganguli, Frank Black, Sergio Sanudo-Wilhelmy and Ed Boyle

*A035: Dust in High Latitudes: From its Origins to its Impacts
Session ID#: 8015

Primary Convener: Santiago Gasso, GESTAR/NASA, Silver Spring, MD, United States
Conveners: John Crusius, USGS Western Regional Offices Seattle, Seattle, WA, United States, Gisela Winckler, Lamont -Doherty Earth Observatory, Palisades, NY, United States and Paul A Ginoux, NOAA Princeton, Princeton, NJ, United States

*OS010: Exploring the Dust-Ocean Connection in a Changing Climate
Session ID#: 8749

Primary Convener: Maurice Levasseur, Laval University, Quebec-Ocean, Quebec City, QC, Canada

Conveners: William L Miller, University of Georgia, Athens, GA, United States and Mitsuo Uematsu, University of Tokyo, Bunkyo-ku, Japan

2016 Ocean Sciences Meeting, 21-26 February 2016, New Orleans, Louisiana, USA.

For further information : <http://osm.agu.org/2016/>

*CT001: Atmospheric deposition and ocean biogeochemistry
Session ID#: 9243

Primary Chair: Ana M Aguilar-Islas, University of Alaska Fairbanks, Fairbanks, AK, United States

Chairs: Clifton S Buck, Skidaway Institute of Oceanography, Savannah, GA, United States and Meredith Galanter Hastings, Brown Univ-Geological Sciences, Providence, RI, United States

*CT002: Integrating approaches to understanding the distribution and transfer of trace elements in the upper water column

Session ID#: 8750

Primary Chair: Rachel Shelley, LEMAR/UBO, Brest, France

Chairs: Peter L Morton, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL, United States and Sunil Kumar Singh, Physical Research Laboratory, Ahmedabad, India

*CT003: Kinetics: the force driving trace metal distributions in marine waters

Session ID#: 9486

Primary Chair: Christian Schlosser, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany

Chairs: Eric P. Achterberg, GEOMAR Helmholtz Centre for Ocean Research Kiel, Chemical Oceanography, Kiel, Germany, Christoph D Voelker, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven, Germany and Alessandro Tagliabue, University of Liverpool, Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom

*CT008: The role of particles in the cycling of trace elements and their isotopes in the ocean

Session ID#: 7493

Primary Chair: Hélène Planquette, LEMAR, CNRS, Plouzané, France

Chairs: Phoebe J Lam, University of California Santa Cruz, Department of Ocean Sciences, Santa Cruz, CA, United States and Benjamin S. Twining, Bigelow Lab for Ocean Sciences, East Boothbay, ME, United States

*CT009: Trace Elements and Isotopes at the Interfaces of the Atlantic Ocean

Session ID#: 9208

Primary Chair: Geraldine Sarthou, LEMAR UMR 6539 CNRS UBO IRD IFREMER, IUEM, Plouzané, France

Chairs: Edward A Boyle, Massachusetts Institute of Technology, Earth Atmospheric and Planetary Sciences, Cambridge, MA, United States, Gideon Mark Henderson, University of Oxford, Earth Sciences, Oxford, United Kingdom and Micha J.A. Rijkenberg, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands

*CT010: Trace Metal Bioavailability and Metal-Microorganism Interactions

Session ID#: 8373

Primary Chair: Julia M Gauglitz, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States

Chairs: Randelle Bundy, Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA, United States and Jill N Sutton, IUEM/UBO, Technopôle Brest-Iroise, Place Nicolas Copernic, Plouzané, France

*CT011: Trace metal speciation in seawater: measurements, modelling and impact on marine biogeochemistry

Session ID#: 9231

Primary Chair: David R Turner, University of Gothenburg, Gothenburg, Sweden

3-56

Chairs: Stan MG van den Berg, University of Liverpool, Liverpool, L69, United Kingdom, Sylvia Gertrud Sander, University of Otago, Dunedin, New Zealand and Kristen N Buck, University of South Florida Tampa, Tampa, FL, United States

GEOTRACES Tutorial:

*T014: What Controls the Distribution of Dissolved Iron in the Ocean?

Session ID#: 9303

Primary Chair: Alessandro Tagliabue, University of Liverpool, Liverpool, L69, United Kingdom

3.6 Capacity building

At-Sea Training GEOTRACES gratefully acknowledges support from SCOR to enable one scientist per year from a developing nation to participate in a GEOTRACES cruise. These opportunities are vital to the development of technical expertise in sampling and sample handling for contamination-prone elements aboard “dirty” ships.

Sampling Systems It is a goal of GEOTRACES that every nation carrying out oceanographic research should have access to a trace metal-clean sampling system. GEOTRACES offers guidance based on past experience in the design and construction of sampling systems as well as advice in operating these systems as shared facilities. A complementary goal is to establish a programme whereby scientists who have accrued experience in operating these systems can share that knowledge with scientists from nations that are in the process of acquiring clean sampling systems.

An updated status of trace metal-clean sampling systems to support GEOTRACES research is provided in the table below. Scientists interested in developing one of these systems for their own use are encouraged to contact the GEOTRACES IPO or any member of the SSC, who will arrange for contact with an appropriate person to provide technical information about the design, construction and cost of a system.

Nation	Status	System/ Carousel	Bottles	Depth
Australia	Complete	Powder coated aluminium, autonomous 1018 intelligent rosette system	12 x 10-L Teflon-lined Niskin-1010X	6000 m; 6 mm Dynex rope
Australia	2nd system (complete)	Polyurethane powder-coated aluminium autonomous Seabird rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	12 x 12-L Teflon-lined OTE external-spring Niskin-style bottles	1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope with coupling to 6000 m CTD wire

Brazil	Complete	GEOTRACES WATER SAMPLER - 24-bottle sampler for use with modem equipped 911plus CTD	24 X 12-L GO-Flo	3000 m; Kevlar cable
Canada	Complete	Powder coated aluminium with titanium CTD housing, Seabird Rosette	24 X 12-L GO-Flo	2300 m; conducting Vectran soon to be upgraded with 5000 m conducting Vectran 06/2013
China - Beijing	Complete	Towed fish	NA	Surface
China - Taipei	Complete	Teflon coated rosette	Multi- size GO-Flo	3000 m; Kevlar line
France	Complete	Powder coated aluminium with titanium pressure housing for CTD	24 X 12-L GO-Flo	8000 m; conducting Kevlar
Germany	CTD and bottles purchased, winch planned	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L Niskin-X	8000 m; conducting Kevlar
Israel	Complete	Powder coated aluminium, SeaBird Rosette	12 X 12-L Niskin; 8 X 12-L GO-Flo (Teflon coated)	2000 m, steel conducting cable
Italy	Complete	Go-Flo bottles on Kevlar line	5 x 20-L Go-Flos	Kevlar
Japan	Complete	Powder coated aluminium	12-L Niskin-X	10000 m; titanium armored cable
Netherlands	Complete	Titanium frame	24 X 12-liter GO-Flo	10000 m; conducting Kevlar
Netherlands	Complete	Titanium frame	24 X 27-liter ultraclean PVDF	10000 m; conducting Kevlar
New Zealand	Complete	Powder coated aluminium	5-L Teflon-lined Niskin-X	4000 m; 8 mm Kevlar line
Poland	Complete	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X	300m Kevlar

3-58

			Teflon coated	
Poland	Complete	Teflon pump on-line	Surface water pump	1.5m fixed
Poland	In development	Pump CTD	Teflon hose 10mm	Up to 200m
South Africa	Complete	Powder coated aluminium, titanium housing/fittings	24 X 12-liter GO-Flo	6500 m; Kevlar cable
UK	Complete	2 x Titanium frame, Ti pressure housings	24 10-L OTE 24 10-L OTE	2 x 8000m conducting Kevlar
USA - CLIVAR	Complete	Powder coated aluminium	12 X 12-L GO-Flo	1500 m; conducting Kevlar
USA - GEOTRACES	Complete	Powder coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-Flo	8000 m; conducting Kevlar
USA- University of Alaska Fairbanks	Complete	Seabird Rosette. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	No Kevlar line available yet.
USA- Old Dominion University	Complete	Seabird Rosette. SBE-19plusV2 CTD unit. Powder coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 5-L Teflon-lined Niskin-X	2000 m 0.5-inch Kevlar wire
USA – Polar Programs	Complete	Powder coated aluminium with titanium pressure housings and fittings	12 X12-L Niskin-X	3000 m; conducting Kevlar

4. Plans for coming years

Field Programme

The completion of the GEOTRACES research Arctic programme (4 cruises in 2015 and 1 more planned for 2016) will be one important target of the field programme for the coming reporting year. In addition, other cruises are already planned in the Atlantic Ocean (Germany, Netherlands), Pacific Ocean (Japan and Germany) and Southern Ocean (Australia).

Next Intermediate Data Product

GEOTRACES plans to release **the second Intermediate Data Product at Goldschmidt 2017** (13-18 August 2017, Paris, France). Thus, preparing the next Intermediate Data Product will be the top priority for the GEOTRACES community. A procedure and clear timeline for data submission and review will be established and communicated in order to ensure the timely release of the next IDP.

GEOTRACES synthesis of results strategy

GEOTRACES plans to launch a three-pronged synthesis initiative. The first component focuses on sources and sinks of TEIs at ocean boundaries, starting with the workshop “[The biological and climatic impacts of ocean trace-element chemistry](#)” (7-8 December 2015, Royal Society in London, UK, see « GEOTRACES Workshops » above).

The second component focuses on internal cycling of TEIs within the ocean. This will be organised by U.S. GEOTRACES, in collaboration with the Ocean Carbon and Biogeochemistry Programme (OCB) in mid-2016.

The third component will be centered on geochemical tracers used as paleoceanographic proxies with a workshop planned for 2017. GEOTRACES is exploring a partnership with the Past Global Changes project (PAGES) in hosting this workshop.

The first two workshops will use the wealth of data in the 2014 Intermediate Data Product (IDP2014) and demonstrate to the broader oceanographic community the usefulness of the IDP2014. The 2017 workshop will have access to the first and second IDPs, as well as to the results of the 2015 and 2016 workshops.

Together, these workshops cover the main scientific goals of GEOTRACES and are designed to respond to the expectation that GEOTRACES results benefit other oceanographic disciplines.

Acknowledgements

We offer our special thanks to Ed Urban, who continues to provide tremendous support and valuable advice to the implementation of the GEOTRACES programme.

Written and compiled by:

Ed Boyle and Reiner Schlitzer (Co-Chairs GEOTRACES SSC)

Greg Cutter and Maeve Lohan (Co-Chairs of the GEOTRACES S&I Committee)

Abby Bull (GEOTRACES Data Manager)

Catherine Jeandel (GEOTRACES IPO Science Director)

Elena Masferrer Dadas (GEOTRACES IPO Executive Officer)

June 2015

3-60

3.4 Surface Ocean–Lower Atmosphere Study (SOLAS) (joint with IGBP, WCRP, and CACGP)

Sarma, Turner

Terms of Reference:

- To develop the Surface Ocean - Lower Atmosphere Study (SOLAS) Science Plan and an Implementation Strategy, in accordance with guidance of the sponsoring organisations.
- To oversee the development of SOLAS in accordance with its Science Plan/Implementation Strategy.
- To collaborate, as appropriate, with other related projects of IGBP, WCRP, SCOR and CACGP and related projects and programmes (e.g., IHDP, DIVERSITAS, IOC and the Global Ocean Observing System (GOOS), etc.)
- To establish appropriate data management policies to ensure access to, sharing of, and preservation of SOLAS data, taking into account policies of the sponsors.
- To report regularly to SCOR, IGBP, WCRP and CACGP on the state of planning and accomplishments of SOLAS.
- The SOLAS SSC, its subsidiary groups and International Project Office shall operate in accordance with the operating procedures for IGBP Projects and as required by other co-sponsors.

Chair:

Véronique Garçon
LEGOS/UMR5566,
18 Avenue Edouard Belin,
30155 Toulouse Cedex, France
Phone: + 33 5 61 33 29 57,
fax: + 33 5 61 25 32 05,
e-mail: Veronique.Garcon@cnrs.fr

Members:

Emmanuel Boss Anja Engel Cristina Facchini Hui-wang Gao Christophe Garbe Michele Graco Christophe Heinze	USA GERMANY ITALY CHINA-Beijing GERMANY PERU NORWAY	Ilan Koren Lisa Miller Yukihiro Nojiri Alfonso Saiz-Lopez VVSS Sarma Brian Ward	ISRAEL CANADA JAPAN SPAIN INDIA IRELAND
--	---	--	--

Executive Committee Reporter: John Turner

Executive Officer: Emily Breviere

SOLAS Annual Report to SCOR

Reporting period: June 2014- August 2015
Version of 2 Sept 2015 by Dr Emilie Brévière

I. Progress on implementation of project science and implementation plans, and schedule for major project activities, including open science meetings, major data releases, synthesis activities, and project completion

I.a. SOLAS Scientific Steering Committee

In September 2014, Eric Saltzman, Chair of the SOLAS Scientific Steering Committee since July 2011, stepped down unexpectedly due to his employment by the U.S. National Science Foundation. A fast-tracked search for a new Chair began led by Emilie Breviere, Brian Ward and Alfonso Saiz-Lopez. In the meantime, Cecile Guieu, vice-chair took on the role of interim Chair. In December 2014, Veronique Garcon, who was an SSC member for 6 years from 2007 to 2012, was approved by the SOLAS sponsors to serve as SOLAS SSC Chair beginning in January 2015. Her term will end in December 2017.

In January 2015, VV SS Sarma from India, Maurice Levasseur from Canada, Emmanuel Boss from USA and Cristina Facchini from Italy joined the SSC. SOLAS has an Executive Committee composed of the Chair, Cecile Guieu, Lisa Miller and Christoph Heinze.

The SOLAS SSC met in Rehovot, Israel, 16-18 June 2014 for its 14th SSC meeting and will meet on 11-13 September 2015 in Hamburg, Germany, following the SOLAS Open Science Conference 2015 in Kiel, Germany.

The current membership of the SSC is listed below (15 members including Chair):

Last name	First name	Country of employment	Gender	Scientific expertise	SOLAS expertise	Term end on 31 Dec
Boss	Emmanuel	USA	M	Ocean optics and biogeochemistry	Remote sensing, cross themes	2017
Engel	Anja	Germany	F	Microbial biogeochemistry, sea surface microlayer	Microlayer, cross themes	2017
Facchini	Cristina	Italy	F	Physical and chemical processes in multiphase atmos. systems	Themes 4 and 5: aerosols, clouds and atm chem	2017
Gao	Huiwang	China	M	Atmospheric deposition and ecological effect	Theme 3: Atm deposition	2017

3-62

Garbe	Christoph	Germany	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, ESA connection	2016
Garçon	Veronique	France	F	Marine biogeochemistry and ecosystems dynamics	Integrated topics	2017
Graco	Michelle	Peru	F	Biogeochemical cycles in upwelling systems, OMZ	Integrated topics	2017
Guieu	Cecile	France	F	Marine ecosystems/nutrients	Theme 3: Atm deposition	2015
Heinze	Christoph	Norway	M	Carbon cycle modeling/paleooceano	Theme 1: greenhouses gases	2015
Koren	Ilan	Israel	M	cloud physics	Theme 4: aerosols, clouds	2015
Levasseur	Maurice	Canada	M	Ocean biogeochemistry, dimethylsulfide, Arctic, ice algae	Theme 4: aerosols, clouds	2017
Miller	Lisa	Canada	F	Sea-ice/CO ₂ exchanges	Integrated topics, PICES connection	2016
Nojiri	Yukihiro	Japan	M	Ocean carbon	Theme 1: greenhouses gases	2015
Saiz-Lopez	Alfonso	Spain	M	Atmospheric halogens/modelling	Theme 5: Atm chem., IGAC connection	2016
Sarma	VVSS	India	M	Biogeochemical cycling of C and N in the ocean and estuaries, stable isotopic geochemistry/ocean acidification	Theme 1: greenhouses gases	2017
Ward	Brian	Ireland	M	Air-sea physical interaction	Theme 2: fluxes of mass and energy, WCRP liaison	2016

In December 2015:

- Cecile Guieu, Yukihiro Nojiri and Christoph Heinze will rotate off the SOLAS SSC after two terms.
- Ilan Koren will end his first term on the SOLAS SSC.

I.b. Development of the SOLAS Mid-term strategy

Since 2008, SOLAS has supported the development of Mid-term strategy (MTS) themes, identified as areas where progress can be accelerated significantly with the support of an international programme such as SOLAS. The following publication describes the MTS themes:

Law C. *et al.* (2013) Evolving Research Directions in Surface Ocean - Lower Atmosphere (SOLAS) Science. Environmental Chemistry. Available on our SOLAS website and at
http://www.publish.csiro.au/view/journals/dsp_journals_pip_abstract_Scholar1.cfm?nid=188&pid=EN12159

Over the last 12 months a lot of effort has been dedicated to advance the new science plan; therefore, some topics of the Mid-term strategy have less progressed than in previous years:

- **Sea-ice biogeochemistry and interactions with the atmosphere**

Recent activities of the MTS on sea-ice are intrinsically linked to the SCOR WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII), chaired by Jacqueline Stefels and Nadja Steiner, which will end in 2016. Below is a summary report on WG 140 activities for 2014/2015, by Jacqueline Stefels.

Overview of activities:

Task Group 1 on Methodologies and Intercomparisons (Leads: Lisa Miller and Lynn Russell):

A review of sea-ice methodologies has been published in *Elementa: Science of the Anthropocene*: Miller et al. (2015) Methods for biogeochemical studies of sea ice: The state of the art, caveats, and recommendations. This paper is the first of a Special Feature in *Elementa* on sea-ice biogeochemistry that is initiated by WG 140. TG1 has stimulated discussion and compiled information on opportunities to organize an intercalibration field campaign on a reasonable time scale. Several options are still under discussion.

Task Group 2 on Data (Leads: Klaus Meiners and Martin Vancoppenolle):

The collation of chlorophyll datasets from both the Arctic and the Antarctic are almost finalized and partly published. Several new collaborations have been established around the collation of other parameters: inorganic carbon budget, organic carbon budget, macro nutrients, iron, algal biodiversity.

Task Group 3 on Modeling (Leads: Nadja Steiner and Clara Deal):

A paper on “What sea-ice biogeochemical modellers need from observationalists” has been submitted to *Elementa* as part of the WG 140 special issue. The WG 140 Special Feature within the open-access journal *Elementa: Science of the Anthropocene* is a major product of this TG and of WG 140 as a whole. It will contain a collection of synthesis papers reviewing particular biogeochemical processes in sea ice and respective model applications, but also research papers are accepted. Currently, 20 contributions are planned, of which 7 are published/submitted.

The life span of WG 140 under the umbrella of SCOR is coming to an end. Hence, new avenues need to be explored in order to continue this new and highly successful collaboration between modelers and experimentalists. The network is a very good mix between young and senior researchers from all over the world. The group now consists of 85 scientists from 16 countries. During the SOLAS OSC a discussion session will be dedicated to discuss the future.

3-64

- **Air-sea gas fluxes at Eastern Boundary upwelling systems**

The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), in cooperation with some established experts, have set up a global ocean oxygen network. This group intends to connect scientists from around the globe, including coastal and open ocean scientists; modelers, biological, chemical and physical oceanographers. Preliminary possible objectives/goals have been identified:

- Identification and linking existing oxygen databases
- Identification and linking real time/continuous oxygen observations and monitoring systems (Argo, moorings)
- Developing integrated oxygen research that links coasts and seas, developing global, cross-basin/teleconnection research
- Understanding oxygen interactions with other climate and human stressors
- Promoting better global and regional climate models of oxygen, understanding feedbacks between atmosphere and ocean
- Advancing understanding of forces shaping ocean oxygenation
- Linking oxygenation to fisheries production and dynamics
- Understanding animal migrations and movements in the context of ocean oxygenation
- Socio-economic consequences of oxygenation changes (gains and losses)
- Linking oxygenation to H₂S emission
- Roles of oxygen in shaping global and local patterns of biodiversity
- Calibrations and proxies to learn about the roles of oxygenation in ocean biogeochemical and biodiversity from the paleo record
- Linking oxygen to harmful algal blooms

The first meeting of this network will take place before the 2015 AGU Fall Meeting 2015 in San Francisco.

Other activities related to this MTS Theme include the following:

- A session has been proposed at the IMBER IMBIZO IV on 26-30 Oct. 2015 in Trieste, Italy.
- Another session entitled “Eastern boundary upwelling systems: Natural laboratories for studying the impacts of multiple stressors on marine ecosystems” has been proposed at the AGU Fall meeting in December 2015 in San Francisco, USA
- The SOLAS Chair will participate in the 9th World Ocean Forum at Busan, South Korea on 20-22 October 2015, and will give an invited lecture entitled “Biogeochemical cycles and marine ecosystems in a changing oceanic stratification” within Session 3 Ocean Science and Climate-Environment.
- The SCOR group WG 144 “Microbial Community Responses to Ocean Deoxygenation” is preparing a “White paper” on “Recommendations for best practices for investigations in oxygen-deficient marine systems” and is holding a workshop at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany from 30 August to 3 September 2015.

- An ITN Marie Curie VOYaGE (Variability of Oxygen in Marine ecosystems and Climate change) proposal was submitted for the 2015 call H2020-MSCA-ITN without success and will be resubmitted in 2016.

• Ship plumes: impacts on atmospheric chemistry climate and nutrient supply to the oceans

Interest in this topic has increased over the last couple of years, such that an invited plenary talk is scheduled to take place at the SOLAS Open Science Conference 2015 in Sept. in Kiel, Germany, as well as a discussion session.

I.c. SOLAS- IMBER Carbon Group

Much of the science of SOLAS Focus 3 overlaps with IMBER and thus a joint SOLAS/IMBER Carbon Group (SIC) was formed during a meeting held in Colorado in Oct. 2005. This group is working in close collaboration with International Oceanic Carbon Coordination Project (IOCCP). The SIC group is currently subdivided into three working groups:

***WG1-Surface Ocean Systems.** Chair: Andrew Lenton (Australia)

The Surface Ocean CO₂ Atlas (SOCAT) is a largely volunteer, international activity by the marine carbon community, with more than 100 contributors working to assemble surface ocean carbon dioxide (CO₂) data in a uniform, quality-controlled format. Version 1 was made public in 2011, version 2 in 2013 and the release of version 3 is planned for 2015. A one-day workshop on SOCAT and SOCOM (Surface Ocean pCO₂ Mapping Intercomparison) is being planned on the Monday 7 Sept. 2015, a day before the opening of the SOLAS Open Science Conference 2015. This side event of the SOLAS OSC15 has been chosen to release the SOCAT version 3.

SOCAT version 2 provided 44 years of surface water fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global oceans and coastal seas with 10.1 million unique data points. The SOCAT synthesis and gridded data products can be interrogated via interactive online viewers or downloaded in a variety of formats via the SOCAT website (www.socat.info). Three publications document SOCAT versions 1 and 2 (Pfeil et al., 2013; Sabine et al., 2013; Bakker et al., 2014). About 3 million new fCO₂ values from 1957 to 2013 have been included in SOCAT version 3. Quality control by regional groups is about to start. The quality control criteria have been adapted for version 3 to accommodate calibrated CO₂ data from new sensors and alternative platforms.

Applications of SOCAT include process studies, quantification of the ocean carbon sink, its seasonal to year-to-year variation and ocean carbon cycle modelling. The Global Carbon Budget (www.globalcarbonproject.org/carbonbudget/) uses SOCAT for quantification of the annual ocean carbon sink. The Surface Ocean pCO₂ Mapping intercomparison (SOCOM) is a recent initiative that compares surface ocean CO₂ gridded products, derived by a variety of methods, many of them based on SOCAT.

***WG2-Interior Ocean.** Chair: Nicolas Gruber (Switzerland)- update from 1 Sept 2015.

WG2 has focused its recent activities entirely on the analysis of the carbon data from the hydrographic surveys with the aim to determine the change in the ocean's anthropogenic CO₂ content since the 1990s. They are now in the final stages (paper draft completed), and hope to finish this synthesis project by early 2016. WG2 contributed also to the planning of the upcoming joint GO-SHIP/Argo/IOCCP meeting in Galway on the topic of "Sustained ocean

3-66

observing for the next decade” <http://www.gaic2015.org>. In addition, they continue to support the development and application of biogeochemical sensors on Argo floats, although this area has developed a lot of momentum and is strong enough to move forward without much need for help from WG2. WG2 likely will reengage in full in this area when time is ripe to address data synthesis and integration in a global/basin-scale manner.

*WG3-Ocean Acidification. Chair: Jim Orr (France), update from May 2015

The last annual meeting of the SIOA working group was in May 2015, supported financially by SOLAS and IMBER. The Chair of the SIOA working group is Jim Orr. SIOA Members are all Members of the Advisory Board of the OA-ICC (Ocean Acidification International Coordination Centre), based at the IAEA Environment Laboratories in Monaco since 2012 for 3 years. Many SIOA Members are focal points for the OA-ICC activities, and Jim Orr is the Scientific Coordinator of the project. The IAEA Project Officer is Lina Hansson and the Programme Manager is Michel Warnau. There is an OA-ICC web site (www.iaea.org/ocean-acidification) and a news stream (news-oceanacidification-icc.org). The activities of the OA-ICC are to promote (1) the development of a global observation network; (2) use of joint platforms and facilities; (3) collaboration between natural and social sciences; (4) Intercomparison exercises; (5) Joint ocean acidification experiments; (6) best practices in OA research; (7) Online bibliographic database; (8) Data management; (9) capacity building; and (10) information sharing and communication.

With regard to science, the OA-ICC continues to support the development of a Global Ocean Acidification Observing Network (GOA-ON; www.goa-on.org), in particular by encouraging the participation of developing countries. The GOA-ON science plan was recently printed and copies are available on request. The OA-ICC co-organised with the Centre Scientifique de Monaco (CSM) the 3rd international workshop of the socio-economic impacts of ocean acidification (Monaco, 12-14 January 2015). The OA-ICC co-supported the expert meeting ‘Oceans 2015 initiative’, on 20-22 April in Monaco, with the goal to translate greenhouse gas emissions trajectories into an impact scenario for ocean acidification and warming. The OA-ICC offers two online databases related to ocean acidification: a bibliographic database and a data compilation on the biological response to ocean acidification.

With regard to communication, the OA-ICC provides daily updates on ocean acidification through its news stream. The OA-ICC was present at the UNFCCC COP20 in Lima, Peru in December 2014 and at the 16th session of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea in New York City on 6-10 April 2015.

In terms of capacity building side, OA-ICC provide travel grants to conferences; for example, the travel grant provided by the OA-ICC to the SOLAS Open Science Conference 2015 is allowing 4 scientists from developing countries to participate to the conference.

I.d. SOLAS metadata portal

The SOLAS metadata portal was set up by the SOLAS project integration initiative (2007-2013) with the intention to help SOLAS scientists identify what data exist, the data originator and where the data are currently stored. The portal is hosted by NASA and the metadata files are

stored on the international standard Global Change Master Directory (GCMD). The resource is freely available to the entire community.

The SOLAS metadata portal is an on-going effort. Scientists can help expanding the SOLAS Metadatabase by completing a simple template available at <http://tinyurl.com/328zjr5> and email it to solas@geomar.de

I.e. Task teams

SOLAS/IGAC Task Team: Halogens in the Troposphere (HitT)

The primary objective of the SOLAS/IGAC Halogens in the Troposphere task team (HitT) is to determine and quantify the importance of reactive halogen compounds in tropospheric chemistry and climate forcing. The goal of HitT is to facilitate international collaboration between laboratory, field, and model activities regarding tropospheric halogen chemistry especially in the following domains: polar regions, salt lakes, marine boundary layer (both remote and coastal), volcanoes, free troposphere, and urban areas.

The co-chairs are Roland von Glasow (University of East Anglia, UK) and Ulrich Platt (University of Heidelberg, Germany).¹ In 2015, the leaders of the task team and Alfonso Saiz-Lopez (SOLAS SSC member) met at the EGU 2015 and decided to write a Perspectives document with the envisioned future for the Task, which would include some new aspects in the field that were not specifically targeted in the Task's White Paper. Work is under progress. Everyone interested by the activities of this task team can subscribe to the HitT mailing list at <http://www.hitt-task.net/>. - The EGU session 2015 "Halogens in the troposphere" was very well attended and a repeat of this session has already been approved for EGU 2016. Fall AGU in 2015 will include a session on "Wintertime Atmospheric Chemistry: emissions, dispersion, aerosols, halogens and unusual oxidants." Several other sessions at AGU will also be relevant to HitT. A workshop on "Global importance of tropospheric halogens" (main organisers Martyn Chipperfield, Leeds; Roland von Glasow, UEA); was planned for autumn 2015, but will be postponed to 2016, if new funding can be arranged.

Task Team: Asian Dust and Ocean EcoSystems (ADOES)

The goal of ADOES is to quantitatively understand the deposition flux and bioavailability of Asian dust, and its impact on biogeochemical processes and ocean ecosystem in order to provide scientific bases for the mechanism of eolian dust-ocean ecosystem-radiative gases-climate change. The co-chairs are Huiwang Gao (Ocean University of China, China), Guangyu Shi (Chinese Academy of Sciences, China) and Mitsuo Uematsu (University of Tokyo, Japan).

ADOES leaders reported on the progress of the WESTPAC ADOES Working Group (2012-2015) during the 10th Intergovernmental Session of the IOC Sub-Commission for the Western Pacific (WESTPAC-X) at Phuket, Thailand on 12-15 May 2015. The 4-yr lifetime of the working group is completed. A new working group with a new title and new terms of reference is desired, along with the recruitment of more scientists from the Southeast Asian countries on the studies of dust and smoke from forest fires and their impacts on ocean ecosystems.

¹ Update: Roland von Glasow unfortunately passed away in September 2015, so there will need to be a replacement co-chair appointed by SOLAS.

3-68

-The ADOES activity was introduced as a part of the WESTPAC posters during the 28th Session of the IOC Assembly at UNESCO Headquaters in Paris France on 18-25 June 2015. A research cruise for SOLAS and GEOTRACES was conducted around the Ryukyu Islands, including the East China Sea, by a new R/V *Shinsei Maru* (1,629 t) belonging to JAMSTEC, Japan from 25 June to 6 July 2015. Young foreign scientists (Post doc and graduate students) from South Korea, China and Brunei joined the cruise.

A research cruise for ADOES and China SOLAS was conducted from the East China coast to the Northern West Pacific by R/V *Dongfanghong* 2, lasting 40 days from March to May 2015. More than 60 young scientists joined this cruise to investigate atmospheric chemistry processes, atmospheric deposition flux and marine nitrogen cycle.

A workshop entitled “Sources, formation and deposition of particles in rural and marine atmospheres and potential climate impacts” is being held on 27-28 August 2015 in Qingdao, China. About 30 scientists from China, USA, UK and Japan were invited, and dozens of young scientists, including post-docs and graduate students, will attend. The talks will cover observation and modelling of dust aerosols, inorganic and secondary organic aerosols, cloud condensation nuclei (CCN) activity of aerosols, incubation experiments for responses of phytoplankton to elements from atmospheric deposition and primary organic aerosols from marine sources, etc.

SOLAS/IGAC Task Team: Air-Ice Chemical Interactions (AICI)

The IGAC/SOLAS Air-Ice Chemical Interactions Task Team (AICI) was created in 2003. The goal of AICI is to assess the significance of the processes observed in the polar regions at the air-ice interface at local, regional, and global scales by bringing together the laboratory, field, and modeling communities. The co-chairs of AICI are V. Faye McNeill (Columbia University, USA) and Thorsten Bartels-Rausch (Paul Scherrer Institut, Switzerland). The main activity of AICI/OASIS in 2014-2015 was the CASSII (Chemical Atmosphere-Snow-Sea Ice Interactions) workshop, which was held in Cambridge, UK in October 2014. Below is reported the write-up of this meeting published in the IGAC newsletter. The next workshop will take place in Paris, France in Spring/Summer 2016.

More than 60 scientists from 15 countries in Europe, North America and Asia gathered last October in Cambridge (UK) for a 3-day workshop on Chemical Atmosphere-Snow-Sea Ice Interactions. The meeting objectives were to discuss research status and future science priorities of a highly inter-disciplinary field of research, which is being fostered by the IGAC activities AICI (Ice Air Chemical Interactions) and OASIS (Ocean – Atmosphere – Sea Ice - Snowpack). CASSII was organized locally by the British Antarctic Survey and generously sponsored by IGAC and EGU to enable the participation of 15 early career scientists.

Within the AICI/OASIS community it is now recognized that the air-snow-sea ice system plays an important role in the global cycling of nitrogen, halogens, trace metals or carbon, including greenhouse gases (e.g. CO₂ air-sea flux), and therefore may also influence climate.

Its impact on atmospheric composition is illustrated by dramatic ozone and mercury depletion events that occur within or close to the sea ice zone (SIZ) mostly during polar spring and are catalyzed by halogens released from SIZ ice, snow or aerosol. Recent field campaigns in the

Arctic and Antarctic highlight the importance of the SIZ as a biologically active area and as a chemical reservoir and reactor, even during polar night. The growing literature on lab experiments and field studies allows to develop and improve parameterizations of processes at the snow grain or even molecular scale for use in regional or global climate models. But to date climate models with coupled snowpack or sea ice chemistry are still in their infancy. The research of the past 15 years has been reviewed recently in two AICI special issues of *Atmospheric Chemistry and Physics* (ACP 2007 & 2013).

Much progress has been achieved since the inception of OASIS in 2002. However, large uncertainties remain regarding the regional or global impacts of air-ice-ocean chemical exchange processes, e.g. their role in the natural variability of tropospheric ozone, for the surface energy budget or for cloud formation in the high latitudes. More research is needed to understand chemical species and processes involved, the role of ice microbial communities as chemical sinks or sources, as well as feedbacks with a very dynamic snow and ice environment, which is currently undergoing rapid change. For example, the sources of reactive halogens (e.g. bromine and iodine) and of their precursor species such as organic halogens are still poorly known, but are important to assess the variability of polar tropospheric ozone or quantify linkages to the formation of cloud condensation nuclei and clouds. Complex questions are impossible to answer within a single scientific discipline, hence it will be critical to better integrate the communities of atmospheric and cryospheric sciences as well as oceanography. This can be achieved for example through special sessions or town hall meetings at scientific conferences, but also by better publicizing of ongoing projects, collaboration opportunities or an “expert” directory. For further detail see the scientific program and list of attendees of CASSII at http://www.antarctica.ac.uk/about_bas/events/cassii2014/index.php.

I.f. SOLAS Open Science Conference 2015

The OSC15 will take place in Kiel, Germany at the Christian-Albrechts-Universitaet zu Kiel during the week of **7-11 September 2015**. The local organising committee (LOC) is composed of Hermann Bange (GEOMAR), Gernot Friedrichs (Univ Kiel), Christa Marandino (GEOMAR), Birgit Schneider (Univ Kiel), Emanuel Soeding (Future Ocean Cluster of Excellence Kiel) and a young post doc Jonathan Durgadoo (GEOMAR). The SOLAS OSC15 will be taking place in conjunction with two major events: (1) the SOPRAN final meeting, to take place on the Monday 7 Sept. in the afternoon; and (2) the OSC15 will be part of the Future Ocean Cluster of Excellence semester theme on “Processes at Ocean Interfaces: from science to society” of the summer 2015.

The Scientific Organising Committee is composed of the SSC and one member of the LOC. The conference website was set up on Conference Manager, a SCOR-leased tool (www.solas-int.org/osc2015.html). The registration opened on 1 Sept. 2014 and early registration closed on 1 June 2015. As of August 2015, 230 participants from 33 different countries have registered, 80% will present a poster. SCOR kindly provided a travel grant for scientists from developing countries to attend the conference; the grant was distributed to 10 scientists. The Ocean Acidification-International Coordination Centre also provided a travel grant that allowed 4 scientists from developing countries to attend.

3-70

For this edition of the OSC, SOLAS is inviting 9 keynote speakers and selected 22 other speakers from the poster abstracts pool, a strong new feature of this OSC. Among the 22 speakers, 6 are from developing countries and 11 are early career scientists. The conference scientific theme will be future-forward looking; the themes of the 8 plenary sessions are the ones forming the SOLAS 2015-2025 science plan. The plenary talks are followed by 3 to 4 parallel discussion sessions each day, which were proposed by the community and poster sessions. The full programme may be found at <https://www.confmanager.com/main.cfm?cid=2778&nid=16562> or on the conference app Whova.

As side event of the conference, a workshop for early career scientists will take place in two parts, one on the 7 Sept. and the other on 11 Sept., Seventeen early career scientists will learn how to present their research to an audience in various situations. This workshop was organized by the early career scientist from the LOC. Two addition side-events will take place on 7 Sept. in parallel to the SOPRAN final event and the ECS workshop. Representatives of international programmes with a marine component will meet and discuss potential topics needing a collaborative and integrative approach across programmes to advance. And a SOCAT/SOCOM (Surface Ocean CO₂ Atlas/Surface Ocean pCO₂ Mapping Intercomparison) workshop will take place and launch the release of the SOCAT V3. On the 11 Sept., there will be a Nordic SOLAS gathering. SOLAS also took the opportunity to organize a dinner on 8 Sept. to assemble the 17 SOLAS national representatives that will be present at the conference, to promote the role that the national representatives play and also to engage them into the implementation strategy planning of the SOLAS next phase.

After the conference, the IPO is planning to run a survey to collect the participants' comments and feedback. Short reports informing about the outcome of the parallel discussion sessions will be collected and made available on the SOLAS website.

I.g. SOLAS 2015-2025: Science Plan and Organisation

SOLAS celebrated its 10-year anniversary in 2014! The SOLAS community has accomplished a great deal towards the goals of the original Science Plan & Implementation Strategy and Mid-term Strategy as the open-access Synthesis Book on '*Ocean Atmosphere Interactions of Gases and Particles*' edited by Peter Liss and Martin Johnson highlights. But, there are still major challenges ahead that require coordinated research by ocean and atmospheric scientists. With this in mind, in 2013, SOLAS have begun an effort to define research themes of importance for SOLAS research over the next decade. These themes have become part of a new Science Plan for the next phase of SOLAS (2015-2025). SOLAS being a bottom-up organisation, a process in which community consultation played a central role, see below for details, was adopted. In December 2014, a complete version of the new Science Plan was submitted to the current SOLAS sponsors (SCOR, IGBP, WCRP and iCACGP) and also Future Earth for review. Feedback were received in June 2015, all very positive. The SOLAS SSC is currently addressing the comments in order to have the approved version of the Science Plan by the end of 2015. The draft of the new science plan submitted to the SOLAS sponsors is available at http://www.solas-int.org/about/future_solas.html.

Table of content:

Executive summary

Introduction

Science plan

Core themes

Theme 1: Greenhouse gases and the oceans

Theme 2: Air-sea interface and fluxes of mass and energy

Theme 3: Atmospheric deposition and ocean biogeochemistry

Theme 4: Interconnections between aerosols, clouds and ecosystems

Theme 5: Ocean biogeochemical control on atmospheric chemistry

Crosscutting themes

Integrated topics

SOLAS science and geoengineering

SOLAS science and society

Organisation and management

Organisation

Communication, capacity-building, and global networking

Data management

Linkages to other projects and activities

Outlook

Acronyms

Appendix

References

Details of the procedure followed to produce the new Science Plan:

- Following the SOLAS Open Science Conference 2012, where the SOLAS community met in May 2012 in Seattle, USA to share SOLAS research results, the SSC identified 8 research themes which could compose the SOLAS next phase (2015-2025).
- In Summer 2013, short White Papers on the 8 themes were written.
- In Fall 2013, an online community consultation took place, providing an opportunity to the community to share their ideas and participate early on in designing the next phase of SOLAS. The themes were presented at various venues (workshops, conferences...).
- In December 2013, a workshop was held in Plymouth, UK for early-career scientists to brainstorm and discuss the scientific scope of the next phase of SOLAS. Shortly after the workshop, the participants delivered a detailed document summarising their discussions with the goal to advise the SSC.
- In January 2014, a workshop took place in Galway, Ireland with some SSC members with the aim to take into consideration the inputs from the community consultation and the advising document from the early-career scientists' workshop. The scientific themes of the SOLAS next phase were revised and refined. The scientific scope is divided into five themes, and two sections, one describing the interconnected nature of the five themes as integrated topics and one highlighting the societal relevance of SOLAS science.

3-72

- In July 2014, following the 14th SOLAS SSC meeting in Israel, a draft of the Science Plan of the next SOLAS phase (2015-2025) was circulated to a large number of SOLAS engaged scientists, the SOLAS national representatives for example, for review.
- Over summer 2014, the SSC took the numerous reviews into account and delivered in fall/winter 2014 the final version of the plan.

I.h. Engagement with Future Earth: Research for Global Sustainability

Since the Future Earth interim Secretariat was opened, SOLAS has had regular communication with the officers on various topics. The communication continues now that the permanent Secretariat is in place. Also, communication is regular with Corinne Le Quéré, Future Earth Science Committee member, via Skype. The SOLAS Chair and the Future Earth Executive Director Paul Shrivastava have met on a couple of occasions. SOLAS continues to contribute to various structural documents of Future Earth, lately on the Knowledge Action Network and, in particular, the Ocean one.

In December 2014, SOLAS submitted to Future Earth its transition statement in order to get co-sponsored. In April 2015, SOLAS received the reviews from Future Earth and addressed them in May. In June 2015, SOLAS was informed by Future Earth that the application has been approved and that the Memorandum of Understanding is about to be signed. As per August 2015, SOLAS has not yet signed the MoU.²

I.i. Possible topics across projects/programmes with a marine component for co-design and co-production of knowledge in marine sciences

A meeting took place in March 2015, co-organised by SCOR in Kiel, Germany, where SCOR projects (IMBER, SOLAS) and others (IOCCP, PAGES, CLIVAR) met to discuss about the position of marine sciences in the context of the Sustainable Development Goals, Future Earth etc. Following that meeting, SOLAS started an effort to develop cross-projects topics. In April 2015, at the IGBP SC meeting in Vienna, SOLAS, IMBER, LOICZ, IGAC and PAGES agreed to a small number of potential topics; these were sent with some descriptive paragraphs to Future Earth projects or soon to be with a marine component for addition and development. More recently, this document was sent to other relevant international programmes, such as GESAMP, WCRP, CliC, GEOTRACES, ecoSERVICES etc. On 7 September 2015, some representatives of programmes will meet for an afternoon discussion on this subject to design the way forward.

As of August 2015, the document is a draft and a non-exhaustive list of possible topics for co-design and co-production of knowledge in marine sciences. The ultimate intention of this document is to foster interactions between international projects on co-designed and co-produced knowledge in marine sciences.

²Update: The MoU was signed at the 2015 SOLAS SSC in September 2015

The topics listed so far include the following:

- Extreme events in EBUS
- Atmospheric chemistry services
- Changes in the Arctic: threat or opportunity
- Environmental risk from deep-sea mining
- Conservation of reef fishes and sustainable co-management of inshore small-scale fisheries

II. Activities (including capacity building) and publications that resulted from the project's work since the previous year's report

II.a. International SOLAS Summer School

The SOLAS International Summer School is a biennial, two-week program designed to immerse early-career scientists in SOLAS sciences and provide them with the skills necessary for their future scientific careers. SOLAS believes that by providing excellent training, it adequately prepares these future scientists to contribute to the understanding of global change and its significant environmental and societal challenges. Since 2003, SOLAS offered 6 Summer Schools, 5 in Cargese, Corsica and the most recent one in 2013 in Xiamen, China. Despite the success of the schools and the frequent requests of information on the next edition of the school, there is no plan underway for another school. This was prevented by the clash created by the SOLAS Open Science Conference 2015 in Kiel, location of the IPO and the uncertainty until recently of the future of the IPO in GEOMAR beyond 2015. However, a new location has been investigated: Cape Verde, in particular the INDP and Ocean Observatory in Mindelo.

II.b. SOLAS synthesis paper in Anthropocene

SOLAS has submitted a paper to contribute to the IGBP synthesis effort to the journal *Anthropocene* in May 2015, after almost 2 years of drafting. Five major achievements have been reported in the short paper: Authors are Emilie Brévière, Dorothee Bakker, Hermann Bange, Timothy Bates, Thomas Bell, Philip Boyd, Robert Duce, Véronique Garçon, Martin Johnson, Cliff Law, Christa Marandino, Are Olsen, Birgit Quack, Patricia Quinn, Christopher Sabine, and Eric Saltzman. This article should be published in time for the IGBP final event at the AGU Fall Meeting in December 2015 in San Francisco, USA. The abstract follows:

The domain of the surface ocean and lower atmosphere is a complex, highly dynamic component of the Earth system. Better understanding of the physics and biogeochemistry of the air-sea interface and the processes that control the exchange of mass and energy across that boundary define the scope of the Surface Ocean-Lower Atmosphere Study (SOLAS) project. The scientific questions driving SOLAS research, as laid out in the SOLAS Science Plan and Implementation Strategy for the period 2004-2014, are highly challenging, inherently multidisciplinary and broad. During that decade, SOLAS has significantly advanced our knowledge. Discoveries related to the physics of exchange, global trace gas budgets and atmospheric chemistry, the CLAW hypothesis (named after its authors, Charlson, Lovelock, Andreae and Warren), and the influence of nutrients and ocean productivity on important biogeochemical cycles, have substantially changed our views of how the Earth system works and revealed knowledge gaps in

our understanding. As such SOLAS has been instrumental in contributing to the International Geosphere Biosphere Programme mission of identification and assessment of risks posed to society and ecosystems by major changes in the Earth's biological, chemical and physical cycles and processes during the Anthropocene epoch. SOLAS is a bottom-up organization, whose scientific priorities evolve in response to scientific developments and community needs, leading to the decision to launch a new 10-year phase. SOLAS (2015-2025) will focus on five core science themes that will provide a scientific basis for understanding and projecting future environmental change and for developing tools to inform societal decision-making.

II.c. IGBP landmark synthesis event at AGU Fall Meeting 2015

IGBP, one of the SOLAS sponsors, will come to a close at the end of 2015. To celebrate its scientific and institutional legacy, in particular to Future Earth, IGBP will hold a series of scientific sessions and other events at the Fall Meeting of the American Geophysical Union (AGU) in San Francisco, USA.

The IGBP event at AGU has three aims: (a) present and discuss the results of IGBP's final synthesis; (b) reflect on IGBP's science and policy legacy, and (c) mark the transition of its community to Future Earth. The activities will include trans-disciplinary and crosscutting scientific sessions, an early-career scientists' gathering (in collaboration with Future Earth), and an evening reception to celebrate the programme's legacy. IGBP is co-sponsoring over 60 scientific sessions covering a range of topics. SOLAS initiated and proposed sessions, also contributed to the planning of the other parts of the events. SOLAS will be present at the IGBP Landmark Synthesis event.

II.d. Future Earth cluster activity

SOLAS is involved in the Future Earth Cluster activity: ArcticSTAR Initiative: Solution-oriented, TrAnsdisciplinary Research for a Sustainable Arctic, Faye McNeill from Columbia University is lead scientist. This cluster brings together several existing communities of Arctic researchers from the natural and social sciences to develop a plan for how Arctic issues, specifically those related to global environmental change and considered priorities by Arctic communities, should be addressed through Future Earth. The breadth and scope of issues linked to environmental change in the Arctic cannot be addressed by any one disciplinary approach, any one nation or programme, or without the active engagement and participation of Northern people. Bringing together Arctic researchers and stake- and rights-holders to share ideas, facilitate collaboration across disciplinary and national boundaries, and co-design and co-produce knowledge is critical to addressing the key scientific and societal challenges posed by environmental change in the Arctic. The overarching goal is to enable a solution-oriented, transdisciplinary approach to Arctic research that will provide critical knowledge regarding how the Arctic region is changing, how these changes impact the diversity of life, human systems and governance in the Arctic and beyond, and how Arctic societies may prepare for and respond to these changes.

ArcticSTAR is the result of a preliminary effort, funded by Future Earth in 2014, which brought together three proposal teams from the 2014 Future Earth call for proposals: 'International, Interdisciplinary Polar Science Network' (PI: V. Faye McNeill), 'Circumpolar Arctic Coastal Communities Observatory Network (CACCON)' (PI: Don Forbes), and 'Arctic Coastal

Governance in a Global Context: Knowledge, Learning, and Multi-Level Decision Making' (PI: Ilan Chabay). The three original proposal teams represent a coalition of existing international, multidisciplinary research networks and communities representing thousands of researchers working on Arctic matters. These groups have ongoing engagement with Arctic residents, Inuit organisations such as Inuit Circumpolar Council Alaska and Canada (ICCA, ICC) and Inuit Tapiriit Kanatami Canada (ITK), as well as the Russian Association of Indigenous Peoples.

II.e. Collaboration with ESA

The OceanFlux project series aimed at reinforcing the scientific collaboration between ESA and SOLAS. The overall project objective was twofold: (1) Support the development of novel products and enhanced EO-based observations responding to the needs of the SOLAS community and (2) Advance in the integration of EO-based products, in-situ data and models in order to contribute to SOLAS major scientific gaps. Three projects have been identified and were carried out (2011-2013):

1. OceanFlux GHG, <http://www.oceanflux-ghg.org>
2. OceanFlux Upwelling, <http://upwelling.eu/>
3. OceanFlux SSA, <http://oceanflux.fmi.fi>

ESA is very interested in continuing the collaboration with SOLAS, though additional funding depends on its budget. In order to continue collaboration and identify the areas of common interest, ESA, EGU and SOLAS organised a topical conference on "Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS". The conference was held in Frascati (Rome), Italy on 28-31 October 2014. This joint ESA-EGU-SOLAS Conference brought together the Earth observation and SOLAS communities, as well as scientific institutions and space agencies involved in the observation, characterisation and forecasting of ocean-atmosphere interactions and their impacts. A detailed report has been written and is now being revised by SOLAS. This report should serve as a basis for a synthesis document ESA-SOLAS Earth Observations and SOLAS science priorities that ESA would like to submit to their programmatic review in October 2015.

II.f. Collaboration with PICES

The North Pacific Marine Science Organization (PICES; <http://www.pices.int>) is an intergovernmental scientific organization with the mandate to promote and coordinate marine research in the northern North Pacific and adjacent seas. The present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America.

A ½-day workshop took place on 17-26 Oct 2014 in Korea on “SOLAS into the future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program” at the PICES annual meeting 2014 “Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future”. The workshop was proposed and run by Lisa Miller, Minhan Dai and Yukihiro Nojiri. The history of SOLAS, from the 1990s, was reviewed, as well as the activities of the 1st phase of SOLAS. Lower atmospheric aerosol sciences, iron fertilization experiments, and the establishment of the ocean surface pCO₂ database were highlighted.

3-76

The five themes, their key questions, and cross-cutting issues of the proposed new SOLAS science plan were introduced. A lot of the discussion was centered on ocean observatories and automated monitoring systems, which includes substantial needs for technological developments.

Lisa Miller is also representing SOLAS at key meetings of the PICES Annual Meeting. After the last Annual PICES Meeting in 2014 in Korea, Lisa reported that the new PICES executive secretary, Robin Brown, expressed curiosity about Future Earth, noting that on the surface, they appear to be a good fit for PICES, but how that would actually happen is unclear. As an intergovernmental organization dedicated to marine science, PICES may make a good partner for SOLAS in trying to find ways to explore Future Earth's co-design precepts.

Ocean observatories: Quite a bit of discussion is also surfacing in PICES about ocean observatories, and this may be another useful place for future collaborations between PICES and SOLAS. In particular, several PICES scientists are focussing on developing observatories able to continue functioning during typhoons. The Korea Institute of Ocean Science and Technology is working on a robust wave glider and a bottom-mounted cabled observatory developed by the Okinawa Institute of Science and Technology (<http://otc.oist.jp/equipment/observatory.html>) has successfully collected data throughout a typhoon off Okinawa, identifying unexpected covariations between physical and biogeochemical parameters, with profound implications for SOLAS science.

Section on Carbon and Climate (S-CC): The S-CC has begun compiling regional ocean acidification 'outlooks', for critical areas around the Pacific. Draft reports are expected to be ready for this year's annual PICES meeting, in October, and a special topic session on ocean acidification trends is being planned for the 2016 PICES meeting in San Diego. It may make sense for SOLAS to co-sponsor that session.

A surface nutrient data synthesis is being planned for some time after 2016. This is being led by Tsuneao Ono of the National Research Institute of Fisheries Science of Japan.

Leticia Cotrim Da Cunha, SOLAS Brazil national representative and colleagues from Latin American countries submitted a proposal to run a one-day workshop on SOLAS jointly with BROA (Brazilian Research on Ocean Acidification) at the PICES Climate Change Symposium 2015 in Santos, Brazil, on 23-27 March 2015. The joint workshop (W2/W6) combined invited talks by Silvana Birchenough (Cefas, UK), Rosane G. Ito (Federal University of Rio Grande, Brazil), Christian Vargas (Universidad de Concepción, Chile), and Arne Körtzinger (GEOMAR Helmholtz Centre for Ocean Research, Germany), along with other selected talks and breakout group discussions corresponding to the main BrOA network and SOLAS topics. Most of the participants were directly involved with different Ocean Acidification issues (bioassays, paleoclimate, biogeochemistry). Participants came mostly from Brazil but also from France, United Kingdom, Monaco, Germany, USA, Chile, and Portugal, and actively participated to the discussions. During the breakout discussion session, participants agreed on the need to push a common activity such as creating the Latin American OA network (LAOCA). As there was a strong OA community, it was a unanimous idea that there is a need of a common ground on standardization of methods and data management. The need to use new technologies on sensors and platforms was also agreed. Thus, it was suggested that training workshops involving

emerging research groups could be done, such as training courses focusing on standardization of procedures and new technologies for marine CO₂-system measurements. One of the ideas was to suggest the SOLAS International Project Office to have its next Summer School focusing on CO₂-system measurements, including new technologies for autonomous sensors.

A more detailed report is available in the Summer PICES Newsletter p8 at:

https://www.pices.int/publications/pices_press/volume23/PPJuly2015.pdf.

SOLAS supported partially 7 early-career scientists to attend the symposium in Santos, Brazil.

The 24th PICES Annual Meeting (PICES-2015) will be held on 14-25 October 2015, in Qingdao, China, under the theme Change and Sustainability of the North Pacific. Unfortunately, the budget of SOLAS does not allow to support participation or to have a SOLAS representative at the PICES annual meeting.

II.g. SOLAS France day workshop

SOLAS Scientists in France organized a one-day workshop, on 29 June 2015 in Paris, France. SOLAS scientists (established and younger) from French institutes from Paris, Toulouse, Marseille, Brest, Nice, Lyon and Lille, shared results and knowledge, with the ultimate goal to determine how SOLAS France can contribute to the next phase of SOLAS. Nineteen presentations were given; most of the talks are available at <http://solas.ipgp.fr>. Dr Sandrine Paillard, Future Earth, Paris global hub, made a presentation on Future Earth 2025 vision and scope and latest developments.

II.h. SOLAS communication

SOLAS website: <http://www.solas-int.org/>

SOLASNews newsletter (NL) emailed to ~2200 scientists and airmailed to ~100 scientists, mainly from developing countries. Copies are held by the SOLAS IPO for distribution at SOLAS-relevant conferences and meetings. The NL is also available from the SOLAS website. The SOLAS News is printed and airmailed from China courtesy of State Key Laboratory of Marine Environment Science, Xiamen University. Since issue 11, SOLAS also implemented an on-screen reader pdf version. Issue 17 (May 2015) proposed articles that introduced the topics and/or keynote speakers of the SOLAS Open Science Conference 2015 and some updates of partners' projects.

E-bulletins are sent to more than 2,200 SOLAS scientists roughly 10 times per year and previous issues are archived on the website at <http://www.solas-int.org/archive.html>. The bulletins contain news from SOLAS, opportunities for meetings, abstract submission deadlines, recent publications, vacancies and news from relevant partner project and collaborators.

Flyers. The IPO has created an A5 flyer, with the support of the IGBP designer Hilarie Cutler and the funding from the French CNRS/INSU. The flyer informs on the outline of the new science plan. The flyer has not been circulated yet.

3-78

II.i. SOLAS national networks

Twenty-nine nations are part of the SOLAS network. Each has a representative:

Australia: Sarah Lawson and Andrew Bowie	Japan: Mitsuo Uematsu
Belgium: Nathalie Gypens (NEW)	Korea: Kitack Lee
Brazil: Leticia Cotrim Da Cunha	Mexico: Jose Martin Hernandez
Canada: Maurice Levasseur	Ayon
Chile: Laura Farias	Netherlands: Jacqueline Stefels
China (Beijing): Minhan Dai	New Zealand: Cliff Law
China (Taipei): Gwo-Ching Gong	Norway: Siv Lauvset
Denmark: Lise Lotte Soerensen and Mikael Sejr	Peru: Michelle Graco
France: Remi Losno	Poland: Timo Zielinski
Germany: Hermann Bange and Ulrich Platt	Russia: Sergey Gulev
India: VVSS Sarma (NEW)	Spain: Alfonso Saiz-Lopez (NEW)
Ireland: Brian Ward	Southern Africa: Carl Palmer
Italy: Chiara Santinelli	Sweden: Katarina Abrahamsson
Finland: Gerrit de Leeuw	Turkey: Baris Saglioglu and Mustafa Koçak
	UK: Tom Bell
	USA: Bill Miller ³

Implemented in Jan. 2009, the national representatives of the SOLAS nations are asked to report annually about the SOLAS activities in their country. To facilitate the reporting effort, a template form is provided. In January 2015, 19 reports were received and posted on the SOLAS website. The information contained in the reports has been a great source of information for the IPO to report to sponsors, but also to facilitate the coordination job and to redistribute the results and progress from some nations to the rest of the SOLAS community via the Newsletters and the website. All the reports received during the reporting period are available in an Addendum to this report (posted on the SCOR meeting page at http://scor-int.org/SCOR_EC_2015.html).

II.j. Endorsed projects

Over the reporting period, SOLAS endorsed the project AIR-SEA LAB. Information about support letter and endorsement are accessible on the website, along with the endorsement submission form.

III. Income and expenses for the past year and budget for the coming year, including funding from all sources (not only SCOR funding)

III.a. SOLAS International Project Office, Kiel

The SOLAS IPO is hosted at the GEOMAR Helmholtz-Centre for Ocean Research Kiel in Kiel, Germany. The office is currently staffed with the executive officer, Dr. Emilie Brévière and the project officer, Stefan Kontradowitz. GEOMAR provides office space and funds the executive officer salary since 1st February 2011 until August 2016. The project officer salary is supported

³ Bill Miller is in the process of being replaced as U.S. representative because he is serving in a rotator position at the U.S. National Science Foundation.

since 1 February 2013 by the German Ministry of Education and Research (BMBF) via the German national SOLAS project ‘SOPRAN’ Phase 3 until January 2016. The IPO has benefiting since mid-March 2014 from a master student help for the OSC2015 (38 hours per month) funded by BMBF until Sept 2015.

In Spring/summer 2015, GEOMAR confirmed that it will provide office space and the salary of the executive officer, Dr. Emilie Brévière until 2020, however GEOMAR informed that it won’t be able to take over SOPRAN once it is ending (Jan 2016), the salary of the project officer, Stefan Kontradowitz. As per today unfortunately, no other promising avenue is being investigated.

3.5 International Quiet Ocean Experiment

Shapovalov

2015 Annual Report International Quiet Ocean Experiment

The Science Plan of the International Quiet Ocean Experiment was approved by both SCOR and the Partnership for Observation of the Global Oceans (POGO) since the 2014 SCOR General Meeting. The plan was published and distributed in mid-2015. The editors of the plan were Peter Tyack (Univ. of St. Andrews), George Frisk (Florida Atlantic Univ. and Woods Hole

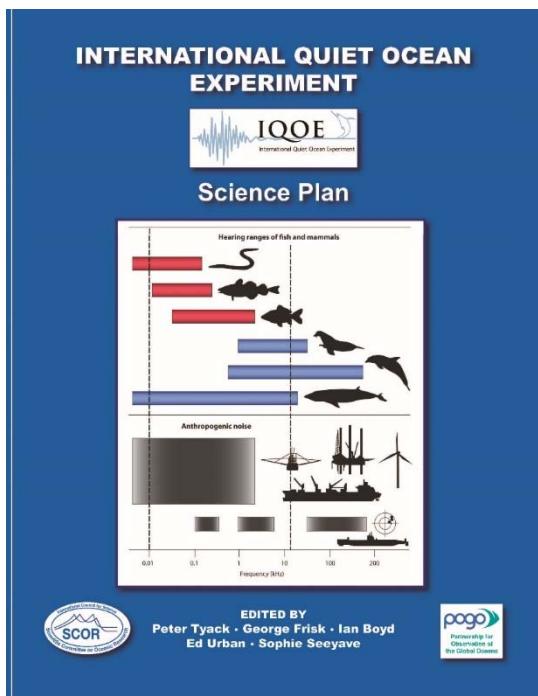
Oceanographic Institution), Ian Boyd (Univ. of St. Andrews), Ed Urban (SCOR), and Sophie Seeyave (POGO). The document is based on an open science meeting hosted by IOC in Paris in 2012. The IQOE Science Plan is available at http://www.scor-int.org/IQOE/IQOE_Science_Plan-Final.pdf.

Since publication of the plan, the editors of the plan and financial sponsors have been working to establish a foundation of implementation activities.

Funding: SCOR budgeted US\$10,000 for IQOE implementation activities in 2015. A small portion of this amount has been used for printing expenses. Additional amounts were used to partially support a meeting of editors and sponsors in Woods Hole, Massachusetts, USA and for a meeting on 29-30 September 2015 in Washington, DC with project stakeholders. An additional US\$90,000 per year for three years have been committed from Monmouth

University and Rockefeller University. POGO will provide 10,000 euro for an activity called “Implementing IQOE Science Recommendations on Marine Noise Exposure and Broad-Scale Acoustic Monitoring.” Funding for a second year will be contingent on demonstrated progress in achieving the milestones listed in the project proposal. Funding will continue to be sought from other sources to support an IQOE International Project Office (IPO) and IQOE activities. For example, a proposal has been submitted to NERC (UK) for support of an IPO at St. Andrews. Decisions about this support should be made by the end of 2015.

Meetings: IQOE was represented by Peter Tyack at the 2015 Annual POGO meeting in January in Tenerife, Spain. POGO approved IQOE as a POGO project at that meeting. IQOE was represented Jennifer Miklas-Olds of Pennsylvania State University at International Hydroacoustics Workshop 2015 in Vienna, Austria on 29-30 June. A meeting was hosted by Jesse Ausubel in Woods Hole, Massachusetts, USA on 8-9 July to plan the initial phases of IQOE implementation. This phase will begin by identifying databases of acoustic data that could be made publicly available and discussion of potential members of the inaugural IQOE Steering Committee. IQOE will work at the intersection of scientific research, ocean observations,



industrial and naval activities, and environmental concerns, so much foundational work will need to be devoted to creating liaisons between IQOE and a wide variety of organizations.

Steering Committee: The editors of the Science Plan and IQOE sponsors put together a long list of potential IQOE SC members, from which a balanced list of potential SC members has been compiled. We are in the process of contacting the potential members to determine their willingness to serve on the SC and will submit a nomination memo to SCOR and POGO in the near future. We will aim to have the first SC meeting early in 2016. SCOR and POGO linkages will be sought in relation to all IQOE committees and activities.

Outreach: The successful launch of IQOE will depend on effective outreach to the scientific community, the potentially affected providers of acoustic data (CTBTO, industry, and navies), and sectors with an interest in appropriate regulation of sound in the ocean (industry, navies, environmental NGOs, the public). Each of these audiences will be most effectively reached by outreach tailored to their interests. It will be important to continue to stress that information produced by IQOE will not only result in better protection for marine organisms, but also will benefit sound producers as regulations and government decisions will be based on better information.

An IQOE Web site has been developed with basic information about the project (see www.iqoe.org). The site includes information about the development of the project, products that have resulted, people who have been involved, and resources for the community, such as links to relevant programs.

The IQOE Science Plan has been distributed to the scientific community. However, it was decided that a different kind of document about IQOE should be developed for industry and navies, who might perceive the science of IQOE as being designed to create stricter regulations, which is not the purpose of IQOE.

A PowerPoint slide deck has been developed for use by IQOE “ambassadors”.

Jesse Ausubel will be delivering the 35th Annual Michelson Lecture on 15 October 2015 at the U.S. Naval Academy in Annapolis, Maryland (see <http://www.usna.edu/NewsCenter/2015/09/jesse-ausubel-to-deliver-naval-academy-s-35th-annual-michelson-lecture.php>). Ausubel’s lecture will be on “Ocean Past, Ocean Future: Reflections on the Shift from the 19th to 21st Century Ocean” and will focus on sound in the ocean, including information about IQOE.

We look forward to reporting progress and getting feedback from the SCOR annual meeting in Goa, India in December 2015 and the POGO annual meeting in Yokohama, Japan in January 2016.

Submitted by

Ed Urban, SCOR Executive Director, and Sophie Seeyave, POGO Executive Director

3.6 Second International Indian Ocean Expedition

Hood, D'Adamo, Burkill

SCOR, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the Indian Ocean Global Ocean Observing System (IO-GOOS) continue to work toward launch of the Second International Indian Ocean Expedition (IIOE-2) on 4 December 2015.

IIOE-2 Science Plan: SCOR took the lead on developing the IIOE-2 Science Plan, with the work carried out by a committee led by Raleigh Hood (USA). The IIOE-2 Science Plan was accepted by the SCOR Executive Committee in mid-2015 and adopted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO at its 2015 General Assembly in June 2015. Raleigh Hood and Ed Urban are working on gathering permissions to reprint figures in the plan and high-resolution figures for the document. Several of the figures have been re-drawn by a graphic artist, who is also doing the formatting for the report. Copies of the report will be printed by the time of the Indian Ocean symposium in Goa, India on 30 Nov.-4 Dec. 2015.

IIOE-2 Implementation Plan: IOC is taking the lead on creating the IIOE-2 Implementation Plan, which is also planned to be completed by the time of the Indian Ocean symposium. The work is being done through the IOC Interim Planning Committee (IPC), which is chaired by Satheesh Shenoi, who is a SCOR Nominated Member from India. Peter Burkill and Raleigh Hood are IPC members. SCOR has committed to working to help specifically with two of the themes of the Implementation Plan, related to science and capacity development.

Launch of the IIOE-2: The official launch of the IIOE-2 will take place on 4 December 2015, with a formal ceremony at Goa, India, at the end of the Indian Ocean symposium. The first cruise of the IIOE-2 will depart from Goa on that day, headed from Goa to Mauritius, on board the ORV *Sagar Nidhi*. The cruise will include significant participation of non-Indian scientists.

Town Hall Session at Ocean Sciences 2016: A Town Hall session has been proposed at Ocean Sciences 2016, led by Raleigh Hood, to update the international ocean science community about the status and progress of the project.

National IIOE-2 Committees: SCOR is encouraging the formation of national IIOE-2 committees, to coordinate national research in the Indian Ocean and promote increased funding for such work. National contributions will provide a strong foundation for the IIOE-2. Although not all these countries have formed a national committee, they have submitted abstracts for a plenary session on national IIOE-2 plans at the Indian Ocean symposium: Australia, China, Germany, India, Indonesia, Italy, Japan, Norway, and the UK. The U.S. IIOE-2 Committee held its first conference call on 1 October to organize its work.