

3.0 LARGE-SCALE OCEAN RESEARCH PROJECTS

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3.1 GEOTRACES

Devey

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: Andrew Bowie (Australia) and Phoebe Lam (USA)

Other Members: Eric Achterberg (Germany), Adrian Burd (USA), Zanna Chase (Australia), Jay Cullen (Canada), Susanne Fietz (South Africa), Tina van de Flierdt (UK), Vanessa Hatje (Brazil), Marina Kravchishina (Russia), Rob Middag (The Netherlands), Hajime Obata (Japan), Haojia Abby Ren (China-Taipei), Yeala Shaked (Israel), Kazuyo Tachikawa (France), Antonio Tovar-Sanchez (Spain), And Liping Zhou (China-Beijing)

Ex Officio Members:

Maeve Lohan (UK), Co-Chair of the Standards and Intercalibration Committee
Walter Geibert (Germany), Co-Chair of the Standards and Intercalibration Committee
Alessandro Tagliabue (UK), Co-Chair of the Data Management Committee
William Landing (USA), Co-Chair of the Data Management Committee

IPO Executive Officer: Elena Masferrer Dodas

IPO Science Director: Catherine Jeandel

Executive Committee Reporter: Colin Devey

**GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2017/2018**

May 1, 2017 to March 30, 2018

1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs

Andrew Bowie, Australia
Phoebe Lam, USA

Members

Eric Achterberg, Germany
Adrian Burd, USA
Zanna Chase, Australia
Jay T. Cullen, Canada
Susanne Fietz, South Africa
Tina van de Flierdt, UK
Vanessa Hatje, Brazil
Marina Kravishina, Russia

Rob Middag, Netherlands
Hajime Obata, Japan
Haojia (Abby) Ren, China-Taipei
Yeala Shaked, Israel
Kazuyo Tachikawa, France
Antonio Tovar-Sanchez, Spain
Liping Zhou, China-Beijing

The SSC membership (listed above) includes scientists from 15 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; internal cycles of the elements in the oceans; 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

The GEOTRACES programme is enjoying a very successful implementation, with 105 cruises completed, 935 peer-review publications published and its second Intermediate Data Product released in August 2017.

2.1 Status of GEOTRACES field programme

The GEOTRACES field programme is progressing excellently. Overall, 105 cruises have been completed (this included 11 International Polar Year cruises).

During the past year (1 May 2017 to 30 March 2018), 10 cruises were completed. This includes three new section cruises, one by Australia in the Southern Ocean, one by Japan in the Pacific Ocean, and one from the United Kingdom in the Atlantic Ocean (Figure 1). In addition, 6

process studies (with a total of 7 cruises) were completed by Brazil, Canada France, Netherlands, South Africa and the UK.

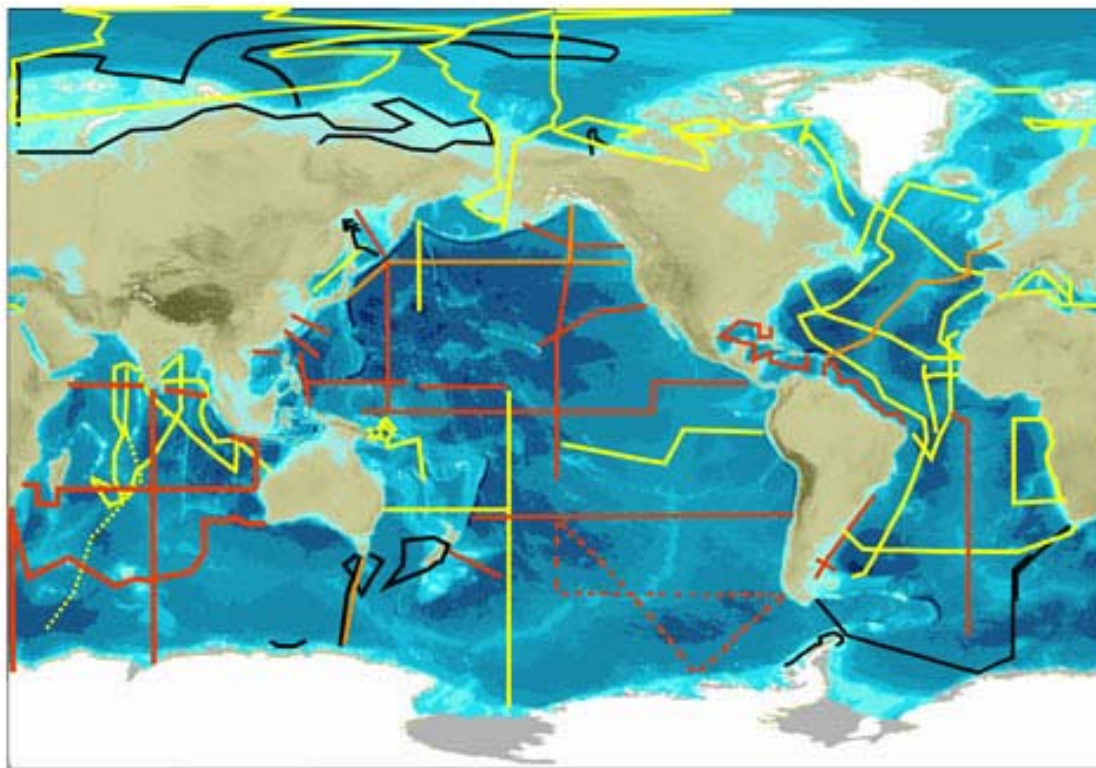


Figure 1. Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past year. 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 Products

Release of GEOTRACES Intermediate Data Product 2017

The second GEOTRACES Intermediate Data Product (IDP2017) was successfully released on 16 August 2017 at the Goldschmidt 2017 Conference in Paris (France). More than 350 persons attended the launch event (Figures 2 and 3).

The new product includes hydrographical and biogeochemical data from 41 cruises (1,866 stations) across all five ocean basins. More than 325 scientists from 22 countries have contributed data from 51,005 samples to the product. In total 470 parameters are included in the new product, ranging across micronutrients, contaminants, and radioactive and stable isotopes of trace elements. An exciting new feature compared with the first data product, released in 2014, is that the 2017 IDP also includes biological, aerosols, and rain parameters.

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The IDP consist of two parts:

The **digital data** (available at www.bodc.ac.uk/geotraces/data/idp2017/) contains hydrographic and biogeochemical data from more than 1,800 stations from 39 cruises. The data covers the global ocean, with the data density being highest in the Atlantic Ocean.

A new feature of the IDP2017 is that it offers a new user-friendly on-line interface **webODV** that allows selecting and downloading subsets of digital data. This new interface was developed by Reiner Schlitzer and Sebastian Mieruch (AWI, Bremerhaven, Germany) and it is available here: <https://webodv.awi.de/geotraces>

The **eGEOTRACES Electronic Atlas** (available at www.egeotraces.org) is based on the digital data package and provides section plots and animated 3D scenes for many of the parameters, allowing quick overviews of the occurrence of geochemically relevant tracers. It includes 590 section plots and 130 animated 3D scenes.



Figures 2 and 3. GEOTRACES Intermediate Data Product release event at Goldschmidt 2017.

IDP2017 version 2

A corrected and updated version of the GEOTRACES Intermediate Data Product 2017 (IDP2017v2) was made available in February 2018 during a Town Hall event at the 2018 Ocean Sciences Meeting. A document describing the main revisions made is available here: http://www.geotraces.org/images/stories/geotraces/idp/IDP2017_V2_CHANGES.pdf

IDP2017 publication

A publication describing IDP2017 has been submitted and accepted by the journal *Chemical Geology*:

Schlitzer, R., et al., The GEOTRACES Intermediate Data Product 2017, *Chemical Geology*, in press.

Acknowledgments

The IDP2017 is the result of a truly international effort involving 326 researchers from 22 countries and the giant work of a core group of about 15 persons, including members of the GEOTRACES Standards and Intercalibration Committee, the GEOTRACES Data Assembly Centre, the Data Management Committee, the International Project Office under the leadership of Reiner Schlitzer (AWI, Germany) and Bob Anderson (Lamont, NY, USA). Special thanks to all of them.

Intermediate Data Product download statistics

Overall, the GEOTRACES Intermediate Data Products have been downloaded more than 2,000 times (as of April 2018). That is, the IDP2017 has been downloaded more than 600 times since its release in August 2017, while the IDP2014 has been downloaded 1,451 times since its release in February 2014.

2.3 GEOTRACES Publications

During the reporting period, 117 new peer-reviewed papers have been published. In total, the GEOTRACES peer-reviewed papers database includes 935 papers.

It is important to highlight that an on-line search tool functionality has been added to the GEOTRACES publication database. This new feature allows for simple searches (e.g., author, title or journal), but it also allows for more GEOTRACES-specific searches such as by GEOTRACES cruise or GEOTRACES parameter (please see the International Project Office report below for further details on this new functionality).

Publicity articles to promote GEOTRACES continue to be published nationally and internationally. The complete list of promotional articles is available here:

<http://www.geotraces.org/outreach/publicity-documents>

For complete information about GEOTRACES publications please check the following web pages:

- GEOTRACES peer-reviewed papers database: <http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>
- GEOTRACES special issues: <http://www.geotraces.org/library-88/scientific-publications/geotraces-special-issues>

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2.4 GEOTRACES Science highlights

The GEOTRACES International Project Office regularly edits highlights of published articles, which are posted on the website (<http://www.geotraces.org/science/science-highlight>) and in the electronic newsletter (<http://www.geotraces.org/outreach/geotraces-enewsletter>). Among the numerous highlights published since last year's report, we selected the following five:

Climate change-induced spectacular increase of the land-ocean inputs in the Arctic Ocean

Measurements of radium-228 (^{228}Ra) in the framework of the 2015 U.S. GEOTRACES Arctic Transect (GN01), revealed that the surface water content of this tracer has almost doubled over the last decade, specifically in the Transpolar Drift near the North Pole.

Radium isotopes are excellent tracers of land-ocean inputs. A mass balance model for ^{228}Ra allowed Kipp and co-workers (2018, see reference below) to suggest that this increase is due to an intensification of shelf-derived material inputs to the central basin (Figure 4). These coastal changes, in turn, could also be delivering more nutrients, carbon, and other chemicals into the Arctic Ocean and lead to dramatic impacts on Arctic food webs and animal populations.

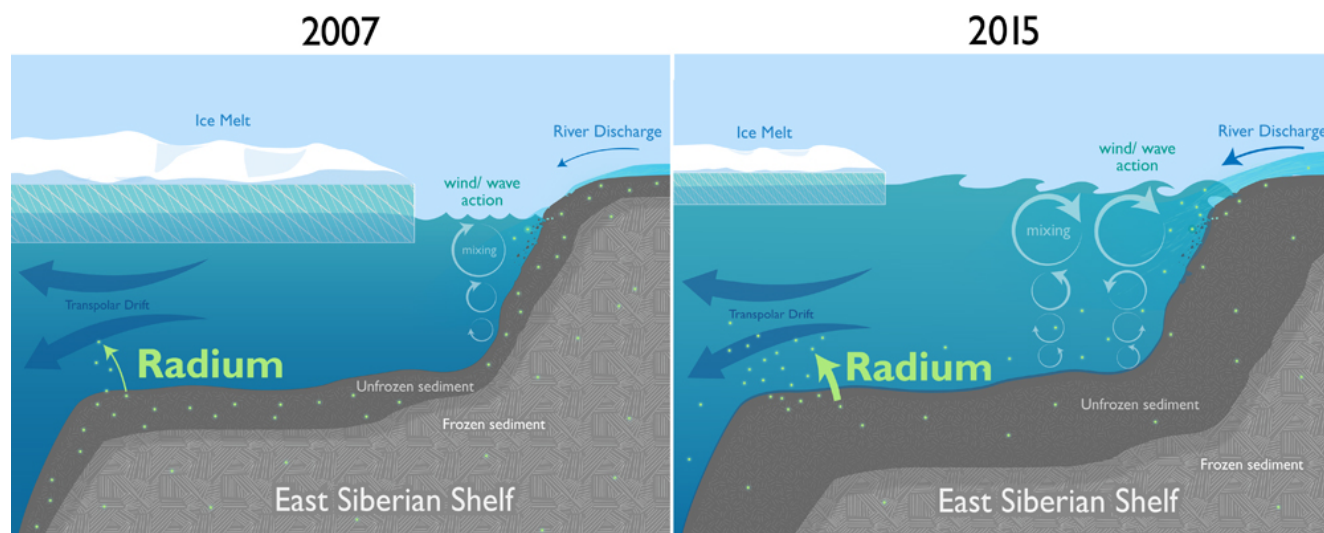


Figure 4. Diminishing sea ice near the Arctic coast leaves more open water near the coast for winds to create waves. The increased wave action stirs up sediments on shallow continental shelves, releasing radium and other chemicals that are carried up to the surface and swept away into the open ocean by currents such as the Transpolar Drift. Artwork: Natalie Renier, Woods Hole Oceanographic Institution.

Reference:

Kipp, L. E., Charette, M. A., Moore, W. S., Henderson, P. B., & Rigor, I. G. (2018). Increased fluxes of shelf-derived materials to the central Arctic Ocean. *Science Advances*, 4(1), eaao1302. DOI: <http://doi.org/10.1126/sciadv.aao1302>

Barium isotope measurements help constraining the oceanic barium cycle

Hsieh and Henderson (2017, see reference below) propose a compilation of the oceanic barium (Ba) concentrations together with its isotopic profiles measured so far. Their review covers the main oceanic basins, comparing data obtained in the North and South Atlantic, North Pacific and the Southern oceans.

Their main conclusions are that near-surface Ba isotope values are controlled by basin-scale balances rather than by regional or short-term processes; isotopic Ba fractionation during its removal from the surface is significant: the global Ba isotope data can be fit by mixing and removal/addition of Ba with a single isotope fractionation of 1.00058 ± 0.00010 ; the resulting Ba isotope composition of the upper ocean waters is correlated with the fraction of Ba utilization at the basin scale; and in the deep waters, it is suspected that external inputs of Ba (released by sediments or hydrothermal sources) can be traced by their specific isotopic signatures. See Figure 5 below.

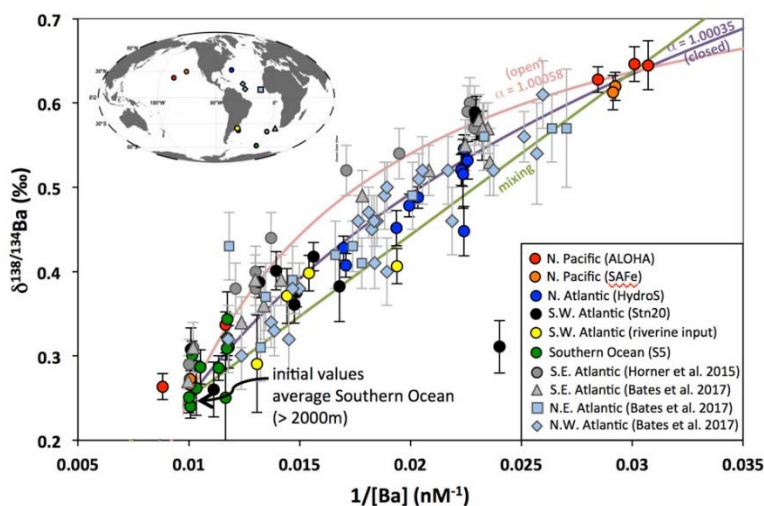


Figure 5. Seawater Ba isotope compositions versus $1/[Ba]$ in the global ocean. The data are fitted with three curves generated by a steady-state (open) model, a Rayleigh fractionation (closed) model and a mixing model, each constrained using an initial composition equal to the average value in the deep Southern Ocean and a final value equal to the surface values in the Pacific Ocean. The results show that seawater Ba isotope compositions are controlled by basin-scale Ba utilization, remineralisation, and ocean mixing during the internal oceanic Ba cycle. External Ba inputs also play important roles in the oceanic Ba isotope budget. For example, riverine input introduces light Ba isotopic signatures to the surface ocean; and sediment or hydrothermal inputs may introduce heavy Ba isotopic compositions to the deep water, which have been identified with the non-conservative behaviour of Ba isotopes during the N-S Atlantic deep water mixing. Such distinct Ba isotope signatures from these sources can become useful tracers for constraining Ba inputs in the present and past ocean.

Reference:

Hsieh, Y.-T., & Henderson, G. M. (2017). Barium stable isotopes in the global ocean: Tracer of Ba inputs and utilization. *Earth and Planetary Science Letters*, 473, 269–278.

<http://doi.org/10.1016/j.epsl.2017.06.024>

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Why did the concentration of atmospheric carbon dioxide rise so much and so quickly during the last deglaciation?

During the Last Glacial Maximum, the deep southern Pacific waters were stratified, efficiently accumulating old, CO₂-rich waters. Basak and co-authors (2018, see reference below) measured neodymium isotopes in sediment cores that clearly show that when these deep waters became less stratified as the climate warmed, they released their carbon, which could escape to the atmosphere...what a tempting prospect and beautiful teaser for the forthcoming PAGES-GEOTRACES workshop of December 2018!



View from RV Polarstern while collecting sediment samples used in the study by [Basak et al.](#)

Reference:

Basak, C., Fröllje, H., Lamy, F., Gersonde, R., Benz, V., Anderson, R. F., Molina-Kescher, M., Pahnke, K. (2018). Breakup of last glacial deep stratification in the South Pacific. *Science*, 359(6378), 900–904. DOI: <http://doi.org/10.1126/science.aao2473>

Shelf sediment dissolved iron source via non-reductive dissolution in the Gulf of Alaska

Crusius and co-workers (2017, see reference below), reveal temporal and spatial variability in the sources of iron (Fe) to the northern Gulf of Alaska, based on data from cruises from three different seasons from the Copper River (AK) mouth to beyond the shelf break. April data were the first to show late winter Fe behavior before surface-water nitrate depletion began. Sediment resuspension during winter and spring storms generated high “total dissolvable Fe” (TDFe) concentrations of ~1000 nmol kg⁻¹ along the entire continental shelf, which decreased beyond the shelf break. In July, high TDFe concentrations were similar on the shelf, but more spatially variable, and driven by low-salinity glacial meltwater. Conversely, dissolved Fe (DFe)

concentrations in surface waters were far lower and more seasonally consistent, ranging from ~ 4 nmol kg^{-1} in nearshore waters to ~ 0.6 - 1.5 nmol kg^{-1} seaward of the shelf break during April and July, despite dramatic depletion of nitrate over that period. The April DFe data can be simulated using a simple numerical model that assumes a DFe flux from shelf sediments, horizontal transport by eddy diffusion, and removal by scavenging. Calculations suggest dust is an important Fe source beyond the shelf break. See Figure 6 below.

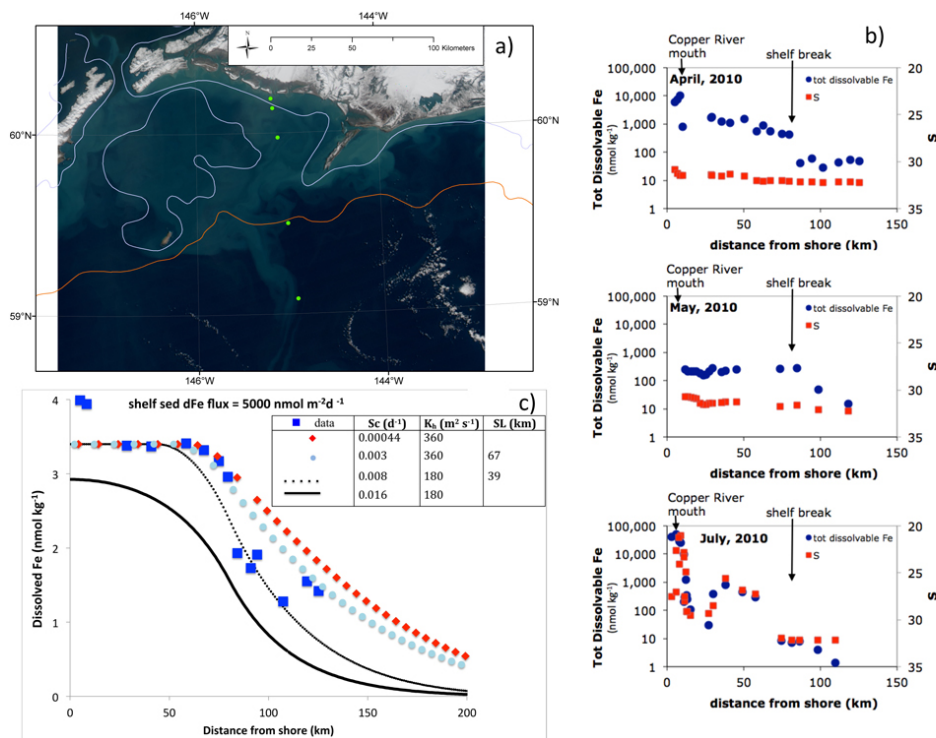


Figure 6. Seasonal and spatial variability in Fe in the northern Gulf of Alaska: a) Sampling region in the northern Gulf of Alaska extending from the Copper River Mouth to ~ 50 km beyond the shelf break. The surface water transect was carried out along the line defined by the green dots (which define sampling stations). This is superimposed upon a MODIS image from 9 April 2010 that shows resuspended sediments (light blue) landward of the 500-m depth contour (orange line). b) Surface water total dissolvable Fe (TDFe) concentrations and salinity plotted versus distance from shore during April, May and July. c) Dissolved Fe (DFe) data (blue squares) from April, along with several time-dependent model simulations that bracket the data, with varying flux of DFe from the shelf sediments, horizontal eddy diffusion, and removal by chemical scavenging.

Reference:

Crusius, J., A. W. Schroth, J. A. Resing, J. Cullen, and R. W. Campbell (2017), Seasonal and spatial variabilities in northern Gulf of Alaska surface-water iron concentrations driven by shelf sediment resuspension, glacial meltwater, a Yakutat eddy, and dust, *Global Biogeochem. Cycles*, 31, doi:[10.1002/2016GB005493](https://doi.org/10.1002/2016GB005493).

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Widespread nutrient co-limitation discovered on GEOTRACES cruise

Browning and co-workers (2017, see reference below) find that multiple nutrients must be supplied to stimulate phytoplankton growth on the southeast Atlantic GEOTRACES GA08 cruise. The paper has been published in *Nature*. Experiments to date have suggested that across most of the ocean surface marine phytoplankton are limited by either nitrogen or iron. But simultaneously low concentrations of these and other nutrients have been measured over large extents of the open ocean, raising the question: are phytoplankton in these waters only limited by one nutrient?

Browning and co-workers tested this by conducting experiments throughout the SE Atlantic GEOTRACES GA08 cruise, where seawater samples were amended with nitrogen, iron, and cobalt—alone and in all possible combinations. They found that adding both nitrogen and iron in combination was needed to stimulate any significant phytoplankton growth over 1000s of kilometres of ocean. Furthermore, addition of cobalt in combination with nitrogen and iron further enhanced phytoplankton growth in a number of experiments. See Figure 7 below.

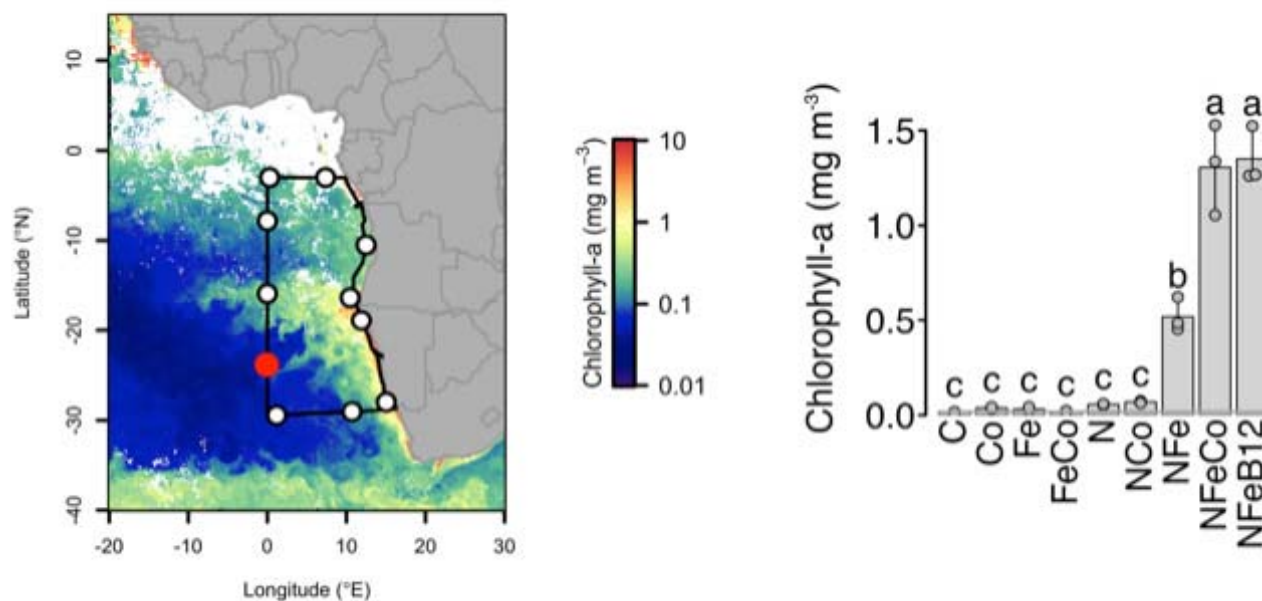


Figure 7. Experiments were conducted throughout the SE Atlantic GEOTRACES cruise transect (lines and dots on the map) and demonstrated that nitrogen and iron had to be added to significantly stimulate phytoplankton growth. Supplementary addition of cobalt (or cobalt-containing vitamin B12) stimulated significant additional growth. Experimental responses illustrated in the right panel are from the site indicated by the red point on the map.

Reference:

Browning, T.J., Achterberg, E.P., Rapp, I., Engel, A., Bertrand, E.M., Tagliabue, A. and Moore, C.M., 2017. Nutrient co-limitation at the boundary of an oceanic gyre. *Nature*. 551, 242–246 doi:[10.1038/nature24063](https://doi.org/10.1038/nature24063).

3. Activities

3.1 GEOTRACES Intercalibration Activities

The GEOTRACES Standards and Intercalibration (S&I) Committee said goodbye to Greg Cutter and Peter Croot and we thank them for all their hard work over many years. We welcomed four new members, Ana Aguilar-Islas from the University of Alaska-Fairbanks, Yoshiko Kondo from Technology Nagasaki University, Peter Sedwick from Old Dominion University, and Alyson Santoro from University of California-Santa Barbara.

The S&I Committee is currently composed of Ana Aguilar-Islas, Karen Casciotti, Tina van de Flierdt, Walter Geibert, Lars-Eric Heimbürger, Yoshiko Kondo, Maeve Lohan, H el ene Planquette, Peter Sedwick and Alyson Santoro. Maeve Lohan and Walter Geibert serve as co-chairs.

The S&I Committee had no in-person meetings during this reporting period but had virtual meetings:

Virtual meetings (GoToMeeting):
22 May 2017

Virtual S&I-DMC co-chair meetings:
20 May 2017

In addition, the committee is in constant communication via email and through shared online platforms, and the co-chairs are in regular personal contact with members of the DMC and BODC.

Intercalibration for IDP2017:

For IDP 2017, all new data was intercalibrated prior to the release. Overall, the S&I Committee approved 111 intercalibration reports and intercalibrated 458 different parameters. During the meetings of the S&I Committee, all datasets were introduced by the assigned committee members, and discussed by the full committee. In nearly all cases, questions of the committee about data quality could be easily resolved and only a limited number of parameters did not pass intercalibration, mostly due to issues with sampling methods.

New intercalibration procedures were constructed for the many new parameters released in IDP2017:

- Aerosols and rain
- HPLC pigments
- Single cell trace metals
- Targeted metaproteomics
- Leachable particulate trace metals
- Artificial radionuclides

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In addition, more than 85% of data from IDP2014 that were not previously intercalibrated were intercalibrated for IDP2017.

The S&I Committee handled the records for the inventories of all data submitted for intercalibration, which benefited a lot from the well-defined parameter names when preparing IDP2017. Just prior to the release of IDP2017, the S&I Committee was involved in communications about the status of various datasets based on these records. The Committee was involved in identifying issues with IDP2017 and helping Reiner Schlitzer with intercalibrated data for IDP2017 v2.

The Cruise and Methods manual (Cookbook) was updated (new methods and sampling handling procedures) by the S&I Committee in time for the release of IDP2017. This is third version, which is now available on the GEOTRACES website (<http://www.geotraces.org/images/Cookbook.pdf>).

New Intercalibration activities:

Lars-Eric Heimburger led a large ship-based intercalibration effort in the Mediterranean Sea in June 2017 for mercury speciation, in particular for gaseous dimethyl mercury. This involved collecting samples onboard and running analyses in a laboratory back on land. Ana Aguilar-Islas and Peter Sedwick are leading a sea-ice intercalibration effort and collected ice cores from the Ross Sea in April-June 2017. They will be distributing samples for analyses soon.

S&I on www.geotraces.org and other support by the International Project Office (IPO)
With the help of the IPO in Toulouse, the web resources for standards and intercalibration on www.geotraces.org were carefully reorganised and updated with the latest information on intercalibration procedures throughout the year. In general, support of the IPO in setting up the meetings, communicating with the GEOTRACES community and co-ordinating interaction of the S&I Committee with the other GEOTRACES committees proved to be extremely useful.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanographic Data Centre (BODC), with the head office located in Liverpool; the GEOTRACES Data Manager (Helen Snaith) is based at the BODC office in Southampton, UK. 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 all GEOTRACES data activities from inception to completion. This takes into account the following components:

- Interactions between PIs and national data centres in order to encourage regular and timely data and metadata submissions

- liaising with the Data Management Committee and S&I Committee to ensure issues and questions relating to GEOTRACES and its progress can be discussed, and deadlines can be met.
- input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies
- Collating data and metadata for the IDP2017 and IDP2017v2
- maintaining and modifying GDAC web pages 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/>).

Helen Snaith took over as the GEOTRACES Data Manager in May 2017 when the previous data manager, Chris Daniels, had to take extended sick leave. Helen has carried out the overall project management for the position. In addition, Donna Cockwell, also based at BODC in Southampton, has acted as the lead for data ingestion, and data and metadata collation, with additional ingestion time provided by Emma Slater, based in BODC in Liverpool. Since April 2017, Donna has been working almost full time on data ingestion and preparation for the IDP2017 release in August 1027, and then on the corrections and addition of data for the release of IDP2017v2.

Data overview

The data management of the GEOTRACES Project is a large undertaking, with a total of 105 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 the GEOTRACES cruises, with 15 different nations having run a major GEOTRACES IPY/section/process study cruises.

Summary of completed GEOTRACES cruises to date:

Section cruises	IPY cruises	Process studies	Compliant data
38	11	47	9

In addition, 2 intercalibration cruises have been completed.

Delivery of IDP2017

The data and metadata for the first release of IDP2017 were delivered to AWI over a very tight timeframe. The loss of the principle data manager in late April 2017 resulted in a compressed delivery that overran the original planned delivery date. Additional issues in integrating some specific data types resulted in a few datasets not being included in the August 2017 release.

Working with the S&I Committee, GDAC was able to prioritise data expected to be approved in March 2017, meaning that all data delivered were included as in scope – not just those delivered by the April 2016 ‘guaranteed inclusion’ deadline. The following table provides the number of datasets approved by the S&I Committee (IDP2014 and IDP2017), received by BODC, ingested

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into the BODC system and delivered for inclusion in IDP2017 by August 2017. Several datasets were included into the IDP without full ingestion into the GDAC system first. These were primarily CTD data that were still awaiting sufficient metadata to allow full ingestion, but had sufficient documentation to be incorporated into the IDP release.

Summary of data delivered for IDP2017

	Approved by S&I	Received by BODC		Ingested		Delivered	
	Number	Number	% Approved	Number	% of Received	Number	% of Approved
Atlantic	781	774	99%	671	87%	756	98%
Pacific	242	229	95%	229	100%	229	100%
IPY	29	29	100%	29	100%	29	100%
Process Cruises	37	36	97%	28	78%	30	83%
Compliant Data	50	34	68%	34	100%	34	100%
Total	1139	1102	97%	991	90%	1078	98%

Delivery of IDP2017v2

After the first release of IDP2017, there were several issues identified in the datasets and it was decided to create a second release, IDP2017v2. During the period from September 2017 to January 2018, GDAC worked closely with the S&I Committee to identify any data that had been approved and submitted, but not correctly ingested into BODC.

Some errors in parameter naming were identified, as well as one identified mis-labelling of units, and an issue where errors reported as 2sigma had been reduced to the required 1sigma values, but the same scaling had inadvertently been applied to the values as well as the errors.

Inconsistency in flag definitions between data submission, storage at BODC and usage in the IDP were identified and consensus reached as to how to provide consistent flag values across datasets.

During this period, a solution was reached to enable the single cell trace metal data, not ingested or included in the original release, to be delivered to GEOTRACES and included in the second release. A Summary of data delivered for IDP2017v2 by February 2018 is given below, with the changed figures highlighted.

Summary of data delivered for IDP2017v2

	Approved by the S&I	Received by BODC		Ingested		Delivered	
	No	No	%age of App.	No	%age of Rec.	No	%age of Rec.
Atlantic	780	774	99%	774	100%	774	100%
Pacific	242	229	95%	229	100%	229	100%
IPY	29	29	100%	29	100%	29	100%
Process Cruises	37	37	100%	31	84%	31	84%
Compliant Data	50	49	98%	49	100%	49	100%
Total	1138	1118 (+16)	98%	1112 (+121)	99%	1112 (+34)	99%

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 one person, the IPO Executive Officer, Elena Masferrer Dodas. 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.

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This year, we want to highlight the following new products:

- GEOTRACES eNewsletter Special Issue – Outreach #2 – Questions and Answers

A second issue of the GEOTRACES eNewsletter devoted to Outreach was published in December 2017. This special issue featured a video introducing the International GEOTRACES Programme. Following a suggestion from Ed Urban, short video interviews of selected SSC members were conducted during the 2016 Scientific Steering Committee held in Toulouse. Questions related to the GEOTRACES programme were asked to these members as, for example, how was the programme developed, why was it important for the programme to commit to developing a merged global database with rigorous data quality control, what is the international coverage of the programme, and others... The interviews were conducted in both English and French (with subtitles). Later, the IPO worked with Jean-Hugues Babary from Centre for the Development of the Pedagogy at the Université Paul Sabatier and the journalist Jean François Hait in editing the videos which are presented in this eNewsletter.

This issue is available here: <http://www.geotraces.org/outreach/geotraces-eNewsletter/listid-12/mailid-861-geotraces-outreach2>.



Figure 8. GEOTRACES eNewsletter Special Issue devoted to Outreach.

- New query capability for the GEOTRACES Publications database

The GEOTRACES publication database existing in Mendeley has been made into a searchable on-line database available on the following GEOTRACES web page: <http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>. This database includes publications that are relevant for GEOTRACES research, along with Master and PhD dissertations.

Three types of search functionalities are available:

- (1) Simple search: users can search publications by “author”, “title” or “journal” entering the desired term into a search box,
- (2) Advanced search: by means of dropdown menus, users can select publications by “author”, “title”, “GEOTRACES cruise”, “year” or “type of document”, and
- (3) Parameter search: allows users to access a list of publications by specific TEI. In addition, users can retrieve publications by group of parameters (e.g., aerosols, dissolved TEIs, etc.) or by pre-defined subgroups (e.g., dissolved trace elements, etc.).

In each case, search queries for “parameter” or “GEOTRACES cruise” will only list those publications linked to data included in the IDP2017.

This facility has been accomplished thanks to a grant from the Observatory Midi-Pyrenees (OMP; Toulouse, France). To develop this database we benefited greatly from the help of Guillaume Brissebrat from the OMP’s Data Centre (SEDOO).

- Intermediate Data Product 2017 Reference List

Based on the above-described GEOTRACES Publication Database, and thanks to the help of Guillaume Brissebrat, we have been able to create a URL system that allows linking each IDP2017 data point to an up-to-date list of relevant publications for these data (see Figure 9 showing a list of publications for Fe_D_CONC_BOTTLE from the GP16 cruise track). This reference database is dynamic and updated whenever new papers are published, so future requests of the publication list related to Fe_D_CONC_BOTTLE along GP16 will, in addition to what is shown in Figure 9, also include new papers published since then. This dynamic inclusion of papers published after the release of the data product was a required feature for the IDP2017, because many datasets included in it were unpublished at the time of data submission.

GEOTRACES References

Cruise: GP16
Parameter: Fe_D_CONC_BOTTLE

6 publications found.

2017

Fitzsimmons, J. N., John, S. G., Marsay, C. M., Hoffman, C. L., Nicholas, S. L., Toner, B. M., German, C. R., & Sherrell, R. M. (2017). Iron persistence in a distal hydrothermal plume supported by dissolved-particulate exchange. *Nature Geoscience*, 10(3), 195–201. doi:10.1038/ngeo2900

Heller, M. I., Lam, P. J., Moffett, J. W., Till, G. P., Lee, J.-M., Toner, B. M., & Marcus, M. A. (2017). Accumulation of Fe oxyhydroxides in the Peruvian oxygen deficient zone implies non-oxygen dependent Fe oxidation. *Geochimica et Cosmochimica Acta*, 211, 174–193. doi:10.1016/j.gca.2017.05.019

John, S. G., Helgoe, J., Townsend, E., Weber, T., DeVries, T., Tagliabue, A., Moore, K., Lam, P., Marsay, C. M., & Till, C. (2017). Biogeochemical cycling of Fe and Fe stable isotopes in the Eastern Tropical South Pacific. *Marine Chemistry*. doi:10.1016/j.marchem.2017.06.003

Saniial, V., Kipp, L. E., Henderson, P. B., van Beek, P., Reys, J.-L., Hammond, D. E., Hawco, N. J., Saito, M. A., Resing, J. A., Sedwick, P., Moore, W. S., & Charette, M. A. (2017). Radium-228 as a tracer of dissolved trace element inputs from the Peruvian continental margin. *Marine Chemistry*. doi:10.1016/j.marchem.2017.05.008

2016

Boiteau, R. M., Mende, D. R., Hawco, N. J., McIlvin, M. R., Fitzsimmons, J. N., Saito, M. A., Sedwick, P. N., DeLong, E. F., & Repeta, D. J. (2016). Siderophore-based microbial adaptations to iron scarcity across the eastern Pacific Ocean. *Proceedings of the National Academy of Sciences of the United States of America*, 113(50), 14237–14242. doi:10.1073/pnas.1608594113

2015

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

Figure 9. List of publications related to Fe_D_CONC_BOTTLE along GP16 cruise track.

- Release of the Intermediate Data Product 2017

In order to ensure the successful release of the IDP2017, we have

1. Proposed solutions to the different committees to facilitate their task. For example, we developed an on-line Google form that allowed collection of user's permissions to publish their data along with the list of publications for these data.
2. Developed the GEOTRACES Publication database and IDP2017 reference list mentioned above.
3. Organised the communication (advertising) of the new data product internationally by (1) publishing special online newsletters and announcements that were distributed via the GEOTRACES mailing list, via other international programme's mailing lists, and sent directly to all identified GEOTRACES stakeholders; and (2) coordinating the organisation of two Town Hall meetings (in Goldschmidt 2017 and Ocean Sciences 2018).
4. Developed the IDP2017 promotional materials (one brochure and one roll-up banner).
5. Helped in organising the SCOR booth at Ocean Sciences.
6. Coordinated the production of the USB cards that contained the *eGEOTRACES Atlas* and were distributed at the Town Halls that were organised at the Goldschmidt 2017 and Ocean Sciences 2018 international conferences.

All these tasks were completed under significant time pressures.

- GEOTRACES website (<<http://www.geotraces.org>>)

As a special feature to be highlighted, we would like to announce that a new web page devoted to GEOTRACES Synthesis of Results Initiative and products has been added on the GEOTRACES site: <http://www.geotraces.org/science/synthesis-of-results>.

We want to thank Olivier Boebion (IT system administrator at Observatoire Océanologique de Villefranche sur Mer, France) for all his technical assistance with the GEOTRACES web site.

- Some statistics

20 new highlights published (155 in total)

6 eNewsletter published, including one special issue (bimonthly 32 in total)

117 new peer-reviewed papers included in the GEOTRACES Publication Database (935 in total)

116 new articles published on the GEOTRACES website

105 new announcements sent through the GEOTRACES mailing list

110 new posts on Facebook and 440 likes (top post reached 1.6K)

532 tweets and 700 followers (top tweet reached 3.1K)

117 new subscribers on the GEOTRACES website

3.4 GEOTRACES Workshops

A list of completed or planned GEOTRACES Workshops is available below:

[Explore GEOTRACES IDP 2017 data with Ocean Data View, 2-3 May, Qingdao, China.](#)

A hands-on workshop to teach standard and advanced Ocean Data View (ODV) methods for the exploration and scientific analysis of environmental data was held on 2-3 May 2018, in Qingdao, China. A total of 82 participants attended the workshop, including graduate and undergraduate students as well as young scientists, from Ocean University of China. During the workshop, the GEOTRACES Intermediate Data Product 2017 (IDP2017) was used as an example dataset. For Day 1, participants learned how to use ODV software, creating maps, property-property plots, sections and surface plots. In addition, participants learned how to create ODV data files with their own datasets. For Day 2, part of the participants (14 students) gave presentations based upon the topics in which they have interest, which cover global physical water circulation, GEOTRACES IDP2017 data, time-series data (Station Aloha), their own datasets, etc. Lastly, participants learned some tips for using advanced levels of ODV to work on their own datasets. Thanks to Mariko Hatta for delivering the lectures.

Further information is available at the following GEOTRACES web page:

http://www.geotraces.org/images/stories/documents/workshops/2018_ODV/ODV%20workshop%20report_OUC_final.pdf

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Training Workshop on Metal Speciation and Isotopes, 12-17 May 2018, Xiamen, China.

A training workshop on metal speciation and isotopes in the ocean for GEOTRACES and beyond was organised by the State Key Laboratory of Marine Environmental Science (MEL) in Xiamen, China. The purpose of this workshop was to train graduate students and professionals who are interested in or will study trace metal and isotope biogeochemistry.

It is hoped that the workshop will also serve to enhance capacity of GEOTRACES-related studies. The training included classroom lectures and hands-on experiments in the laboratory equipped with a variety of measurement tools. Subjects covered included electrochemistry, metal speciation, trace metals and their isotopes.

Further information is available at the workshop web page:

<http://mel.xmu.edu.cn/conference/geotraces/>

Forthcoming:

Introduction to the Awesome OCIM, 12 August 2018, Boston, USA.

A workshop to introduce Awesome OCIM (OA), a new modeling toolbox designed to bring cutting-edge transport matrix models to a wide community of users, will be held in August in Boston in the vicinity of the Goldschmidt 2018 meeting. The AO uses Ocean Circulation Inverse Model (OCIM) transport for realistic global 3D circulation. Within this circulation, broad features of the distribution of many marine TEIs can be achieved by combining just a few processes. For example, iron might be modeled as a combination of atmospheric and sedimentary sources, biological uptake, and remineralization. Thorium might be modeled with radioactive production and decay, plus scavenging. A clickable interface allows the user to include processes such as these, and tune their magnitude to match observed GEOTRACES data. Further adjustments to biogeochemical cycling can be achieved with changes to the underlying Matlab code.

For further information please visit the GEOTRACES web page:

<http://www.geotraces.org/meetings/meetings-by-year/eventdetail/331/-/introduction-to-the-awesome-ocim>

GEOTRACES-PAGES Synthesis workshop: Trace Element and Isotope Proxies in Paleooceanography, 3-5 December 2018, Aix-Marseille, France.

In 2015, GEOTRACES launched a three-pronged initiative to synthesise and exploit GEOTRACES results following the three main scientific themes of the programme. Three workshops were planned. The first one focused on sources and sinks of TEIs at ocean boundaries, synthesising results obtained in the Atlantic Ocean basin (December 2015, Royal Society, synthesis paper published in October 2016 at *Philosophical Transactions of the Royal Society A*, DOI: [10.1098/rsta.2016.0228](https://doi.org/10.1098/rsta.2016.0228)). The second workshop focused on the internal cycling of TEIs within the ocean and was jointly organised with the U.S. Ocean Carbon and Biogeochemistry Programme (OCB) in August 2016. This workshop stimulated dialog and

common research projects between a community working on carbon fluxes and another one more focused on trace element cycles. Following this workshop, several products are currently in preparation (see a complete list of the anticipated products on the workshop web page: <https://web.who.edu/geotraces-synthesis/>).

The synthesis effort will continue in 2018 with a third workshop, jointly organised with the Past Global Changes (PAGES) programme, on the synthesis of geochemical proxies used in paleoceanography (3-5 December 2018, Aix-en-Provence, France). By establishing an optimal understanding of the present-day cycles of tracers that are exploited as paleo-proxies, GEOTRACES is providing fundamental information to paleoceanographers who are applying these tools to their reconstructions. The workshop aims at fruitful exchanges within the paleoceanographic community, the GEOTRACES community and the broader oceanographic community of observationalists and modellers to exploit new data to provide a more rigorous calibration of proxies and interpretation of their records.

Further information is available at the workshop web page: <https://geotracespages.sciencesconf.org/>.

BioGEOTRACES Workshop, November 2018, Woods Hole Oceanographic Institution.

A small, 3-day workshop meeting (<20 people) will take place in November 2018 at the Woods Hole Oceanographic Institution. This workshop will focus on the next steps in designing a new international programme—tentatively called GEOBIOMICS—to further the efforts of BioGEOTRACESs beyond those within the GEOTRACES programme. The focus of this initial workshop will be discussing capacity building, intercalibration and challenges of implementing such a programme, as well as identifying its overarching research goals and questions. The vision is for a fully integrated programme that delivers mechanistic insights into how environmental variability shapes biological activity in the ocean. This workshop will finalise a perspective paper (white paper) to submit to a high-profile journal showcasing studies that have linked ‘omics’ data with trace metal distributions in the ocean. This article will highlight the benefits of combining geochemical, physiological and molecular approaches and serve as the basis for future modeling efforts. Many of these insights have been facilitated by BioGEOTRACES efforts within the existing GEOTRACES programme.

3.5 GEOTRACES Summer School

The first GEOTRACES Summer School was held from 20 to 26 August 2017 in Brest, France. The summer school aimed at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals. It brought together 60 students and 26 world-leading international scientists (Figure 10).



Figure 10. 2017 GEOTRACES Summer School Participants.

Throughout the week, a combination of lectures, practical sessions in the laboratory, poster presentations and drop-in sessions were held (Figure 11). The practical sessions included mass spectrometry (MC-ICPMS, MC TI-MS and HR-ICP-MC), modeling, Ocean Data View, voltametry, flow injection analysis, and sampling and sample handling. The programme is available to download from the Summer School web page:

<https://geotraceschool.sciencesconf.org/>.



Figure 11. Images from the first GEOTRACES Summer School.

The summer school was an absolute success, allowing PhD students and early-career researchers to see how their work fits within the international community of GEOTRACES, as well as permitting them to build a network of collaborations that will help them in their careers.

GEOTRACES is grateful to the organising committee: Hélène Planquette, Thomas Gorgues, Geraldine Sarthou, Aurélie Pinna and Nadine Reniers, the Scientific Committee, the sponsors (LabexMER and SCOR), and all the lecturers who made this summer school possible. GEOTRACES plans to organise a second summer school in 2019 in Cadiz, Spain. For further information: <https://geotraceschool.sciencesconf.org/>

3.6 Special sessions at international conferences featuring GEOTRACES findings

The major event this year was the release of the GEOTRACES Intermediate Data Product 2017 at the 2017 Goldschmidt Meeting (August 2017, Paris, France) during a Town Hall session. A second Town Hall session to introduce the Intermediate Data Product 2017 was also held at the 2018 Ocean Sciences Meeting in Portland, Oregon, USA. Also during this conference a joint U.S. GEOTRACES-OCB Town Hall session was organised aiming at assessing community interest in developing a framework for trace element, isotope, and other biogeochemical research in the Gulf of Mexico and Caribbean Sea (see [U.S. national report for further details](#)).

In addition, several GEOTRACES special sessions were held in major international conferences, including the following:

IUPAC 2017 - World Chemistry Congress, 9-14 July 2017, Sao Paulo, Brazil.

For further information: <http://www.iupac2017.org/>

GEOTRACES-session:

*5.8 Trace elements cycling, processes and fluxes across interfaces

Energy, Water and Environmental Sciences (EE)

Symposium Organisers: Roberto M. Torresi and Daniel Belanger.

Co-organiser: Vanessa Hatje

Goldschmidt 2017, 13- 18 August 2017, Paris, France.

For further information: <http://goldschmidt.info/2017/>

GEOTRACES or GEOTRACES-related sessions:

*10i: Cycles of Trace Elements and Isotopes in the Ocean: GEOTRACES and Beyond

Convenors: Tim Conway, Geraldine Sarthou, Tianyu Chen, Gregory de Souza, Aridane G. González, Kristen Buck, Tina van de Flierdt, Walter Geibert, Zhimian Cao, Catherine Jeandel

*10g: Submarine Groundwater Discharge: Forms, Delivery, Timing, Processes, Pathways and Scaling of Biogeochemical Fluxes

Convenors: Hans Dürr, Nils Moosdorf, Michael Böttcher, Hannelore Waska, Jing Zhang, Walter Geibert

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*10h: Non-Conventional Stable Isotopes in the Ocean: Novel Applications, Technological Advances and Future Applications

Convenors: Horner Tristan, Pearce Christopher, Philip Pogge von Strandmann, Kathleen Scheiderich, Juan Carlos Silva-Tamayo

*10m: Insights into Ocean Processes Through the Application of Radioactive Tracers

Convenors: Paul Morris, Guizhi Wang, Virginie Sanial

*10n: Nutrient Biogeochemistry in the Ocean: Past, Present and Future

Convenors: Scott Wankel, Sinhué Torres-Valdés, Kimberly Popen Dorf, William Haskell, Christian März, Damien Cardinal, Wiebke Mohr, C. Mark Moore, Francois Fripiat, Xingchen Wang, Jia-Zhong Zhang

*17g: Paleoceanographic and Paleoclimate proxies: Their standing on Elderfield's proxy development Curve

Convenors: Marie-Laure Bagard, Marie Boye, Oscar Branson, Sambuddha Misra, Guillaume Paris, Kauzyo Tachikawa

Ocean Sciences 2018, 11- 16 February, Portland, Oregon, USA.

For further information: <http://osm.agu.org/2018/#>

GEOTRACES or GEOTRACES-related sessions:

*The Behavior of Trace Elements and Isotopes in Different Ocean Basins: New Insights from Comparisons and Contrasts

Primary Chair: Gregory A Cutter, Old Dominion University, Ocean, Earth and Atmospheric Sciences, Norfolk, VA, United States

Co-chairs: Adrian Burd, University of Georgia, Athens, GA, United States, Jay Thomas Cullen, University of Victoria, Victoria, BC, Canada and Tung-Yuan Ho, Research Center for Environmental Changes Academia Sinica, Taipei, Taiwan

*Abiotic and Biotic Retention, Recycling, and Remineralization of Metals in the Ocean

Primary Chair: Philip W Boyd, University of Tasmania, Institute for Marine and Antarctic Studies, Hobart, Australia

Co-chairs: Kristen N Buck, University of South Florida Tampa, College of Marine Science, Tampa, FL, United States; University of South Florida, College of Marine Science, St. Petersburg, FL, United States, Jessica N Fitzsimmons, Texas A&M University, Department of Oceanography, United States and Alessandro Tagliabue, University of Liverpool, Liverpool, United Kingdom

*The Dawn of BioGEOTRACES: Metal-Microbe Interactions in the Ocean

Primary Chair: Adrian Marchetti, University of North Carolina, at Chapel Hill, Department of Marine Sciences, Chapel Hill, NC, United States

Co-chairs: Maria Teresa Maldonado, University of British Columbia, Vancouver, BC,

Canada, Alessandro Tagliabue, University of Liverpool, Liverpool, United Kingdom and Yeala Shaked, Hebrew University, Interuniversity Institute for Marine Sciences, Eilat, Israel

*Biogeochemical Processes Across Oxic-Anoxic Transitions

Primary Chair: Jeffry V Sorensen, University of Victoria, School of Earth and Ocean Sciences, Victoria, BC, Canada

Co-chairs: Roberta Claire Hamme, University of Victoria, School of Earth and Ocean Sciences, Victoria, BC, Canada and Tim M Conway, University of South Carolina, Columbia, SC, United States

*Ocean Biogeochemistry and Air-Sea Interactions

Primary Chair: Francesc Peters, Institute of Marine Sciences (ICM, CSIC), Barcelona, Spain

Co-chairs: William M Landing, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL, United States, Oliver Wurl, Carl von Ossietzky Universität Oldenburg, Institute for Chemistry and Biology of the Marine Environment, Wilhelmshaven, Germany and Brian Ward, National University of Ireland, Galway (NUIG), School of Physics, Galway, Ireland

*Bridging Microbial, Stable Isotope, and Micronutrient Approaches to Marine Carbon and Nitrogen Recycling

Primary Chair: Patrick A Rafter, University of California Irvine, Irvine, CA, United States

Co-Chair: Robert T Letscher, University of New Hampshire, Earth Sciences, Durham, NH, United States and Alexis Pasulka, California Polytechnic State University

Forthcoming:

Association for the Sciences of Limnology and Oceanography (ASLO) 2018 Summer Meeting, 10 -15 June 2018, Victoria, BC, Canada

For further information: <https://aslo.org/victoria2018/main>

GEOTRACES-related session:

*SS82: Emerging Models of Trace Metal Bioavailability to Aquatic Organisms

Conveners: David Semeniuk, Randelle Bundy and Anne Cremazy.

Goldschmidt 2018, 12- 17 August 2018, Boston, USA.

For further information: <https://goldschmidt.info/2018/index>

GEOTRACES session:

*Session 07i: New Insights in Marine Trace Element Biogeochemistry

Conveners: Christian Schlosser, Florian Scholz, Rene Boiteau, Tim Conway, Daniel Ohnemus, Jennifer McKay, William Homoky and Jessica Fitzsimmons.

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3.7 Capacity building

Activities In an effort to help build GEOTRACES capacity in East Asia, Bob Anderson (director of the U.S. GEOTRACES project office) participated in two meetings in the Republic of (South) Korea in late 2017. Korea has recently acquired the NIOZ-TITAN clean sampling system for use aboard their new global-class research vessel ISABU. Following a successful test of their system in the summer of 2017, Korean scientists are keen to begin developing an ambitious GEOTRACES programme, with a focus on the Indian Ocean, where they plan to use the ISABU during each of the next several years. During these meetings, Anderson offered advice about the design and scientific goals of Korean GEOTRACES research. For further information please read the [U.S. GEOTRACES national report](#) available in the Annex.

Thanks to the sponsorship of the SCOR Visiting Scholars Programme, Catherine Jeandel, director of the GEOTRACES IPO, was enabled to travel to Brazil in June 2017 to give a 3-week course on “Tracers in the Oceans: applications of isotopes to unveil processes controlling trace element distributions” and provide training on isotope dilution techniques for the determination of rare earth elements at the laboratories of CIEnAm at Universidade Federal da Bahia. Sixteen graduate students from various universities of Brazil attended the course and had the opportunity to discuss their work with Jeandel. As a continuation of this activity one student will visit Jeandel for a few weeks to deepen her knowledge and practical skills in Nd chemistry. For further information, please read the [Brazilian national report](#) available on the Annex.

Travel Grants GEOTRACES gratefully acknowledges support from SCOR to enable scientists from developing countries and countries with economies in transition to participate in the GEOTRACES Summer School.

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.

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 911 plus 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	5000 m conducting Vectran
China - Beijing	Complete	Seabird Rosette. Powder coated aluminium with titanium pressure housings and fittings	24 x 12-L OTE GO-Flo; 24 X 12-L Teflon-lined Niskin-X	8000 m; conducting Kevlar
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	Complete	Powder coated aluminium with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo	8000 m; conducting Kevlar
India	Complete	Powder coated	24 X 12-L Niskin-	8000 m;

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		aluminum with titanium pressure housings and fittings	X	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	7000 m; Vectran conducting Cable
Netherlands	Complete	Titanium frame	24 X 24-liter ultraclean polypropylene	10000 m; conducting Kevlar* <i>*There is only one cable for the two systems</i>
Netherlands	Complete	Titanium frame	24 X 24-liter ultraclean PVDF	10000 m; conducting Kevlar* <i>*There is only one cable for the two systems</i>
New Zealand	Complete	Powder coated aluminium	13 X 5-L Teflon-lined Niskin-X; 13 X 5GO-Flo	4000 m; 8 mm Kevlar line
Norway	In development	Standard 12 positions CTD Rosette GO	5-L Niskin-X	
Poland	Complete* (although the steel cable)	Powder coated aluminum, SeaBird Rosette	8x 10L GoFlo	3000m, steel conducting cable
Poland	Complete	Single bottle	10l G-FLO X Teflon coated	300m Kevlar
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
South Korea	Complete	Pristine	24 X 12-liter PVDF	10,000 m;

		Titanium frame		conducting Kevlar
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 the coming year

Intermediate Data Product 2021

GEOTRACES aims for the next Intermediate Data Product (IDP) to be released in 2021. This is an interval of 4 years following the release of the second IDP, one year more than between the 1st and 2nd IDPs, to allow maximization of new data submissions and to give additional time to the different committees and scientists involved in building the IDP to work on the development of a new on-line metadata portal (see below).

New on-line GEOTRACES metadata portal

Since the GEOTRACES IDPs have been extremely successful, the amount of data to be reviewed, managed and processed has increased considerably. To facilitate the tasks of the core group of persons working on the construction of the product, GEOTRACES aims to create an on-line GEOTRACES data portal that allows (1) major participation of data contributors in directly filling in the information necessary for the evaluation and management of their data into

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the portal, (2) quick and easy access to this information for all people involved in the construction of the product, and (3) more automatic management of these data to allow easier updating and evaluation.

The development of this portal will be an important activity in 2018-2019 and the release of this portal will represent a significant achievement of the GEOTRACES programme. It is anticipated that this portal will be of interest of other scientific communities and international programmes.

Capacity building through GEOTRACES Summer Schools

Following the successful GEOTRACES Summer School organised in August 2017 in Brest, France, GEOTRACES plans to organise a summer school in Spain in 2019, and another one in 2020-2021 in Germany.

Scientific workshops

The following scientific meetings will be organised:

Regional and Basin Workshops:

A fourth East Asia GEOTRACES Workshop will be organised in Xiamen in early 2019. This workshop will continue collaboration advanced by the third East Asia Workshop (16-18 January 2017, Sapporo, Hokkaido, Japan) where a first picture of the current status of the studies in the Northwestern Pacific Ocean (NWPO) was completed and important scientific questions and directions for regional collaborative studies defined.

Future synthesis of results and other workshops:

GEOTRACES plans to design a new strategy to continue its synthesis efforts initiated by the suite of three synthesis workshops described earlier. This strategy could include, for example, a multi basin-scale synthesis workshop that seeks to connect GEOTRACES datasets with the broader datasets and understanding that exist for these regions (e.g., ocean physics, carbon cycle, biological productivity). This will have the potential to place GEOTRACES data within a broader framework of ocean science questions. In any case, the synthesis will continue to respond to the expectation that GEOTRACES results benefit other oceanographic disciplines.

In this context, GEOTRACES will continue its efforts in bringing together the observational and modelling communities fostered by the three Data-Model Synergy Workshops that GEOTRACES organised in 2007, 2009 and 2011. Indeed, the use of GEOTRACES data by joint observational-modelling studies has led to important insights into TEI cycling via the development of new TEI models (for instance, on manganese, cobalt, aluminium, zinc, radium and Th/Pa) and it is for example, facilitating a critical assessment of how the models used for climate projections represent iron cycling (FeMIP, 2016, Tagliabue, A.¹). In addition, following

¹Tagliabue, A., Aumont, O., DeAth, R., Dunne, J. P., Dutkiewicz, S., Galbraith, E., Misumi, K., Moore, J. K., Ridgwell, A., Sherman, E., Stock, C., Vichi, M., Völker, C., Yool, A. (2016). How well do global ocean

the release of the IDPs, modellers have started developing new complementary modelling toolboxes/software linked to GEOTRACES data (one example is the AWESOME OCIM, 2018, John, S. mentioned earlier). GEOTRACES will encourage and explore synergies within these modelling communities, and develop tools that can lead to the organisation of new data-model workshops.

BioGEOTRACES effort

As mentioned before, a new international programme may emerge to further the efforts of BioGEOTRACES efforts beyond those within the GEOTRACES programme. GEOTRACES investigators and the IPO will provide advice and recommendations, as appropriate, to help launch this new initiative.

Education and Outreach

Promotion of the use of the IDP data by the broad oceanographic community will be a priority in the next years leading to the release of the next data product. To date, GEOTRACES has developed several promotional and outreach materials, including printed materials (brochures, posters, banners, postcards, etc.) and other media products (e.g., promotional videos, <http://www.geotraces.org/outreach/other-outreach-materials/videos/1468-21-questions-and-answers>) and it uses social networks such as Twitter, Facebook, YouTube, etc. to promote its science and products. Several GEOTRACES PIs have collaborated with schools and teachers and have developed educational materials, including educational books for children. In addition, GEOTRACES is very active in organising sessions at international conferences, with about 50 sessions organised in the last 3 years including Ocean Sciences, ASLO, and Goldschmidt international conferences.

All these actions have given GEOTRACES visibility within the broad international oceanographic community. While GEOTRACES will continue this effort, GEOTRACES effort will also be placed in developing specific new products focused on stimulating the use of IDP data within the broader ocean science community. These products may include, for example, hands-on workshops to work with Ocean Data View (ODV) (similar to the Workshop Exploring GEOTRACES data with ODV held on August 2016 in Yokohama, Japan, during the Goldschmidt Conference and in May 2018 in Qingdao, China) or development of videos to show examples of successful data access and use (e.g., video informing investigators about the use and maintenance of GO-Flo bottles: <http://www.geotraces.org/sic/historical-resources/1083-learn-how-to-disassemble-and-clean-go-flo-bottles-2>).

biogeochemistry models simulate dissolved iron distributions? *Global Biogeochemical Cycles*, 30(2), 149–174.
doi:[10.1002/2015GB005289](https://doi.org/10.1002/2015GB005289)

See also the FeMIP SCOR Working Group web page: http://www.scor-int.org/SCOR_WGs_WG151.htm

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Acknowledgements

Once more, we wish to express our gratitude to SCOR and Ed Urban for the continuous support and valuable advice generously given to help with the implementation of the GEOTRACES programme.

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May 2018

3.2 Surface Ocean–Lower Atmosphere Study (SOLAS) (joint with Future Earth, WCRP, and CACGP)

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: Lisa Miller (Canada)

Other Members: Katye Altieri (South Africa), Philip Boyd (Australia), Erik van Doorn (Germany), Cristina Facchini (Italy), Laura Gallardo (Chile), Véronique Garçon (France) (ex officio), Santiago Gassó (USA), Ilan Koren (Israel), Arne Körtzinger (Germany), Mohd Talib Latif (Malaysia), Maurice Levasseur (Canada), Peter Minnett (USA), Jun Nishioka (Japan), Anna Rutgersson (Sweden), Alfonso Saiz-Lopez (Spain), Parvadha Suntharalingam (UK), Guiling Zhang (China-Beijing)

Executive Officer: Jessica Gier

Executive Committee Reporter: John Turner

SOLAS Annual Report to SCOR

Reporting period: May 2017 - May 2018
Version of 14 May 2018 by Jessica Gier

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 2015-2025: Science Plan and Organisation

Over the period of 2015 and early 2016, the comments from 14 reviewers, selected by the SOLAS four sponsors WCRP, SCOR, ICACGP and Future Earth, were implemented. After we got the official approval of the four sponsors, the final hard copy document was released in May 2017. The *SOLAS 2015-2025: Science Plan and Organisation* (SPO) is available to download from the SOLAS website (<http://www.solas-int.org/about/solas.html>) and printed copies are available upon request from the IPO.

The SOLAS science mission is organised around five core themes:

Core Theme 1: Greenhouse gases and the oceans

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

Core Theme 3: Atmospheric deposition and ocean biogeochemistry

Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems

Core Theme 5: Ocean biogeochemical control on atmospheric chemistry

In addition, the study of these themes will be integrated in efforts to understand key environments, for example, upwelling systems, polar oceans, and coastal waters, as well as to evaluate the environmental efficacy and impacts of geoengineering proposals, policy decisions, and societal developments.

I.b. SOLAS 2015-2025. Implementation Strategy 2016-2018

SOLAS chose to use a pragmatic approach with a continually evolving 2-year implementation strategy. This approach means that the document is a moving target that is regularly (i.e., annually) updated. The implementation is intended to be a web-based document only and is available for download from the SOLAS website at <http://www.solas-int.org/activities/implementation.html>. The latest iteration of the Implementation Strategy was released online in April 2018.

I.c. Collaboration with IMBER-SOLAS-IOCCP-GCP-CLIVAR-WCRP on Ocean Carbon

A new 'Carbon Think Tank' evolved from an IMBER-SOLAS-IOCCP-GCP-CLIVAR-WCRP meeting on future ocean carbon cycle research which took place in August 2017 in Interlaken, Switzerland. SOLAS committed 5000 €, and both IMBeR and IOCCP also confirmed financial support. In addition, SOLAS confirmed on average one day per week of its IPO staff time (Project Officer) to facilitate the development of the group. A first meeting is currently planned for the end of 2018 or the beginning of 2019, to be held in Paris, France.

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. Access the portal [here](#).

The SOLAS metadata portal is an on-going effort. Scientists can help expand the SOLAS Metadata base by completing a [simple template](#) and emailing it to solas@geomar.de. In addition, SOLAS has strong connections to the Surface Ocean CO₂ Atlas (SOCAT) and the Global Ocean Data Analysis Project (GLODAP) through the carbon working group(s). The *in-situ* observations are brought together in global collections through SOCAT and GLODAP, internationally supported and endorsed by SOLAS, the Integrated Marine Biosphere Research project (IMBeR), the International Ocean Carbon Coordination Project (IOCCP), and numerous national funding bodies.

I.e. *SOLAS Workshops on Core Themes 4 and 5*

Two parallel workshops will take place 27-29 November 2018 in Rome, Italy:

Workshop on Influence of coastal pollution on marine atmospheric chemistry: effects on climate and human health, Maria Cristina Facchini, Alfonso Saiz-Lopez, and Hiroshi Tanimoto.

Coastal pollution (air and water) is currently increasing and will most likely continue in the future as anthropogenic environmental pressure upon coastal marine areas increases. Coastal pollution has the potential to contribute to changes in marine atmospheric chemistry including air quality in coastal areas, in addition to contributing to global air pollution and climate. Furthermore, the influence of the coastal pollution on the atmospheric chemistry of gas and particles can have adverse effects on human health in populated coastal environments. Within this context, this 2-day workshop invites contributions on laboratory, field, and modelling work in the following topics:

1. How coastal pollution (air and water) affects gas and particles emitted over the coasts and human health;
2. Effects on air quality-climate system (regional scale) and human health.

The Workshop is structured as a series of oral and poster presentations, and it will include discussion time for several specialized working groups on:

- Coastal Air pollution and marine emission of gas and particles
- Water pollution and coastal marine emission of gas and particles
- Effects on climate and human health.

This Workshop is co-sponsored by SOLAS and IGAC.

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Workshop on the Interconnections between aerosols, clouds, and marine ecosystems in contrasting environments, Maurice Levasseur, Ilan Koren, and Emmanuel Boss.

Several large national and international research programs have been initiated during the last five years in order to improve our understanding of the complex and highly dynamical interconnections between aerosols, clouds, and marine ecosystems (e.g., NAAMES, NETCARE SOAP, ACE, MarParCloud, R2R, PEACETIME, and Tara Pacific). These interconnections were investigated in the North Atlantic, Arctic, Southern, and Pacific oceans, the Mediterranean Sea, and coral reef regions. The number and size of these programs illustrate the dynamic nature of this field of research. Participants in these different programs, as well as all interested researchers working on this topic, are invited to attend the workshop in order to share and compare their findings to cross-fertilize between these programs and contribute to a community paper.

L.f. SOLAS Open Science Conference 2019

The SOLAS Open Science Conference 2019 will take place on 21-25 April 2019 in Sapporo, Hokkaido, Japan. The Local Organising Committee (LOC) from Hokkaido University is composed of Jun Nishioka, Yuzo Miyazaki, and Sohiko Kameyama. The organising committee for the Early Career Scientist Event is composed of Yoko Iwamoto of Hiroshima University, Sohiko Kameyama of Hokkaido University, and Martine Lizotte from Laval University, Canada. The venue and banquet place are booked. Hotels will be blocked. The OSC website was launched in April 2018, and the registration and abstract submission, as well as travel support application will open in May 2018. The abstract submission and registration website is prepared. The first flyer version and a post card were designed by the IPO. The IPO visited the conference venue in Sapporo and consulted with the LOC. Website: www.solas-int.org/osc2019.html

L.g. Collaboration with Climate and Cryosphere (CliC) and the Scientific Committee on Antarctic Research (SCAR) on Biogeochemical Exchange Processes at Sea Ice Interfaces (BEPSII)

Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII) started in 2011 with a focus on sea-ice biogeochemistry. BEPSII was a SCOR working group from 2012 until September 2016, and has since been endorsed as a SOLAS-CliC Activity (2016) and as a SCAR Action Group. The 2017 BEPSII annual meeting was co-sponsored by SOLAS. BEPSII is now coordinating community activities linked to the biogeochemistry of sea ice-influenced environments, with ~120 involved scientists. Website: <https://sites.google.com/site/bepsiiwg140/home>

L.h. Collaboration with International Global Atmospheric Chemistry (IGAC)

The Cryosphere and Atmospheric Chemistry (CATCH) mission is to facilitate atmospheric chemistry research within the international community, with a focus on natural processes specific to cold regions of the Earth. Cold regions include areas that are seasonally or permanently covered by snow and ice, from the high mountains to the polar ice sheets and sea ice zones, as well as regions where ice clouds are found. CATCH scientists achieve these objectives by designing joint projects in the field and lab, and via modeling studies, as well as collaborating across disciplines. CATCH takes advantage of the inherently international nature

of polar and cold region research. CATCH addresses overarching science questions that are not achievable by any single nation. New website: <https://sites.google.com/view/catchscience/home>

SOLAS/IGAC Task Team: Halogens in the Troposphere (HitT). The primary objective of the SOLAS/IGAC Halogens in the Troposphere (HitT) task team 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. During the EGU meeting in 2017 a 'Halogens in the troposphere' session took place with convener Alfonso Saiz-Lopez, co-conveners Rolf Sander, Ulrich Platt, and Nicole Bobrowski.

Li. Collaboration with Integrated Marine Biosphere Research project (IMBeR) The SOLAS-IMBeR Ocean Acidification Working Group (SIOA) and OA-ICC annual meeting 2018 will take place in Monaco from 26 to 28 June 2018.

The SIOA provides a key advisory role to the Ocean Acidification International Coordination Centre (OA-ICC) at the International Atomic Energy Agency in Monaco. The SIOA/ IAEA OA- ICC continue to act as an international coordination platform for ocean acidification research and collaboration by:

- Ensuring that scientists have access to recently updated, state-of-the-art software to calculate ocean acidification parameters, and that ocean acidification data collected across the globe are properly archived, accessible, and comparable. This is particularly relevant in the context of reporting of countries on the UN Sustainable Development Goal (SDG) 14.3.
- Acting as a hub for global stakeholders interested in ocean acidification, providing unique resources such as its comprehensive bibliographic database and a news stream updated daily with information on ocean acidification scientific articles, media coverage, jobs, and meetings.
- Providing increased awareness about ocean acidification with contributions to major reports and working groups, highly visible international events and meetings, training courses, the OA-ICC web site, news stream, and communication products.
- Providing enhanced capacity in ocean acidification research and networking opportunities in 2017 for 52 researchers from 24 IAEA Member States. That adds to similar capacity-building efforts for more than 200 scientists from over 50 countries during the project's life time.
- Contributing to the development of international and regional coordination activities and networks, such as GOA-ON, LAOCA, and OA-AFRICA.
- Contributing to methodology development for UN SDG14.3 on Ocean Acidification and equipping countries to report towards that target.

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Ii. Collaboration with Ocean Carbon & Biogeochemistry (OCB)

A New Ocean-Atmosphere Interaction Subcommittee has been created and members appointed. Overall, 28 nominations were received and a small committee of scientists from the OCB and SOLAS scientific leadership independently reviewed all of the nomination packages and then engaged in an open discussion, followed by a ranking/voting process.

The inaugural subcommittee includes the following 12 members: Rachel Stanley (Wellesley College, subcommittee chair), Thomas Bell (Plymouth Marine Laboratory), Yuan Gao (Rutgers), Cassandra Gaston (Univ. Miami, RSMAS), David Ho (Univ. Hawaii), David Kieber (SUNY Syracuse), Katherine Mackey (Univ. California, Irvine), Nicholas Meskhidze (NC State Univ.), Bill Miller (Univ. Georgia), Henry Potter (TAMU), Penny Vlahos (Univ. Connecticut), and Patricia Yager (Univ. Georgia).

The scientific focus of this subcommittee is on ocean-atmosphere interactions and their role in marine biogeochemical cycles. There is a substantial overlap between the scientific goals of the OCB and SOLAS communities, and this subcommittee seeks to strengthen communication and collaboration between ocean and atmospheric scientists to create a thriving, collaborative air-sea interaction research community in the United States. The OCB Project Office will host and provide logistical support for this subcommittee. More information [here](#).

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

II.a. SOLAS Science and Society workshop

At the SOLAS Open Science Conference in Sept 2015, a discussion session on SOLAS Science and Society took place and generated a lot of interest. In 2017, Erik van Doorn, a social scientist specializing in the Law of the Sea, including aspects from deep-sea mining to fisheries and marine protected areas, was appointed to the SOLAS SSC. Erik is also keen to work with natural scientists and involved with the Future Ocean Cluster of Excellence Kiel. He is also a co-author of a massive open online course on the oceans (MOOC-<http://www.oceanmooc.org/en/index.php>), experience that will be an asset to the SSC while exploring new avenues for capacity building.

Following the success of the SOLAS Science and Society workshop in Brussels, Belgium on 26- 27 October 2016, three more workshops were organised in 2017. Erik van Doorn was on two of the three organising committees. A 'SOLAS event report' was published for the events.

- 1. Valuing carbon in the ocean, 30 March-1 April, 2017.** The physical uptake of carbon dioxide by the ocean has increased in response to anthropogenic carbon input to the atmosphere, but this has potentially negative consequences on ocean ecosystems through ocean acidification. While there have been extensive, ongoing discussions in the scientific community about roles and vulnerabilities of the physical, biological and microbial carbon pumps in regulating CO₂ uptake from the atmosphere, society might consider manageable options to enhance the shallow ocean's carbon uptake. The related trade-offs between sequestration benefits and negative consequences were

discussed. A further point of discussion was devoted to the time-scale of carbon storage.

2. **Air-sea interaction and policy, Rome, Italy, 14-15 June 2017.** Participants discussed the interactions between the lower atmosphere and the upper layer of the ocean, and whether such interactions are sufficiently considered in regulations. They concluded that regulations do not need to target the air-sea interface directly, because regulating the source of pollution (e.g., atmospheric sources at the national level) or designated protected areas would be more effective. Although there is a general obligation under international law for nations to prevent, reduce, and control pollution of the marine environment from or through the atmosphere, the regulation of activities on land or ships is mostly a sovereign act of nations, which is exercised pursuant to their national policies. For CO₂, regulation was an evolutionary process and consideration of CO₂ crossing the air-sea interface came only after its confirmed role as a pathway to that leads to lower pH (i.e., ocean acidification). International law increasingly strives to require nations to act collectively through international or regional organisations, or to adopt measures at a regional or national levels, as agreed in binding agreements (hard law) or voluntary instruments (soft law) to regulate threats to the marine environment, such as airborne pollutants, dumping at sea, and trace metals, as well as implement general requirements to conduct environmental impact assessment prior to conducting harmful activities and the prerogative to establish marine protected areas.

3. **International conference on Shipping and the environment-From Regional to Global Perspectives, Gothenburg, Sweden, 24-25 October 2017.** Given its importance for the transport of goods on a global scale, there is a growing interest on the sustainability of the shipping industry. Shipping seems a very carbon-efficient transport medium, but there is an increasing focus on its broader environmental consequences. The Bonus SHEBA project addresses a wide range of environmental impacts of shipping in the Baltic Sea, including air pollution, marine pollution, underwater noise, and climate change, as well as the socio-economic consequences of these impacts. The conference and the SOLAS workshop on “Shipping” on 26 October, 2017, provided a unique opportunity to review the latest research across a broad interdisciplinary perspective and to discuss priorities for future work.

II.b. *Contribution to 2017 Joint IAPSO-IAMAS-IGA Assembly*

Good Hope for Earth Science: Atmospheric Chemistry and Physics for the 21st Century, Cape Town, South Africa, 27 Aug-1 Sept 2017

SOLAS organised the sub-session ‘A tribute to Prof. Roland von Glasow’ within session M01: Atmospheric Chemistry and Physics for the 21st Century. Convenors of the session were James Drummond, Melita Keywood, and John P. Burrows. In the sub-session, SOLAS invited and supported Maria Kanakidou and Rainer Volkamer to present their work and pay a tribute to Roland von Glasow’s contributions to SOLAS science. Two main aspects of his work were highlighted, namely “Halogens in the Troposphere” and “Coastal Megacities”. A ‘SOLAS event report’ was published on the event.

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II.c. SOLAS Representation at the Ocean Sciences Meeting, Portland, Oregon, USA, 12-16 February, 2018.

Town Hall Meeting: A SOLAS Town Hall on ‘Expanding involvement and setting priorities’ was held on 13 February 2018, to introduce the SOLAS Science Plan and international activities, to discuss how SOLAS can be useful to the research community, to generate ideas for new initiatives and collaborations, and to explore priorities for expanding the U.S. SOLAS program. The U.S. SOLAS national representative Rachel Stanley hosted this event. The Town Hall was joined by the SOLAS SSC Chair Lisa Miller and SSC members Philip Boyd, Peter Minnett, Jun Nishioka, and Guiling Zhang. They presented their research and how they are connected with SOLAS. The SOLAS IPO was represented by Jessica Gier and Li Li.

Exhibition booth: Thanks to SCOR, SOLAS participated in an exhibition booth shared among a number of global research projects. The project office and members of the SSC provided conference attendees with information about SOLAS science and how to get involved with SOLAS and distributed copies of the *SOLAS 2015-2025: Science Plan and Organisation*, SOLAS flyers, and SOLAS giveaways.

II.d. Collaboration with ESA and NASA

In October 2016, Ilan Koren and Brian Ward replied to an ESA/Future Earth call for funding for a workshop. The proposal was successful and SOLAS received 12k Euros to organise a follow-up event to the 2016 Frascati workshop on Harnessing Remote Sensing to Address Critical Science Questions in the Ocean-Atmosphere.

This SOLAS/ESA/NASA workshop on **Remote Sensing for Studying the Ocean-Atmosphere** took place on 12-15 March 2018 in Washington D.C., USA in order to encourage participation from NASA scientists. The workshop convener was SOLAS SSC member Peter Minnett. The goal of the workshop was to facilitate the exchange of ideas and information about recent developments in remote sensing that can provide new information about the ocean-atmosphere interface, and to help forge collaborations between workshop participants and the wider community. The workshop was attended by about 50 participants, including many NASA scientists, and was a combination of presentations and discussion sessions, and accompanied by a poster session. NASA keynote speakers were directly sponsored by the agency.

Keynote speaker Diego Fernández-Prieto, ESA ESRIN, mentioned ESA’s very high interest in continuing the collaboration with SOLAS, for example through joint activities. A SOLAS ‘event report’ is in preparation.

II.e. 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, the People’s Republic of China, the Republic of Korea, the Russian Federation, and the United States of America.

SOLAS is engaged with the scientific planning of the 4th International Symposium on 'The Effects of Climate Change on the World's Oceans', Washington DC, USA, 4-8 June 2018. SOLAS is a co-sponsor. This is a PICES-ICES-IOC-FAO event.

The PICES 2018 annual meeting will take place in Yokohama, Japan, 25 October-4 November 2018. Lisa Miller will attend that meeting and represent SOLAS.

U.f. *SOLAS Summer School 2018*

The SOLAS Summer School 2018 is scheduled to take place from 23 July to 3 August 2018 in Cargèse, Corsica, France. The program of the school has been finalised, and all lecturers have confirmed. The French Vessel *Tethys* has been guaranteed for the practicals. The website for the school is active and a registration website for students and lecturers was prepared for release. In total, 70 students were accepted. Two proposals are still in the pipeline and if granted the budget is balanced. The latest proposal to be granted was the NASA proposal, and as of now, the school is missing 15k €. Website: <http://www.solas-int.org/solas-summer-school-18.html>

U.g. *SOLAS Time Series in Cape Verde*

Former SOLAS SSC member Anja Engel and Christa Marandino (SOLAS National Representative of Germany) are establishing a SOLAS time series in Cape Verde (SLIC), which was borne out of the Cargèse Workshop on SOLAS Theme 2 in May 2017. Cape Verde would be an ideal location for such a time-series site, as it already hosts the Cape Verde Atmospheric Observatory and Cape Verde Ocean Observatory. Arne Körtzinger, SOLAS SSC member, is picking up the thread. Christa Marandino, Anja Engel, Arne Körtzinger, Jessica Gier, are working with Cordula Zenk, the coordinator of the Ocean Science Centre Mindelo, to further the SLIC time-series concept.

U.h. *Additional SOLAS events*

Past events not mentioned in detail:

- 17th SSC meeting, Bologna, Italy, June 2017
- Side event with IMBeR, CLIVAR, and IOCCP at the 10th International Carbon Dioxide Conference, Interlaken, Switzerland, 21-25 August 2017
- Global Ocean Oxygen Network (GO₂NE) meeting, Monterey, USA, 11-13 September 2017
- SCOR China Meeting, Beijing, China, 28-29 December 2017
- ECV-Ice Intercalibration Experiment, Saroma-Ko, Japan, 1-8 March 2018
- 39th session of the Joint Scientific Committee (JSC-39), Nanjing, China, 16-20 April 2018
- Meeting with sister organisations, Victoria, BC, Canada, 1 May 2018, to facilitate joint activities in global environmental change research
- SOLAS SSC Meeting 2018, Victoria, BC, Canada, 2-4 May 2018.

Upcoming events not mentioned in detail:

- POLAR2018, A SCAR & IASC Conference, Davos, Switzerland, 15-26 June 2018
- BEPSII & ECV-Ice annual meetings, Davos Switzerland, 15-17 June 15-17 2018
- SFB 745 Ocean Deoxygenation conference, Kiel, Germany, Sept. 2018
- OCB Workshop on Oceanic Methane and Nitrous Oxide: The present situation and future

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scenarios, Los Angeles, USA, 28-31 October 2018

- ECV-Ice Intercalibration Experiment, University of East Anglia, UK, autumn 2018
- The 4th Xiamen Symposium on Marine Environmental Sciences, Xiamen, China, 6-9 January 2019
- Geoengineering Workshop focussing on lab- and mesocosm-based fundamental science opportunities, 2019

II.i. *SOLAS IPO welcomed a school pupil*

In August 2017, the SOLAS IPO welcomed a school pupil for a week and showed her what an Ocean Research Institute has to offer and what a project like SOLAS is. Her report is available on the SOLAS website: <http://solas-int.org/events-archive.html>.

II.i. *SOLAS publications*

- Review paper that evolved from the SOLAS Science and Society workshop in Brussels, October 2016: Endres, S, Maes, F, Hopkins, F, Houghton, K, Mårtensson, EM, Oeffner, J, Quack, B, Singh, P, and Turner, D (2018) A New Perspective at the Ship-Air-Sea- Interface: The Environmental Impacts of Exhaust Gas Scrubber Discharge. *Frontiers in Marine Sciences*. 5:139. doi: 10.3389/fmars.2018.00139.
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II.k. *SOLAS communications*

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

Monthly SOLAS e-news: Distribution of 10 SOLAS e-news sent to more than 2,500 SOLAS scientists since the last report to SCOR in May 2017. The e-news contain news from SOLAS, opportunities for meetings, abstract submission deadlines, recent publications, vacancies and

news from relevant partner project and collaborators. The circulation of the e-news is back onto a monthly basis (1st or 2nd Wednesday of each month). Past issues of the e-news can be viewed on the SOLAS website: <http://solas-int.org/archive.html>.

SOLAS event Report series is a new approach to reporting on SOLAS-sponsored or co-sponsored events. An event report is published after each SOLAS-related event. These reports are sent to the sponsors and are released in combination with the monthly e-news.

- [Issue 08 - December 2017](#) - Conference on: “Shipping and the Environment - From Regional to Global Perspectives”, Workshop on “Shipping”, October 2017, Gothenburg, Sweden.
- [Issue 07 - November 2017](#) - 'Good Hope for Earth Science: Atmospheric Chemistry and Physics for the 21st Century, SOLAS sub-session: A tribute to Prof. Roland von Glasow', August 2017, Cape Town, South Africa.
- [Issue 06 - September 2017](#) - Workshop series on SOLAS Science and Society, October 2016, Brussels, Belgium, March 2017, Monaco, and June 2017, Rome, Italy.
- [Issue 05 - September 2017](#) - Workshop on 'Frontiers in ocean-atmosphere exchange: Air-sea interface and fluxes of mass and energy', France, May 2017, Cargèse, Corsica.
- [Issue 04 – July 2017](#) - Community workshop of CATCH (Cryosphere and Atmospheric Chemistry), April 2017, Guyancourt, France.
- [Issue 03 – June 2017](#)- Annual meeting of the Biogeochemical Exchange at the Sea Ice Interfaces, BEPSII, April 2017, La Jolla, USA.
- [Issue 02 - June 2017](#)- Ocean Acidification practical training and networking meeting, February 2017, Dakar, Senegal.
- [Issue 01 - May 2017](#) - Two GESAMP WG38 workshops in parallel on 'Changing Atmospheric Acidity and its Impacts on the Oceanic Solubility of Nutrients' and on 'The Impact of Ocean Acidification on Fluxes of Non-CO₂ Climate Active Species', 27 Feb- 2 March 2017, Norwich, UK.

Poster: A poster presenting SOLAS and its new science plan is available to download on the SOLAS website. Anyone is welcome to freely use it for conferences/meetings/workshops or just to have a brief overview of SOLAS.

Presentation: A SOLAS presentation for workshop organisers is available upon request from the IPO.

Twitter account: The IPO created a SOLAS Twitter account in late 2016. Regular posts (currently 386) have been sent out since Jan. 2017, and the number of followers is steadily increasing (currently 357).

II.k. *SOLAS national networks*

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.

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In April 2018, 20 reports were received and will be 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 coordination and to disseminate the results and progress from some nations to the rest of the SOLAS community. Information provided through the reports is also used to update the implementation strategy.

All the reports received during the reporting period are available in an [Addendum](#) to this document. Current national networks representatives include the following:

- Australia: Sarah Lawson and Andrew Bowie
- Belgium: Nathalie Gypens
- Brazil: Leticia Cotrim Da Cunha
- Canada: Jon Abbatt
- Chile: Laura Farias *
- China (Beijing): Minhan Dai
- China (Taipei): *
- Denmark: Lise Lotte Soerensen and Mikael Sejr *
- Finland: Lauri Laakso
- France: Rémi Losno
- Germany: Christa Marandino and Hartmut Herrmann
- India: VVSS Sarma *
- Israel: Yoav Lehahn
- Ireland: Brian Ward *
- Italy: Chiara Santinelli
- Japan: Jun Nishioka
- Korea: Kitack Lee
- Mexico: Jose Martin Hernandez Ayon
- Netherlands: Jacqueline Stefels *
- New Zealand: Cliff Law
- Norway: Siv Lauvset
- Peru: Michelle Graco
- Poland: Timo Zielinski
- Russia: Sergey Gulev *
- South Africa: Sarah Fawcett
- Spain: Alfonso Saiz-Lopez
- Sweden: Katarina Abrahamsson *
- Turkey: Baris Saglihoglu, Mustafa Koçak, Nazli Olgun
- UK: Tom Bell
- USA: Rachel Stanley

* SOLAS has not yet received the 2017 report

II.L. Endorsed projects since the previous year's report

- October 2017: Processes Influencing Carbon Cycling: Observations of the Lower limb of

- the Antarctic Overturning (PICCOLO)
- Not yet endorsed but will be in May 2018: BIodisponibility and SOIUbily of iron content in desert dust and volcanic ash (BISOU)

Information on endorsed projects is available on the SOLAS website: <http://www.solas-int.org/activities/project-endorsement.html>

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

- Executive Director salary, office space and in kind provided by GEOMAR until December 2020
- Project Officer salary, office space and in kind provided by MEL until September 2020
- US-NSF via SCOR annual grant of 25kUSD until 2018, 2/3rd cover the cost of the SSC meeting
- US-NSF via SCOR extra 40kUSD to hire a contractor, 6 month are left
- Future Earth annual block grant of 15kEUR contributing to the cost of the SSC meeting
- French CNRS 8kEUR in 2017 and in 2018 for SOLAS activities

IV. Update on the Scientific Steering Committee and International Project Office status since the last report

IV.a. SOLAS Scientific Steering Committee

In December 2017 Véronique Garçon's (F, France) term as SOLAS Scientific Steering Committee (SSC) Chair ended. Since January 2018, Lisa Miller (F, Canada), has served as SOLAS SSC Chair. Lisa Miller will be the 5th SOLAS SSC Chair, serving in this position for 3 years.

SOLAS has an Executive Committee composed of the Chair, Lisa Miller, and Ilan Koren, Maurice Levasseur, and Cristina Facchini.

The following SSC members rotated off in December 2017:

- Emmanuel Boss
- Anja Engel
- Huiwang Gao
- Véronique Garçon
- Michelle Graco
- VVSS Sarma

Maurice Levasseur and Cristina Facchini ended their first terms on the SSC and were selected for second terms.

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In January 2018, five new SSC members were appointed:

- Katy Altieri (F, South Africa)
- Laura Gallardo (F, Chile)
- Santiago Gassó (M, USA)
- Arne Körtzinger (M, Germany)
- Mohd Talib Latif (M, Malaysia)

The current membership of the SOLAS SSC:

Last name	First name	Country of employment	Gender	Scientific expertise	SOLAS expertise	Term	End
Suntharalingam	Parvadha	UK	F	Numerical modelling / C, N, S bgc	Theme 1, cross themes	1	2018
Körtzinger	Arne	Germany	M	Carbon cycle, Ocean observation	Theme 1	1	2020
Zhang	Guiling	China	F	Bgc of trace gases	Theme 1	1	2019
Minnett	Peter	USA	M	Remote sensing, Physical air-sea exchange	Theme 2	1	2018
Rutgersson	Anna	Sweden	F	Air-sea physical interaction	Theme 2 WCRP rep	1	2019
Latif	Mohd Talib	Malaysia	M	Microlayer, atmosph. aerosols	Theme 2	1	2020
Altieri	Katy	South Africa	F	Atmospheric molecules, climate policy	Theme 3 Society	1	2020
Boyd	Phil	Australia	M	Marine bgc	Theme 3, geoengineering	1	2018

Gasso	Santiago	USA	M	Remote sensing, aerosols, dust transport	Theme 3 and 4 NASA connection	1	2020
Koren	Ilan	Israel	M	Cloud physics	Theme 4	2	2018
Levasseur	Maurice	Canada	M	Ocean bgc, dimethylsulfide, Arctic,	Theme 4	2	2020
Gallardo	Laura	Chile	F	Atmospheric modeling, pollutants	Theme 4 IGAC Connection	1	2020
Facchini	Cristina	Italy	F	Physical and chemical processes in multiphase	Themes 4 and 5	2	2020
Saiz-Lopez	Alfonso	Spain	M	Atm. halogens/modelling	Theme 5, IGAC	2	2019
Nishioka	Jun	Japan	M	Oc. trace metal bgc cycle, Polar oceanography and sea-ice bgc	Integrated topics	1	2019
Van Doorn	Erik	Germany	M	Law of the Sea	SOLAS Science and Society	1	2019

The current gender and country balance of the SSC is as follows, for a total of 17 members including the chair:

- 7 female members and 10 male members
- 4 members from developing countries and 13 from developed countries

IV.b. SOLAS International Project Office, Kiel

The SOLAS IPO is hosted at the GEOMAR Helmholtz-Centre for Ocean Research Kiel in Kiel, Germany. The office was staffed until October 2017 by Emilie Brévière, Executive Director, and from April 2017 with Jessica Gier as Project Officer. In October 2017, Jessica

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Gier was appointed interim Executive Director. A search committee including Lisa Miller, Véronique Garçon, Arne Körtzinger, and Emilie Brévière interviewed applicants for Executive Director in February 2018. In April 2018, Jessica Gier was appointed.

Minhan Dai secured funding in China for a SOLAS regional hub at MEL, Xiamen University, including a project officer. The search committee appointed Li Li for the Project Officer position in September 2017 for 3 years, full time.

The salary of the Executive Director is supported by GEOMAR until 2020. Salary funding for a second Project Officer position based in Kiel, from IGBP and the US-NSF via SCOR, would last for about another six months, and someone new will be appointed to replace Jessica Gier, who was in that position before her appointment as interim Executive Director. Another request to NSF will be made to maintain the Project Officer position at GEOMAR after the SSC meeting in May 2018. GEOMAR provides office space for the IPO until December 2020.

3.3 International Quiet Ocean Experiment

Urban, Shapovalov

Terms of Reference:

The IQOE Science Committee (SC) has the primary responsibility for coordination and management of IQOE activities that are international in nature. The main duties of the IQOE SC include the following:

- Advocate for and coordinate international activities of the IQOE Science Plan
- Review and report annually on progress in project implementation
- Refine the future project agenda annually and propose updates to the Science Plan as necessary
- Develop and oversee any subcommittees, working groups, and task teams necessary to implement international activities related to the IQOE Science Plan
- Establish and oversee the IQOE International Project Office (IPO) and its staff
- Serve as a resource for national committees
- Organize planning workshops as needed to establish research and observational priorities
- Promote partnerships with other projects and organizations to achieve IQOE goals
- Promote discussion about IQOE benefits with and among all stakeholders
- Endorse proposals for activities that are directly within the IQOE Science Plan or whose results can add to IQOE
- Define IQOE products
- Seek financial resources from national and international funding sources to support the implementation of IQOE
- Foster dissemination of the findings of the IQOE program
- Define indicators and metrics for evaluation and demonstration of IQOE progress

Co-Chairs: George Frisk (USA) and Peter Tyack (UK)

Other Members: Olaf Boebel (Germany), Bishwajit Chakraborty (India), Christ de Jong (The Netherlands), Robert McCauley (Australia), Jennifer Miksis-Olds (USA), Hanne Sagen (Norway), Steve Simpson (UK), Jakob Tougaard (Denmark), and Alexander Vedenev (Russia)

Executive Officer: None

Executive Committee Reporter: Sergey Shapovalov

IQOE News – June 2018

IQOE has been busy since the last message to the IQOE email list in January. The IQOE Science Committee (SC) met for the third time on 12-14 March 2018 at the Bremerhaven, Germany at the Alfred Wegener Institute. The SC received national reports from SC members, updates from IQOE working groups and endorsed projects, and presentations from related projects, organizations, and agencies conducting IQOE-relevant work. Decisions included the following:

- IQOE will continue to seek additional liaisons and endorsed projects
- A supplement to the *IQOE Science Plan* will be written, to update the Executive Summary and implementation activities.
- IQOE will consider draft terms of reference and membership for a working group on opportunities for observing ocean soundscapes before and after moving of shipping lanes, before and after infrastructure projects, etc.
- The IQOE brochure will be revised and distributed at relevant meetings.

Publications Referring to IQOE—Three publications appeared since January referring specifically to IQOE:

- [Miksis-Olds, J.L., B. Martin, and Peter L. Tyack. 2018. Exploring the Ocean Through Soundscapes. *Acoustics Today* 14\(1\):26-34.](#)
- [Williams, R., C. Erbe, I.M.I. Dewantama, and I.G. Hendrawan. 2018. Effect on ocean noise: Nyepi, a Balinese day of silence. *Oceanography* 31\(2\)](#)
- [POGO Task Force on Ocean Biological Observations. 2018. White paper.](#)

Endorsed projects—IQOE has issued five endorsement letters and three of the endorsed projects have been funded; one is still under consideration. IQOE would like to endorse any research project or observation activity that is relevant to IQOE. Information about the endorsement process and endorsed projects can be found at <http://www.iqoe.org/projects>.

Website Improvements and Needs for Input: Features continue to be added to the IQOE Website to make it more useful for the global community of scientists working in the area of ocean acoustics and bioacoustics. Since January, we have added a portal to acoustic data (<http://www.iqoe.org/acoustic-data-portal>), a portal to Websites with information about marine animal sounds (<http://iqoe.org/marine-animal-sounds>), and a page listing organizational liaisons to IQOE (<http://iqoe.org/liaisons>). The IQOE Aquatic Acoustic Archive (<http://iqoe.org/library>) now includes 4,493 references and abstracts.

We still need help from the community to do the following:

- update the database of passive acoustic observatories (<http://iqoe.org/systems>),
- submit IQOE-relevant papers for the IQOE literature database,
- submit entries for the portal to acoustic data,
- submit entries for the portal to marine animal sounds, and
- submit projects for endorsement.

WG Progress—IQOE currently supports four working groups, each of which has made progress since January:

- *WG on Acoustic Measurement of Ocean Biodiversity Hotspots* (chaired by Aran Mooney, USA): this group held its first in-person meeting on 20-21 May 2018 at the Woods Hole Oceanographic Institution. The group is working on a “perspectives” paper on the use of passive acoustics to assess and monitor diversity of marine life. The group also explored the issue of how to help with the identification of unknown sounds made by marine organisms, through an on-line portal, publication, or some other approach.
- *WG on Arctic Acoustic Environment* (co-chaired by Hanne Sagen, Norway and Philippe Blondel, UK): the co-chairs of this group met in February 2018 to do planning for the group’s activities. Dates are being sought for the first in-person meeting; in the meantime, subgroups of the working group will meet at POLAR-2018 in Davos, Switzerland in June 2018 and at the Acoustical Society of America Meeting in Victoria, B.C., Canada in November 2018.
- *WG on Data Management and Access* (chaired by Rob McCauley, Australia): members of this group have held two conference calls and are discussing with the IQOE Science Committee the requirements for IQOE data management.
- *WG on Standardization* (co-chaired by Christ de Jong and Michael Ainslie, Netherlands): this group has created an [Inventory of Existing Standards for Observations of Sound in the Ocean](#) and is working on an overview of calibration facilities for hydrophones.

POGO IQOE Working Group—This group, formed and supported by the Partnership for Observation of the Global Oceans (POGO), conducted two tasks: (1) liaison with the IQOE Web developer to create the online version of the IQOE database of observing systems (<http://iqoe.org/systems>) and (2) creation of an acoustic Essential Ocean Variable (EOV) specification, which is being considered by the Global Ocean Observing System (SOOS) Steering Committee.

ASA Forum—IQOE convened a Forum on Approaches for Studying Effects of Sound on Marine Organisms and Ecosystems on 6 May 2018, in conjunction with the meeting of the Acoustical Society of America meeting in Minneapolis, Minnesota, USA. The recommendations of the meeting have been forwarded to the IQOE Science Committee for action. Forum participants were interested in forming an IQOE working group to make it easier for acoustic and bioacoustic data to be used by managers.

OceanObs’19—The OceanObs series of meetings, at 10-year intervals, have been a major tool of the ocean observation and research communities and agencies to shape the development of GOOS. OceanObs’19 will be held in Honolulu, Hawaii, USA on 16-20 September 2019. Scientists involved in IQOE submitted an abstract to propose a white paper on adding passive acoustics to GOOS. The ideas in this abstract will be combined with the ideas contained in three abstracts on active acoustics, to create a white paper on ocean acoustics for OceanObs’19. From IQOE, Hanne Sagen and Jennifer Miksis-Olds are on the leadership team for this white paper.

Capacity Building—The Scientific Committee on Oceanic Research (SCOR), one of IQOE’s sponsors, is supporting the participation of two students from Brazil to participate in the

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[SeaBASS Summer School](#) on 8-13 July 2018 at the University of New Hampshire. IQOE is exploring the possibility of holding an international summer school on IQOE-related topics in 2019 or 2021.

Stakeholder Engagement

- United Nations— The United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea picks a topic for consideration each year. For 2018, the topic is anthropogenic underwater noise (see http://www.un.org/Depts/los/consultative_process/consultative_process.htm). This issue will be the focus of discussions at the UN Headquarters in New York City on 18-22 June 2018. Peter Tyack (participating on a science panel) and Jesse Ausubel will represent IQOE at this event.

IQOE submitted a list of peer-reviewed references regarding sound effects in the ocean, organized by sound source in 2017 (see <http://iqoe.org/sites/default/files/files/References%20to%20UN.pdf>), which was updated in 2018 (see [http://iqoe.org/sites/default/files/files/References%20to%20UN-V2\(1\).pdf](http://iqoe.org/sites/default/files/files/References%20to%20UN-V2(1).pdf)).

- Industry—Jesse Ausubel made a presentation on IQOE to the World Ocean Council in Halifax, Nova Scotia, Canada in November 2017.

National/Regional Activities

- Europe: The first tethered underwater sound measurement station has been deployed in the North Sea as part of the IQOE-endorsed project JOMPANS (<http://www.northsearegion.eu/jomopans/>).
- UK: The [UK Sound Forum](#) met on 20 June 2018.
- USA: The [U.S. Quiet Ocean Project](#) will hold a data “standards” workshop on 6-7 August 2018 in Washington, D.C. The IQOE-endorsed ADEON project (<https://adeon.unh.edu/>) is well underway, with the next ADEON cruise on the R/V *Endeavor* leaving on 6 June and returning on June 25. The cruise blog is at <https://adeon.unh.edu>.

IQOE Email List: IQOE maintains an email list containing your first name, surname, and email address. We do not collect or store any additional information or share our email list with other organizations. If you wish to unsubscribe from the IQOE email list at any time, please click the “Unsubscribe” link at the bottom of this page.

3.4 Second International Indian Ocean Expedition

Burkill

Terms of Reference:

Co-Chairs: Peter Burkill (SCOR), Vladimir Ryabinin (IOC), and Satheesh Shenoi (IO-GOOS)

Other Members of Core Group: Faiza Al-Yamani (Kuwait), Kentaro Ando (Japan), Zainal Arifin (Indonesia), M.A. Atmanand (India), Rezah M. Badal (Mauritius), Hermann Bange (Germany), Cynthia Chandler (USA), Nick D'Adamo (Australia), Jerome Dyment (France), Joaquim Goes (USA), Johnson Kazungu (Kenya), Somkiat Khokiattiwong (Thailand), Ben Milligan (UK), Yukio Masumoto (Japan), Adrian Matthews (UK), Shailesh Nayak (India), Harrison O. Ong'anda (Kenya), Chari Pattiaratchi (Australia), Rajan Sivaramakrishnan (India), Amit Tandon (USA), Jerome Vialard (France), P.N. Vinayachandran (India), and Nasser H. Zaker (Iran)

Executive Officers: Nick D'Adamo (IOC) and Satya Prakash (INCOIS)

Executive Committee Reporter: Peter Burkill

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3.5 Integrated Marine Biosphere Research (IMBeR) project (joint with Future Earth)

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: Carol Robinson (UK)

Vice-Chairs: Marion Glaser (Germany), Eugene Murphy (UK), Cisco Werner (USA)

Other Members: Laurent Bopp (France), Dan Costa (USA), Chris Cvitanovic (Australia), Mark Dickey-Collas (Denmark), Rubén Escibano (Chile), Gerhard Herndl (Austria), Alistair Hobday (Australia), Oscar Iribarne (Argentina), Olav Sigurd Kjesbu (Norway), Frank Muller-Karger (USA), Alice Newton (Portugal), Suvaluck Satumanatpan (Thailand), David VanderZwaag (Canada), Ingrid van Putten (Australia), and Ying Wu (China-Beijing).

Executive Committee Reporter: Peter Burkill

Executive Officer: John Claydon

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Integrated Marine Biosphere Research (IMBeR)

Annual Report to SCOR 2017-2018

A. Introduction

The Integrated Marine Biosphere Research project (IMBeR) is a global environmental change research initiative co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and Future Earth.

In 2016, IMBeR produced a science and implementation strategy for the next decade, underpinned by the vision, “*Ocean sustainability under global change for the benefit of society*”.

This vision recognises that the evolution of marine ecosystems (including biogeochemical cycles and human systems) is linked to natural and anthropogenic drivers and stressors, as articulated in the new IMBeR research goal to “*Understand, quantify and compare historic and present structure and functioning of linked ocean and human systems to predict and project changes including developing scenarios and options for securing or transitioning towards ocean sustainability*”.

To implement its new vision and goal, IMBeR’s mission is to “*Promote integrated marine research and enable capabilities for developing and implementing ocean sustainability options within and across the natural and social sciences, and communicate relevant information and knowledge needed by society to secure sustainable, productive and healthy oceans*”.

IMBeR science aims to foster collaborative, interdisciplinary and integrated research that addresses important ocean and social science issues and provides the understanding needed to propose innovative societal responses to changing marine systems. Implementation of the new IMBeR Science Plan is underpinned by the International Project Office (IPO) in Bergen, Norway, sponsored by the Institute of Marine Research (IMR) and the Norwegian Research Council, and the Regional Project Office (RPO) in Shanghai, China supported by the State Key Laboratory of Estuarine and Coastal Research (SKLEC) at the East China Normal University (ECNU). The IMBeR research goal is progressed through the activities of regional programmes, working groups and endorsed projects, and is facilitated through focussed workshops (IMBIZOs), conferences and symposia and the training of early career researchers at biennial Climate/Ecosystem (ClimEco) summer schools.

B. Science Plan (2016-2025)

The Science Plan and Implementation Strategy (SPIS; 2016-2025) is developed around three Grand Challenges (GC), focussing on climate variability, global change and drivers and stressors. The qualitative and quantitative understanding of historic and present ocean variability and change (Grand Challenge I) are the bases for scenarios, projections and predictions of the future (Grand Challenge II). These are linked in Grand Challenge III to understand how humans are causing the variability and changes, and how they, in turn, are impacted by these changes, including feedbacks between the human and ocean systems. Priority research areas with overarching and specific research questions are identified for each Grand Challenge. The Grand Challenges are supplemented with four Innovation Challenges (IC) that focus on new topics for IMBeR where research is needed and where it is believed

that major achievements can be made within three to five years. The Innovation Challenges also provide a means for IMBeR to adjust its focus as major science discoveries are made and new priorities arise. During 2017 we mapped the activities of the regional programmes, working groups and innovation challenges on to the objectives of the Grand Challenges and allocated specific members of the Scientific Steering Committee to oversee each of these objectives (Figure 1).

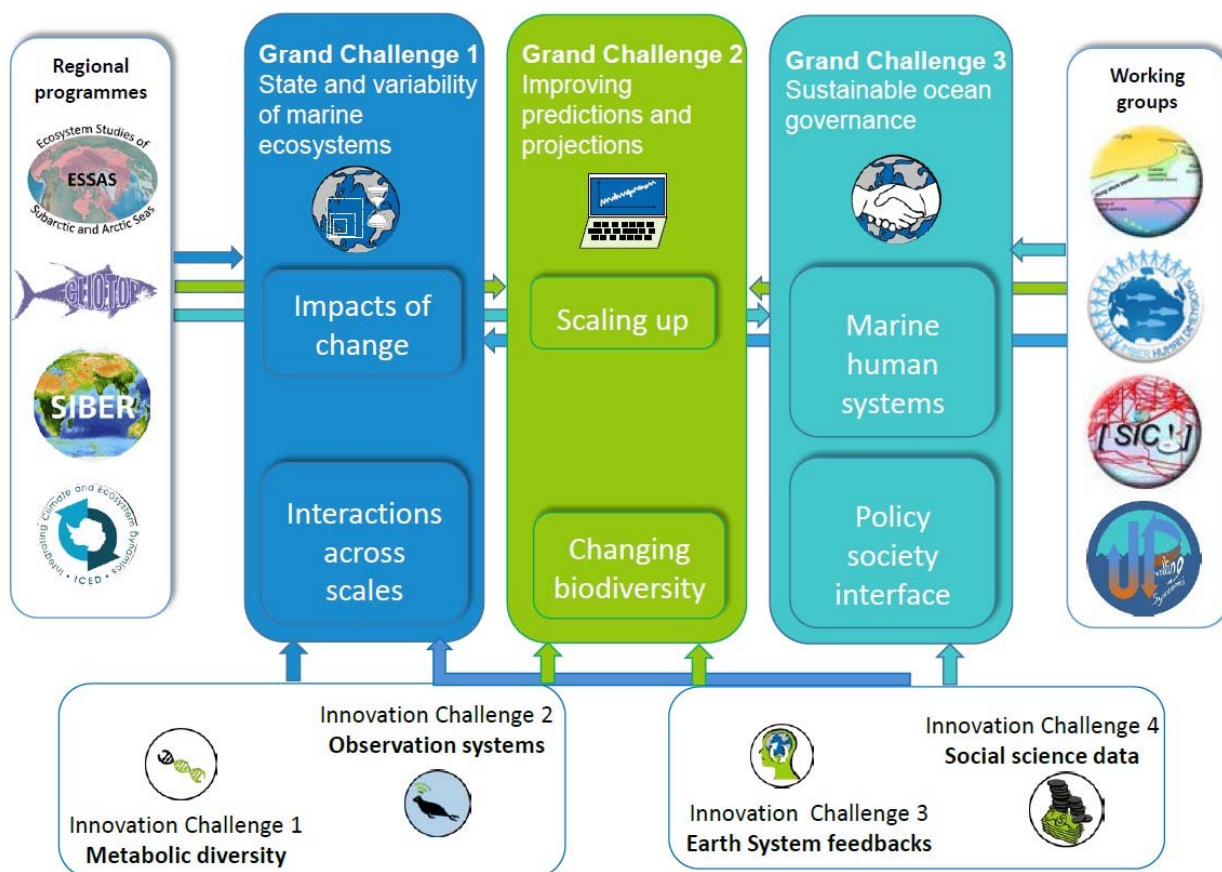


Figure 1. Contribution of the regional programmes, working groups and Innovation Challenges to the objectives of the Grand Challenges

C. Selected science highlights in 2017

A list of publications is given in section K, and activities that have specifically progressed the objectives of the Science Plan are given in section G. Here we identify a selection of studies where IMBeR has contributed to the progression of fundamental knowledge in marine ecology and biogeochemistry.

1. ICED scientists led a multidisciplinary study to assess potential climate change impacts on Southern Ocean ecosystems. The study, which was published in *Frontiers in Marine Science* <http://dx.doi.org/10.3389/fmars.2017.00308>, and featured as a research highlight in *Nature Climate Change* <https://www.nature.com/articles/nclimate3408.pdf?origin=ppub>

stresses the need for an integrated approach to best use climate-model data for ecological insights. As an example, they consider the implications for Antarctic marine ecosystems of changes in sea ice.

2. ICED has emphasized the importance of developing quantified understanding of the life cycles of key species such as Antarctic krill (*Euphausia superba*) in Southern Ocean ecosystems. This study developed and applied an empirical relationship of growth rate to assess seasonal spatial variability in the growth of Antarctic krill throughout the Southern Ocean. It showed that over much of the ocean, the potential for growth is limited, and indicated that there are three restricted oceanic regions where seasonal conditions permit high growth rates, and only a few areas around the Scotia Sea and Antarctic Peninsula suitable for growth of the largest krill (>60 mm). The study demonstrated that projections of impacts of future change need to account for spatial and seasonal variability of key ecological processes within ocean ecosystems. Murphy, E.J. et al., (2017) Scientific Reports 7, 6963. <http://www.nature.com/articles/s41598-017-07205-9>
3. A special issue of *Deep-Sea Research II* outlines research arising from the CLIOTOP (Climate Impacts on Oceanic Top Predators) regional programme 2015 symposium, spanning topics such as conservation biology, trophic ecology, fisheries science, climate change and adaptive management (Hobday et al., 2017; doi:10.1016/j.dsr2.2017.03.008).
4. The CLIOTOP Task Team 2016-02 aims to build policy relevant scenarios for the sustainability of global oceanic ecosystems and fisheries. Maury et al., (2017; <http://dx.doi.org/10.1016/j.gloenvcha.2017.06.007>) developed five contrasting Oceanic System Pathways (OSPs) based on the shared socioeconomic pathways used in climate change research. These OSPs have been chosen to form the official scenario basis of the FishMIP (Fisheries Model Inter-Comparison initiative), the marine component of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP), used to inform model studies in the context of IPCC and IPBES.
5. SIBER has been working to motivate synthesis papers related to the research themes that are articulated in the SIBER Science Plan. The first of these papers on biogeochemical and ecological impacts of boundary currents in the Indian Ocean was published in *Progress in Oceanography* in 2017 (Hood et al. 2017; <https://www.sciencedirect.com/science/article/pii/S0079661117301507>). Evidence from the paleoceanographic record suggests that boundary currents in the Indian Ocean basin have changed significantly over glacial to interglacial timescales. These changes are explored as a means of providing insight into the potential biogeochemical and ecological impacts of climate change in the Indian Ocean.
6. The SOLAS-IMBeR Ocean Acidification Working Group, working through the IAEA Ocean Acidification International Coordination Centre (OA-ICC), has continued efforts to improve the computation of derived variables of the marine carbonate system in Earth system models in order to project the impacts of decreasing pH on marine organisms (Kwiatkowski, L., & Orr, J. C. 2018. Diverging seasonal extremes for ocean acidification during the twenty-first century. *Nature Climate Change*, 8(2), 141

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<http://www.nature.com/articles/s41558-017-0054-0>). Results suggest that projected seasonality changes will tend to exacerbate impacts during the summer and ameliorate impacts during the winter.

7. The Arctic Ecosystem Integrated Survey (Arctic Eis) in the Pacific Arctic (Northern Bering Sea and Chukchi Sea) is an ESSAS-affiliated project which came to an end in 2017. Detailed results can be accessed at <https://web.sfos.uaf.edu/wordpress/arcticeis/> and were published in a special issue of *Deep-Sea Research Part II* (<http://dx.doi.org/10.1016/j.dsr2.2016.11.005>). A few of the highlights include: (a) high densities of young-of-year Arctic cod (*Boregadus saida*), an ecologically important species in the Arctic that is also of potential commercial interest were, for the first time, observed in the northeast Chukchi Sea in 2012 and 2013, suggesting that this area is an important nursery area for the early life history stages of Arctic cod in the Pacific Arctic. (b) Plankton, fish and invertebrate species of Pacific origin typically dominate demersal and pelagic communities throughout the Chukchi Sea, highlighting the importance of advection of Pacific waters through Bering Strait into the Chukchi Sea. However, distinct Arctic populations of some species are associated with Arctic water masses on the northeast Chukchi Sea shelf, reflecting the intrusion of Arctic water masses from the basin onto the shelf. (c) Fishes and crab consume a large variety of pelagic and benthic prey in the Chukchi Sea and diets typically differ among species, water masses and with predator size. While juveniles and small forage fish rely primarily on zooplankton advected from the Bering Sea, there is an increasing reliance on benthic prey with increasing predator size.

D. Regional Programmes

Ecosystem Studies of Subarctic and Arctic Seas (ESSAS)

ESSAS objectives are to understand how climate variability and climate change affect the marine ecosystems of Subarctic and Arctic seas and their sustainability and, in turn, how changes in the marine ecosystems affect humans.

The third ESSAS Open Science Meeting was held in Tromsø, Norway in June 2017. The title of the meeting was *Moving in, out and across the Subarctic and Arctic marine ecosystems: shifting boundaries of water, ice, flora, fauna, people and institutions*. Nine theme sessions were on Paleo-Ecology; Advection and Mixing; Phenology; Shifting habitats and hotspots; Future Climate and its ecosystem effects; Multiple Stressors; Ocean Acidification; Science, Policy and Management; and a General Open Session. A total of 187 scientists of different disciplines from 11 countries attended the meeting. A special issue of the *ICES Journal of Marine Science* will be published by the end of 2018 containing some of the papers presented at the ESSAS OSM.

The Resilience and Adaptive Capacity of Marine Ecosystems in the Arctic (RACArctic) is an ESSAS initiative between Japan, the USA and Norway and is funded by the Belmont Forum. It is a 3-year project, with the objective to synthesize information from completed and ongoing regional studies in order to examine how variability and changes in advection, temperature, pH

and ice dynamics in the Subarctic to Arctic transition zone may affect future marine ecosystems of the Pacific and Atlantic Arctic. Of particular interest is how fish populations and their prey respond to, and may adapt to, natural and anthropogenic changes in the Arctic and how these responses are expected to affect existing and future fisheries, subsistence harvests, and the socio-economic systems that depend upon them. The second meeting was held in March 2017, in Juneau, Alaska, USA. It began with a 1-day stakeholders' meeting and was followed by a 2-day meeting of the Principal Investigators and other contributors. The main activity was the development of outlines for scientific papers on future climate scenarios, their ecological impacts and the challenges these represent for management.

ESSAS held its 2018 Annual Science Meeting in Fairbanks, Alaska in June 2018. A primary focus of the meeting was on remote sensing applications in the study of climate change impacts on high-latitude ecosystems. Additional sessions and workshops focused on ocean acidification and other stressors; the biology, ecology and paleoecology of Arctic Gadids, and the use of Integrated Ecosystem Assessments (IEA) as a framework for understanding and managing subarctic and Arctic marine ecosystems.

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

The ICED regional programme aims to better understand 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.

ICED scientist Jess Melbourne Thomas was selected as lead author of the Polar Regions Chapter for the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. The Special Report will build on the work of the IPCC's Fifth Assessment Report (AR5). A report outline was agreed in March 2017 and the report is scheduled to be finalized in September 2019. Other ICED scientists (including Dan Costa, ICED SSC) have been involved as contributing authors to the Changing Ocean, Marine Ecosystems, and Dependent Communities Chapter.

The Marine Ecosystem Assessment for the Southern Ocean: Assessing Status and Trends of Habitats, Key Species and Ecosystems in the Southern Ocean (MEASO2018) conference was organized in 2018 by ICED SSC member Andrew Constable. MEASO2018 marks the 10-year anniversary of ICED and provided an important opportunity for the ICED community to present its results. The outcomes of the conference are also expected to provide significant input to the Committee on Environment Protection, the Scientific Committee for the Conservation of Antarctic Marine Living Resources, the International Whaling Commission's Scientific Committee and other organisations interested in the management and conservation of Southern Ocean ecosystems.

CLimate Impacts on Oceanic TOP Predators (CLIOTOP)

The CLIOTOP regional programme organises large-scale comparative studies to elucidate key processes involved in the interaction between climate variability and change and human use of the ocean on the structure of pelagic ecosystems and large marine species. CLIOTOP scientists

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edited and contributed to a special issue of *Reviews in Fish Biology and Fisheries* <https://link.springer.com/journal/11160/27/4/page/1> focused on safeguarding the sustainability of tuna fisheries.

CLIOTOP scientists attended several regional and international meetings during 2017, including the VOICE (Variability in the Oxycline and its Impacts on the Ecosystem), GO2NE (Global Ocean Oxygen Network) meeting, regional workshops for the South Pacific and Indian Ocean in support of the second World Ocean Assessment, International Commission for the Conservation of Atlantic Tunas Standing Committee on Research and Statistics sub-committee on ecosystems, XIIth SCAR Biology Symposium, 6th Biologging Symposium, 22nd Biennial conference on the biology of marine mammals, and the 6th Mediterranean Oceanography Network for the Global Ocean Observing System (MonGOOS) meeting.

CLIOTOP Task team 2016-03 co-convened a session with the PICES forecasting group at the Fourth International Effects of Climate Change on the World's Oceans symposium in June 2018. CLIOTOP will hold its fourth international symposium in October 2018 at the National Taiwan Ocean University in Keelung, Taiwan.

Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER)

The SIBER regional programme is co-sponsored by the Indian Ocean GOOS (IO-GOOS), 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.

The 2nd International Indian Ocean Expedition (IIOE-2) was motivated by SCOR, SIBER, IOGOOS and IOP and has become the main scientific focus of SIBER. SIBER is now leading the development of a Science Plan to guide U.S. participation in IIOE-2. This effort was initiated with a U.S. IIOE-2 Science Planning Workshop, convened at Scripps Institution of Oceanography in September 2017. The U.S. IIOE-2 Science Plan was recently released. SIBER SSC members also helped to organize and participated in a joint South Korea-U.S. workshop in Seoul in 1 December 2017 that was aimed at developing a Science Plan to guide South Korea's participation in IIOE-2.

E. Working Groups

IMBeR-Future Earth Coasts Continental Margins Working Group (CMWG)

The CMWG aims to undertake and compare two socio-ecological case studies, one on the sparsely populated, but rapidly changing, Arctic continental margin, and one on the densely populated Chinese marginal seas. A first workshop to plan the Chinese marginal seas case study was convened at the XMAS-III conference in Xiamen, China in early 2017, and the second is planned to take place during the China/Japan/Korea Symposium to be held in Shanghai in October 2018.

Human Dimensions Working Group (HDWG)

The publication of the I-ADApT Synthesis book *Global Change in Marine Systems: Integrating natural, social and governing responses* was the major activity and output from the HDWG in 2017. The 7th HDWG meeting was held in France in 2017, members of the HDWG led the workshop on *Management Strategy Evaluation: Achieving transparency in natural resource management by quantitatively bridging social and natural science uncertainties* at IMBIZO5 in October 2017, and plan to provide a training course at the CJK symposium in September 2018.

IMBeR-CLIVAR Eastern Boundary Upwelling Systems Working Group (EBUS)

In 2017, EBUS submitted a successful proposal to form a SCOR Working Group 155, with the aim to synthesize existing knowledge on the different physical mechanisms occurring over diurnal, intraseasonal, interannual, decadal, and multidecadal timescales and their implications on water column properties, biogeochemical cycles, biodiversity, ecosystem structure and functioning and the regional climate of EBUS.

In collaboration with the CLIVAR EBUS Research Focus, EBUS organized a Session on EBUS at the 2018 Ocean Sciences Meeting on *Biophysical Dynamics of Eastern Boundary Upwelling Ecosystems in a Changing Ocean: Closing the Gap Between Wind Stress and Ecosystem Productivity*, and a session on *Eastern Boundary Upwelling Systems: diversity, coupled dynamics and sensitivity to climate change* was held at the 4th International Symposium on the Effects of Climate Change on the World's Oceans, in June 2018.

EBUS is engaged with the Ocean KAN (Knowledge-Action Network) of Future Earth through the membership of Ruben Escribano on the Development Team. A number of virtual and in-person meetings have taken place through 2017-2018.

SOLAS-IMBeR IOCCP Carbon working group (SIC)

A new carbon working group with participation of IMBeR, SOLAS, the Global Carbon Project and the SCOR and IOC-UNESCO International Ocean Carbon Coordination project (IOCCP) is being planned. A small group of scientists representing IMBeR, SOLAS, CLIVAR and IOCCP met at the International Carbon Dioxide Conference (ICDC10) in Switzerland in August 2017 and again at the Ocean Sciences Meeting in February 2018. A proposal for an integrated ocean carbon working group under the auspices of IOC will be presented to the IOC Executive Council in July 2018, with a first meeting scheduled for early 2019.

Version 6 of the Surface Ocean CO₂ Atlas (SOCAT) was released in 2018 <https://www.socat.info/>. SOCAT is a synthesis activity for quality-controlled, surface ocean fCO₂ (fugacity of carbon dioxide) observations by the international marine carbon research community (>100 contributors). The latest SOCAT version (version 6) has 23.4 million observations from 1957 to 2017 for the global ocean and coastal seas. Calibrated sensor data are also available. SOCAT data is publicly available, discoverable and citable. SOCAT enables quantification of the ocean carbon sink and ocean acidification and evaluation of ocean biogeochemical models.

SOLAS-IMBeR Ocean Acidification (SIOA)

The SOLAS-IMBER Ocean Acidification Working Group provides a key advisory role to the Ocean Acidification International Coordination Centre (OA-ICC), at the International Atomic Energy Agency in Monaco. During 2017, the SIOA led efforts of the OA-ICC to continue to support the establishment of the Global Ocean Acidification Observing Network (GOA-ON), a worldwide collaborative approach with the goal to expand ocean acidification monitoring and capacity building, especially in areas where there is little or no data, to improve software used by the scientific community working on ocean acidification to calculate carbonate chemistry parameters, and to update and improve best practices guidelines for ocean acidification research.

In June 2017, the OA-ICC co-organized a meeting of SCOR Working Group 149 focused on new best practices guidelines for complex multiple stressor experiments, including ocean acidification. A training workshop using the new tools is planned for October 2018, also in Monaco.

Selected highlights of SIOA can be found in the quarterly releases from the OA-ICC available on their web page at <https://www.iaea.org/ocean-acidification>.

F. Endorsed projects

Atlantic Meridional Transect (AMT)

AMT is a multidisciplinary programme that undertakes biological, chemical and physical oceanographic research during an annual voyage between the UK and destinations in the South Atlantic Ocean. The AMT provides a platform for scientists to capture and analyse data related to a range of oceanographic science areas. More than 256 scientists have participated in AMT cruises and many more have worked with AMT data, which are accessible through the British Oceanographic Data Centre (BODC). The data have been used to produce more than 300 scientific papers, and the long-term nature of the data collected is useful in analysing trends and forecasting future outcomes.

Gulf of Trieste Time series (GoTTs)

The Department of Biological Oceanography of the Italian National Institute of Oceanography and Experimental Geophysics is responsible for the Gulf of Trieste site as part of the Long Term Ecological Research network in the North Adriatic. The research activities, which have continued since 1970, range from marine biogeochemistry to ecology and are aimed at understanding the dynamics governing marine ecosystems and to evaluate the role of the ocean in the global energy balance.

Living-resource & Ecosystem Dynamics on the Slope of the South China Sea (LEDS)

The northern slope region of the South China Sea (SCS) is the breeding and nursing ground for commercially valuable fish species such as octopus and tuna. Their vertical migration behaviour potentially forms a key link between lower and higher trophic levels as they act as predators on zooplankton and as prey for bottom and pelagic fishes, and feed in the surface layer during the night while resting and excreting in the deep layer (400-1000m) during the day. This project aims to progress understanding of the role of mesopelagic fish in marine ecosystems, resource protection and utilization, and carbon sequestration in the ocean. Three cruises in the SCS have been conducted in the spring 2017, summer 2015 and fall 2014. During these cruises, remote sensing results of altimetry, ocean colour and sea surface temperature and model results of circulation, nutrient-chlorophyll distributions and Lagrangian Coherent Structure were used for planning and guiding survey areas and station locations; measurements and samples of hydrography, nutrients, microbes, plankton and nekton were taken by sensors, water samplers, plankton nets, trawls and acoustic devices at the same or near-same times and locations; and 2 moorings were deployed at the study area for long-term observations of hydrography and acoustic backscatter. The results revealed that while the surface ocean of the SCS is classically defined as an oligotrophic ocean with low nutrient and phytoplankton concentrations, there is an active layer of mesopelagic fish living in waters between 50 and 1000 m below the surface.

Ocean acidification and Biogeochemistry: variability, trends and vulnerability (VOCAB)

This project aims to address some of the gaps in our current knowledge of the vulnerability of selected marine ecosystems in Irish waters to ocean acidification (OA), by exploring some of the complex biogeochemical processes occurring at fine scales in selected ecosystems, and by studying the larger scale biogeochemistry of ocean waters impinging on those ecosystems. Fine-scale sampling will focus on three areas, one of direct commercial interest (shellfish aquaculture) and two of wider importance (kelp beds and deep water coral ecosystems). NUI Galway and the Marine Institute led the GO-SHIP A02 survey in April/May 2017. The survey had strong international collaboration with on-board teams from Canada, Germany, the UK, and the USA, and additional support from experts in Denmark and France. All GO-SHIP Level 1 parameters were sampled. Analysis of all biogeochemical samples was carried out on board, with a number of laboratory containers set up on the deck of the ship. The last time the full A02 line was carried out was in June 1997 by WOCE.

Ocean Foodweb Patrol – Climate Effects: Reducing Targeted Uncertainties with an Interactive Network (OCEAN CERTAIN)

The goals of OCEAN CERTAIN, which ended in 2017, were to (1) determine qualitative and quantitative changes in the functionalities of the foodweb and the efficiency of the biological pump to export carbon as a response to multi-stressors, (2) identify the interactions (impacts and feedbacks) between climate-related oceanic processes and global climate dynamics, (3) integrate marine ecosystem scenarios with probable socio-economic scenarios to help estimate/quantify human feedbacks to the coupled socio-ecological system, relevant to mitigation and adaptation pathways, (4) develop scenario-based impact prediction capacity, and (5) produce and test decision support tools and systems and assess their ability to support the

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sustainable exploitation of marine resources. Results from the OCEAN CERTAIN project showed an enhanced link between temperature and jellyfish abundance after the 1980s. In the Mediterranean, the synergistic effects of climate and commercial fishing have shifted the pelagic food web dynamics to a state of recurrent massive jellyfish bloom events. The massive jellyfish blooms have had dramatic impacts on ecosystem functioning, fisheries and tourism in the Mediterranean. OCEAN CERTAIN also developed a user-friendly decision support system (DSS) that allows for an integrated analysis of the environmental and social-economic impacts of changes to the ocean food web under different stressor/policy combinations. This DSS combines scientific knowledge and data with local stakeholder knowledge for the three case studies (Mediterranean, Barents Sea and Patagonia). The DSS setup files, and documentation will be made available through the OCEAN CERTAIN web site (www.oceancertain.eu).

Processes and Approaches of Coastal Ecosystem Carbon Sequestration (PACECS)

The aim of PACECS is to investigate the key processes and mechanisms of carbon sequestration in coastal ecosystems in order to propose ways in which to increase the ocean carbon sink. Most of this 'Blue Carbon Sink' resides in the biomass of phytoplankton, bacteria, archaea, and protozoa, and so maximising the efficiency of this sink requires fundamental knowledge of the dynamics of marine microbes.

The Study of Kuroshio Ecosystem Dynamics for Sustainable Fisheries (SKED)

This interdisciplinary study aims to investigate the paradox of high fisheries production in the low-nutrient Kuroshio western boundary current of the North Pacific Ocean, in order to ensure sustainable use of this ecosystem.

Mechanisms of Marine Carbon Storage and Coupled Carbon, Nitrogen and Sulphur cycles in response to global change (MCS-CNS)

The sensitivity of marine biogeochemical cycles to climate change remains unclear, especially for key processes that influence the long-term health of marine ecosystems. By understanding the interactions between the microbial carbon pump and the biological carbon pump, this project aims to decipher the mechanisms of marine carbon storage, and the response of biogeochemical processes to climate change and anthropogenic activities.

Marine Ecosystem Modelling and Forecasting System in the China Seas and Northwestern Pacific (MEMFiS)

Focusing on the ecology of the Bohai, Yellow, East and South China seas, and the Northwestern Pacific, the MEMFiS project aims to develop an integrated modelling and forecasting framework, using high-resolution physical-ecosystem models and data from multiple sources. By investigating ecosystem variability at different temporal and spatial scales, several key scientific questions will be tackled. Marine ecosystem variability will be addressed at the interface of different systems, parameterizations optimized for biogeochemical processes in different regions, data assimilation and ecosystem forecasting using multiple observations not

only from moorings, buoys and ships, but also from bio-Argo, gliders and high-resolution satellite imagery.

Variability of Ocean Ecosystems around South America (VOCES)

The goal of this project is to assess the impact of climate variability - both natural and anthropogenic - on the Humboldt, Patagonia and South Brazil Large Marine Ecosystems (LMEs) which are amongst the most productive in the Southern Hemisphere.

Integrated Arctic Observation System (INTAROS)

INTAROS will develop an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. An integrated Arctic Observation System will enable better-informed decisions and better-documented processes within key sectors (e.g. local communities, shipping, tourism, fishing), in order to strengthen the societal and economic role of the Arctic region.

G. Implementation of the Science Plan in 2017

The IMBeR regional programmes and working groups are working towards the research goal outlined in the SPIS (2016-2025). Progress towards achieving the objectives of the SPIS Challenges during 2017 is outlined below:

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

The Challenge: To develop whole system level understanding of ecosystems, including complex biogeochemical cycles and human interactions, together with understanding of the scales of spatial and temporal variability of their structure and functioning.

Progress towards this challenge is led by IMBeR SSC members Cisco Werner and Alistair Hobday.

ESSAS contributes to this challenge through The Resilience and Adaptive Capacity of Marine Ecosystems in the Arctic (RACArctic) initiative, which examines how variability and changes in advection, temperature, ocean acidity and ice dynamics in the Subarctic to Arctic transition zone may affect future marine ecosystems of the Pacific and Atlantic Arctic.

ICED has continued to develop whole ecosystem level understanding of the structure and functioning of Southern Ocean ecosystems, their variability and response to change across a range of spatial and temporal scales. They have focused detailed work on key species from phytoplankton to whales (Arthur et al. 2017, Kaufman et al. 2017, Meyer et al. 2017), and the structure of food webs (e.g., Saunders et al. 2017). They have also examined physical, chemical and biological interactions (e.g., Belcher et al. 2017, Beekmans 2017) and the effects of past (Tarling et al. 2018) and recent variability and change, such as ocean acidification (e.g., Manno et al. 2017, Peck et al. 2017, Trimboune et al. 2017).

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The long-term overarching goal of SIBER is to improve understanding of the role of the Indian Ocean in global biogeochemical cycles and the interaction between these cycles and marine ecosystem dynamics. In order to quantify the state and variability of Indian Ocean ecosystems, and importantly, the physical forcing that drives this variability, SIBER was instrumental in fostering the development of the 2nd International Indian Ocean Expedition (IIOE-2) and the Eastern Indian Ocean Upwelling Research Initiative (EIOURI).

CLIOTOP Task team 2017-01 has been progressing work analysing isotope data from mid-top predators collected across multiple regions and ocean basins and developing methods for integrating multiple trophic assessment methods (isotopes, fatty acids, mercury and ecosystem models) to better understand marine trophodynamics. The task team has grown its membership, expanding the scope of methodologies that the task team uses to understand climate impacts on marine food webs and the regions from which data have been collected. The task team provided a summary of their work for the IMBeR website (<http://www.imber.info/en/news/expanding-marine-predator-isotopework-community-level-metrics-mercury-isotopes-and-data-modellinkages>) and published the following paper: Houssard, P. et al. 2017. Trophic position increases with thermocline depth in yellowfin and bigeye tuna across the Western and Central Pacific Ocean. *Progress in Oceanography*, 154, pp.49-63.

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

The Challenge: To incorporate understanding of the drivers and consequences of global change on marine ecosystems and human societies at multiple scales into models to project and predict future states.

Progress towards this challenge is led by IMBeR SSC members Laurent Bopp and Eugene Murphy and was the focus of one of the workshops at the IMBIZO5 conference in October 2017.

An initiative to produce policy-relevant future scenarios of ecosystem services in the oceanic realm was recently published (Maury et al., 2017), and the five contrasted Ocean System Pathways (OSPs) developed have been chosen to form the official scenario basis of FishMIP (the Fisheries Model Inter-comparison initiative).

A dataviz tool is under development to provide easy access to the recent CMIP5 climate model projections for ocean ecosystem stressors (warming, pH, oxygen, primary productivity). This tool will enable selection of any ocean region, and show visualization of projections for surface temperature, surface pH, sub-surface oxygen, integrated primary production.

ICED has continued its Model Development Activity in support of creating a suite of models of physical dynamics (ocean circulation and climate), biogeochemical cycles, and biological dynamics (life histories, population dynamics, food web structure) within a hierarchical framework of models of different spatial, temporal and trophic resolution. The ultimate aim of these activities is to advance end-to-end ecosystem modelling approaches that integrate physical, chemical and biological processes. Recent work includes Dinniman et al. 2017, Freer et al. 2017, Kruger et al. 2018, Silber et al. 2017, Murphy et al. 2017, Meyer et al. 2018, and Klein et al. 2018.

ICED has continued its work on developing scenarios of key drivers and projections of ecological change in the Southern Ocean. This has included the publication of the community paper Cavanagh et al. 2017 A Synergistic Approach for Evaluating Climate Model Output for Ecological Applications doi:10.3389/fmars.2017.00308 and the organization, in collaboration with the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), of a workshop in April 2018 to further the scenarios and projections work.

Grand Challenge III: Improving and achieving sustainable ocean governance

The Challenge: To improve communication and understanding between IMBeR science, policy and society to achieve better governance, adaptation to and mitigation of global change, and transition towards ocean sustainability.

This challenge is led by SSC members Marion Glaser, Ingrid van Putten and Mark Dickey-Collas.

One of the objectives of ICED is to determine how Southern Ocean ecosystem structure, functioning and projections should be incorporated into adaptation, mitigation and sustainable management procedures by improving communication and understanding between science, policy and society.

ICED scientists have been involved in the agreement to establish the world's largest Marine Protected Area (MPA), in Antarctica's Ross Sea, via the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). This new MPA came into force in December 2017 and will limit, or entirely prohibit, certain activities in order to meet specific conservation, habitat protection, ecosystem monitoring and fisheries management objectives. Seventy-two percent of the MPA will be a 'no-take' zone, which forbids all fishing, while other sections will permit some harvesting of fish and krill for scientific research. This is a significant achievement and has been several years in the making.

ICED scientists have also continued to engage with CEP (the Antarctic Treaty's Committee for Environmental Protection) and submitted an Information Paper to the 2017 ATCM (ICED, 2017) outlining the role that ICED can continue to play in providing information on climate change impacts on ecosystems to the Antarctic Treaty.

CLIOTOP Co-chair Karen Evans led the chapter on the South Pacific for the first global integrated marine assessment (produced by the United Nations), providing an assessment on the

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state of the marine environment throughout the region, key pressures impacting the marine environment and associated ecosystem services, and identifying factors for sustainability throughout the region. Karen also contributed to a series of three technical abstracts developed from the first assessment for use by policy makers focused on (i) the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction, (ii) the impacts of climate change on the oceans and (iii) the ocean and sustainable development goals under the 2030 Agenda for Sustainable Development. The assessment and technical abstracts were endorsed by the General Assembly of the United Nations and launched at the Ocean Conference in June 2017. The assessment and technical abstracts are available at http://www.un.org/Depts/los/global_reporting/global_reporting.htm.

There is a heightened demand from countries to build capacity to report on Target 3 of the UN Sustainable Development Goal 14 that specifically addresses Ocean Acidification. The SIOA and OA-ICC provide coordination, activities, and resources to help Member States address this target. Several SIOA members, GOA-ON, and the OA-ICC are involved in developing methodologies for the SDG14.3.1 indicator (ocean acidity) led by IOC- UNESCO. They attended an expert meeting focused on that topic in January 2018 in Paris. More information can be found at <https://news-oceanacidification-icc.org/2018/02/22/update-to-sdg14-3-voluntarycommitment-enhancing-global-ocean-acidification-monitoring-and-research-by-go-on/>.

Innovation Challenge 1 To enhance understanding of the role of metabolic diversity and evolution in marine biogeochemical cycling and ocean ecosystem processes.

Progress towards completion of this challenge was led by SSC members Gerhard Herndl and Tatiana Rynearson. The first activity was a workshop at the IMBIZO5 meeting in October 2017 and the preparation of a synthesis paper describing current understanding of metabolic diversity in the light of environmental change and identification of approaches needed to include metabolism and evolution in marine ecosystem models. Future conference sessions are planned, including one at the ASLO meeting in early 2019, and one at the IMBeR Open Science Conference in June 2019.

Innovation Challenge 2 To contribute to the development of a global ecosystem observational and modelling network that provides essential ocean variables (EOVs) and to improve marine data and information management.

IMBeR aims to achieve this challenge through collaboration with ongoing international observing initiatives. One of the most relevant is the Global Ocean Observing System (GOOS) of the IOC-UNESCO through their Biology and Ecosystems Panel whose membership includes two IMBeR SSC members: Dan Costa and Frank Muller-Karger.

Dan Costa and CLIOTOP Co-Chair Kevin Weng participated in the GOOS and the OceanObs Research Coordination Network workshop on **Implementation of Multi-Disciplinary Sustained Ocean Observations** in February 2017. This workshop was tasked with identifying priorities for improving the coordinated planning and implementation of multi-disciplinary observing activities and demonstrations, by bringing together experts in physical,

biogeochemical and biological/ecosystems ocean observations and modelling, users of established observing networks, and communities of practice.

Dan Costa is a co-author of a SOOS manuscript on the Western Antarctic Peninsula for *Progress in Oceanography*, a contributing author for the IPCC special report for **Oceans and Cryosphere in a Changing Climate** and attended the **Biologging conference** in Germany in September 2017.

Several CLIOTOP members provided feedback on a draft paper on essential ocean variables (EOVs) for fish abundance and distribution, and Dan Costa is drafting the EOV text for marine mammals and seabirds for the GOOS Biology and Ecosystems Panel.

CLIOTOP Task team 2016-04 Operational Oceanography in support of Sustainable Top Predators (OOSTOP) launched its website in late 2017, aimed at improving knowledge transfer between people working on operational oceanography, marine species biology, conservation and management; that is, improving the ocean observation-science-policy interface. See <https://oostop.wixsite.com/oostop>.

Innovation Challenge 3 To advance understanding of ecological feedbacks in the Earth System.

This challenge is led by SSC members Laurent Bopp and Eugene Murphy, who have prepared a scoping document assessing which Earth System Models enable potential feedbacks to occur and which do not. Following Hense et al. (2017) *Biogeosciences* 14, 403, they reviewed the three major climate feedback loops of atmospheric CO₂ and the biological carbon pump, marine biota and air-sea fluxes of climate forcing agents such as dimethylsulphide and nitrous oxide, and the influence of marine ecosystems on heat transfer and mixing of the ocean. Links with the WCRP Grand Challenge on Carbon Feedbacks in the Earth System, the SOLAS, IMBeR, IOCCP carbon working group, the SCOR IMBeR SOLAS CLIVar EBUS working groups and FISH-MIP were identified as potential ways to progress the research questions of this challenge possibly through a workshop at the IMBeR Open Science Conference.

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

This Innovation Challenge is championed by the Human Dimensions Working Group. They have initiated conversations with the Human Dimensions groups of other projects, including MSEAS, ICES and PICES about using social science data in ocean management, and are planning to organise a workshop, possibly at the IMBeR Open Science Conference, to plan the way forward.

ICED scientists have been actively developing studies to expand analyses of ecosystems to consider human social and economic system interactions. Following IMBIZO IV, Stuart Corney and Eugene Murphy have been working on an opinion piece “Integrating human dimensions into marine ecosystem models will improve management” that is under review with *Fish and Fisheries*.

H. Other IMBeR activities

IMBIZO 5

The fifth IMBIZO conference ‘Marine biosphere research for a sustainable ocean: Linking ecosystems, future states and resource management’ was held in October 2017 at the Woods Hole Oceanographic Institution, USA. Three concurrent, but interacting, workshops aimed to progress specific aspects of the IMBeR Science Plan. These were (1) Critical Constraints on Projections of Marine Systems (Laurent Bopp and Eric Galbraith), (2) Metabolic Diversity and Evolution in Marine Biogeochemical Cycling and Ocean Ecosystem Processes (Gerhard Herndl and Tatiana Rynearson) and (3) Managing Strategy Evaluation: Achieving Transparency in Natural Resource Management by Quantitatively Bridging Social and Natural Science Uncertainties (Ingrid van Putten and Cisco Werner).

Early Career Researcher Network

The Interdisciplinary Marine Early Career Network (IMECaN) was recently established to provide opportunities for the growing network of IMBeR early career researchers and students, to become more involved with IMBeR and to create more networking and collaborative possibilities. Terms of Reference were approved by the IMBeR Executive Committee, and Chris Cvitanovic (Australia) was appointed as the first early career representative on the IMBeR SSC in January 2018.

IMECaN convened a capacity building workshop in Losinj, Croatia in June 2018 to enable EU-based early career marine researchers to operate effectively at the science-policy-society interface. The IMECaN Organising Committee held its first meeting in conjunction with the workshop to plan future events and activities. The next IMECaN event will be a workshop at the IMBeR Future Oceans2 Open Science Conference in June 2019.

ClimEco6 Summer School August 2018

The sixth IMBeR ClimEco summer school will be held at the Gadjadara University in Yogyakarta, Indonesia on 1-8 August 2018. Almost 200 applications from 57 countries were received for the 60 available places. The theme of the summer school is “Interdisciplinary approaches for sustainable oceans” and participants will be provided with practical ways to deal with the challenges arising from working across social and natural science disciplines.

IMBeR is very grateful to SCOR for the travel support provided to five participants from developing countries.

IMBeR China/Japan/Korea Symposium 2018

The next CJK symposium will be held in Shanghai in September 2018.

IMBeR Open Science Conference 2019

The next IMBeR OSC will be held in Brest, France in June 2019.

International Project Office (IPO, Norway)

Gro I. van der Meeren resigned as the Executive Officer in June 2017. Lisa Maddison became Acting Executive Officer until June 2018 when John Claydon was appointed as Executive Officer.

IMR has confirmed that a renewal of funding after 2020 is unlikely, so IMBeR has begun to investigate other possible hosts for the IPO from 2020.

Regional Project Office (RPO, China)

Xu resigned from the Deputy Executive Officer post in December 2017 and Fang Zuo became the Acting Deputy Executive Officer. After an international recruitment campaign Fang was appointed to the Deputy Executive Officer post in July 2018. Recruitment is currently underway for an Assistant Administrative Officer for the RPO. Funding is available for the RPO from the State Key Laboratory for Estuarine and Coastal research (SKLEC) at the East China Normal University (ECNU) until 2020. SKLEC hosted the 2017 SSC meeting and will host the 2018 China/Japan/Korea IMBeR symposium.

I. Scientific steering committee

The 2017 Scientific Steering Committee consisted of a chair, Carol Robinson (F, UK), *ex officio* member Eugene Murphy (M, UK) and 15 members (9 male and 6 female). Alida Bundy (*ex officio* F, Canada), Ratana Chuenpagdee (F, Canada), Masao Ischii (M, Japan), Svein Sundby (M, Norway) and Tatiana Rynearson (F, USA) rotated off the SSC at the end of 2017. Ruben Escribano will serve a second term, rotating off at the end of 2020.

An open call for nominations for four new SSC members was advertised in 2017. From 36 applications, four new members were proposed and accepted by SCOR and Future Earth – Oscar Iribane (M, Argentina), Alice Newton (F, Portugal), Suvaluck Satumanatpan (F, Thailand) and David VanderZwaag (M, Canada). We also appointed *ex officio* members Olav Kjesbu (M, Norway; to act as an IMR liaison), Chris Cvitanovic (M, Australia; as an early career representative) and Frank Muller Karger (M, USA; as a liaison with GEO BON to contribute to Innovation Challenge 2).

J. Collaborative partners

IMBeR science is strengthened and its impacts extended through on-going and new partnerships and collaborations with international and national organisations, including the International Science Council (ISC), the Scientific Committee on Oceanic Research (SCOR), Future Earth, the World Climate Research Programme (WCRP), and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) which sponsors the Global Ocean Observing

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System (GOOS) and co-sponsors (with SCOR) the International Ocean Carbon Coordination Project (IOCCP).

IMBeR continues to have long -standing collaborations with the SCOR and Future Earth global research projects SOLAS, Future Earth Coasts, PAGES, Earth System Governance and bioDiscovery.

a. Too Big To Ignore (TBTI)

IMBeR is a partner of the TBTI project, which includes 15 partners, 62 scientists from 27 countries. TBTI is conducting a global analysis, based on information systems, to better understand small-scale fisheries and to develop research and governance capacity to address global fisheries challenges.

b. Ocean Carbon Biogeochemistry (OCB)

OCB continues to actively support IMBeR by advertising its activities and events, and by providing financial support for activities. OCB hosted and co-sponsored IMBIZO5 at Woods Hole in October 2017.

c. World Climate Research Project (WCRP)

CLIVAR, a core project of WCRP, and its Indian Ocean panel works closely with SIBER. The IMBeR Eastern Boundary Upwelling working group is co-sponsored by CLIVAR and SOLAS. A representative from the China CLIVAR office attended the IMBeR SSC meeting in Shanghai in April 2017, and discussions are ongoing for a CLIVAR contribution to a newly formulated SOLAS-IMBeR-IOCCP carbon working group.

d. GOOS

SIBER has strong connections with the Global Ocean Observing System in the Indian Ocean (IO-GOOS). Patricia Miloslavich gave a presentation at the IMBeR SSC meeting in 2018, highlighting opportunities for interaction between GOOS and IMBeR. These include a contribution to the specifications for an emerging EOVS on microbes and linking EOVSs to human society. IMBeR were invited to contribute to the draft GOOS 10-year strategy and to be represented at the GOOS Steering Committee meeting in Columbia in June 2018.

e. ICES

Collaboration with ICES continues through the membership of Mark Dickey-Collas (ICES) on the IMBeR Scientific Steering Committee.

f. PICES

IMBeR and PICES continue to collaborate, with representatives from both communities attending and funding each other's summer schools and science meetings. Cisco Werner is the IMBeR liaison with PICES, Carol Robinson is a member of the ICES/PICES working group on Climate Change and Biologically-driven Ocean Carbon Sequestration (WGCCBOCS) and represented IMBeR on the organizing committee of the PICES International Symposium on The Effects of Climate Change on the World's Oceans (ECCWO), held in Washington in June 2018.

K. Selected IMBeR Publications

IMBeR has produced more than 2,500 refereed research papers since 2005, with around 150 papers published in 2017-2018.

ICED

- Ancel, A., Cristofari, R., Trathan, P.N., Gilbert, C., Fretwell, P.T., Beaulieu, M. 2017. Looking for new emperor penguin colonies? Filling the gaps. *Global Ecology and Conservation*, 9: 171-179. [10.1016/j.gecco.2017.01.003](https://doi.org/10.1016/j.gecco.2017.01.003) <http://dx.doi.org/10.1016/j.gecco.2017.01.003>
- Arthur, B., Hindell, M., Bester, M., De Bruyn, P.J.N., Trathan, P., Goebel, M., Lea, M.-A. 2017. Winter habitat predictions of a key Southern Ocean predator, the Antarctic fur seal (*Arctocephalus gazella*). *Deep Sea Research Part II: Topical Studies in Oceanography*, 140: 171-181. <https://doi.org/10.1016/j.dsr2.2016.10.009>
- Barnes, D.K.A., Tarling, G.A. 2017. Polar oceans in a changing climate. *Current Biology*, 27 (11): R454-R460. <https://doi.org/10.1016/j.cub.2017.01.045>
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- Dinniman, M.S., J.M. Klinck, E.E. Hofmann, and W.O. Smith, Jr. 2018. Effects of projected changes in wind, atmospheric temperature and freshwater inflow on the Ross Sea. *J. Climate* 31: 1619-1635.
- Freer, J.J., Partridge, J.C., Tarling, G.A., Collins, M.A., Genner, M.J. 2018 Predicting ecological responses in a changing ocean: the effects of future climate uncertainty. *Marine Biology*, 165 (1), 7-18. <https://doi.org/10.1007/s00227-017-3239-1>
- Gardner, J., Manno, C., Bakker, D.C.E. et al. *Mar Biol* (2018) 165: 8. <https://doi.org/10.1007/s00227-017-3261-3>
- Goedegebuure, M., Melbourne-Thomas, J., Corney, S.P., Hindell, M.A., and Constable, A.J. (2017) Beyond big fish: The case for more detailed representations of top predators in marine ecosystem models. *Ecological Modelling* 359, 182-192.

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Together with this report, we submit a request for funding to support students and researchers from developing countries to attend the IMBeR Open Science Conference to be held in Brest, France in June 2019.