**GEOTRACES SCIENTIFIC STEERING COMMITTEE**
**ANNUAL REPORT TO SCOR 2018/2019**

April 1st, 2018 to March 31st, 2019

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## 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) contains representatives of 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

With 2 GEOTRACES Intermediate Data Products released, 111 cruises completed, 1,230 publications published (45 in high impact journals), 3 international synthesis workshops conducted and more than 40 scientific or training workshops undertaken, the GEOTRACES programme is enjoying a very successful implementation.

### 2.1 Status of GEOTRACES field programme

The GEOTRACES field programme continues to progress successfully. Overall 111 cruises have been completed, corresponding to 30 GEOTRACES sections (with 40 cruises), 32 process studies (with 51 cruises) and 9 compliant data sets, as well as, 11 cruises completed as a GEOTRACES contribution to the International Polar Year (IPY).

During the past year (April 1st, 2018 to March 31th, 2019), 5 cruises have been completed. This includes 1 new section cruise from USA (with 2 cruises, see map below, section in orange) and 3 process studies from Australia, Germany and The Netherlands (see data management section below for further details).

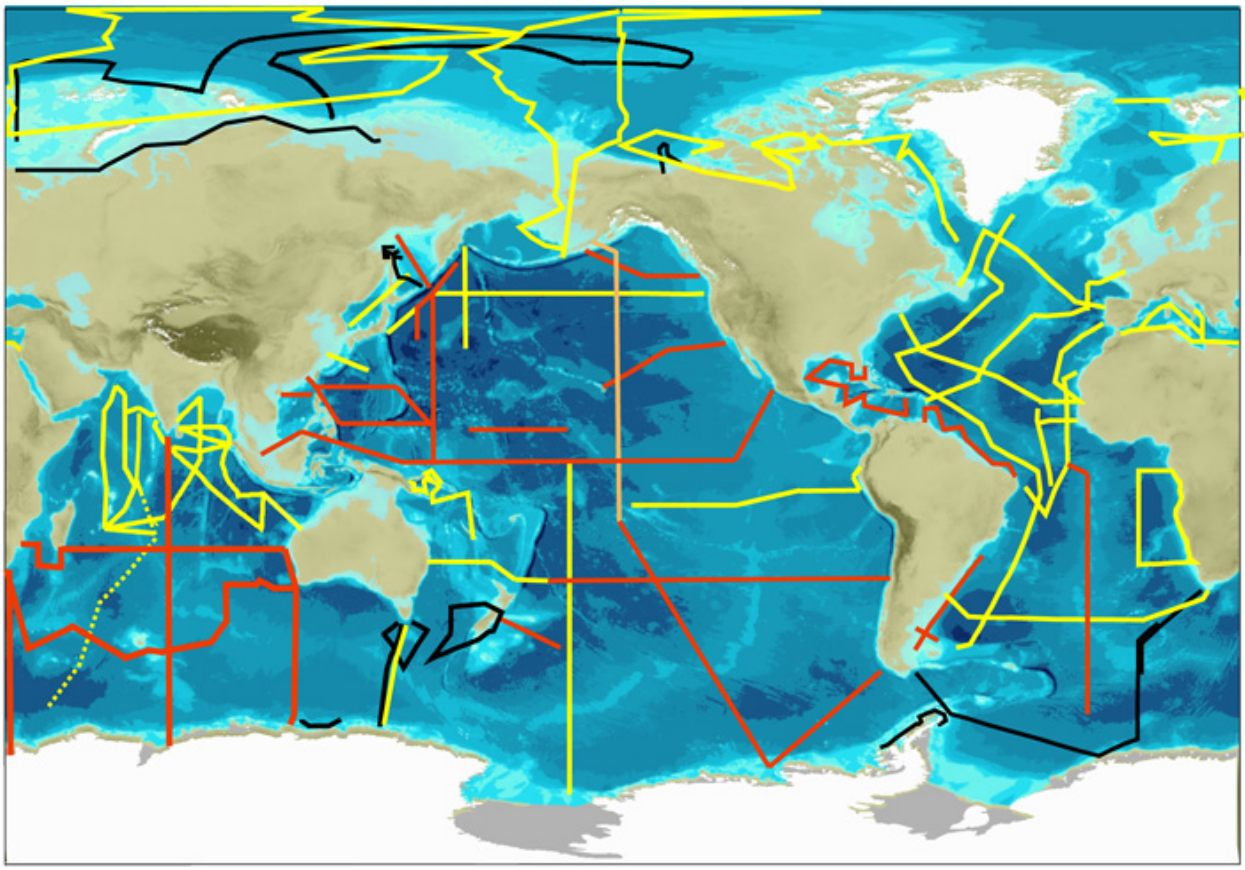

***Figure 1.*** *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past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

***Towards Intermediate Data Product 2021: Development of an on-line metadata portal***

GEOTRACES has successfully released two Intermediate Data Products (IDP, in 2014 and in 2017, https://www.bodc.ac.uk/geotraces/data/dp/) with a new release planned in 2021. The number of parameters and samples compiled into the second IDP released in 2017 compared to the first was about double. This was a clear demonstration of the success of the programme, but also a sobering lesson on the resources required to accomplish this task. For this reason, GEOTRACES has decided to move to a more automated data management process to reduce the amount of work required to build the IDP. The development of an on-line metadata portal has been a major activity of the IPO, S&I, PDC and DMC committees during the reporting period. It is currently (April 2019) undergoing initial testing, and the goal is for it to be functional for data contributors to use for IDP2021. See the GEOTRACES International Project Office report for more details.

***Intermediate Data Product download statistics***

Overall the GEOTRACES Intermediate Data Products have been downloaded more than 2,655 times (as per March 2019). That is, the IDP2017 has been downloaded more than 1,168 times since its release in August 2017, while the IDP2014 has been downloaded 1,487 times since its release in February 2014.

## 2.3 GEOTRACES Publications

During the reporting period, 295 new peer-reviewed papers have been published. In total the GEOTRACES peer-reviewed papers database includes 1,230 publications (45 in high impact journals). This includes peer-reviewed papers that have "GEOTRACES" in either its keywords, abstract or summary, as well as publications that have been reported by the GEOTRACES national representatives in their annual activity reports and which are relevant for GEOTRACES research. PhD and Masters dissertations from GEOTRACES research are also included in the publication database.

***Synthesis papers***

Following the GEOTRACES Synthesis of Results Strategy (http://www.geotraces.org/science/synthesis-of-results) launched in 2015 in partnership with other institutions and international programmes, GEOTRACES has started to produce important synthesis papers that benefit both GEOTRACES but also the broader oceanographic community. Two recent examples of synthesis papers resulting from the workshop organised jointly with the Ocean Carbon and Biogeochemistry (OCB) programme are:

- Hayes, C. T., et al. (2018), Replacement times of a spectrum of elements in the North Atlantic based on thorium supply, Global Biogeochemical Cycles, 32(9), 1294-1311, DOI: https://doi.org/10.1029/2017GB005839
- Hayes, C. T., et al. (2018), Flux of particulate elements in the North Atlantic Ocean constrained by multiple radionuclides, Global Biogeochemical Cycles, 32(12), 1738-1758, DOI: https://doi.org/10.1029/2018GB005994

***Publicity documents***

It is important to mention that in addition to the peer-reviewed publications, publicity articles to promote GEOTRACES are continuously published nationally and internationally. These publications are not included in the GEOTRACES publication database, but have a dedicated web page on the GEOTRACES site. An example is the volume that was published in December 2018 in *Elements Magazine* devoted to GEOTRACES research and showcasing the diverse roles that trace elements and isotopes (TEIs) play in marine biogeochemistry:

Marine Biogeochemistry of Trace Elements and Their Isotopes
Catherine Jeandel, Zanna Chase, and Vanessa Hatje - Guest Editors

http://www.geotraces.org/news-50/news/116-news/1636-elements-magazine-geotraces

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
- List of GEOTRACES promotional articles: http://www.geotraces.org/outreach/publicity-documents

## 2.4 GEOTRACES Science highlights

The GEOTRACES International Project Office regularly generates science highlights of notable published articles, which are posted on the website (http://www.geotraces.org/science/science-highlight) and in the electronic eNewsletter (http://www.geotraces.org/outreach/geotraces-enewsletter). So far, about 200 highlights have been published. Among the numerous highlights published since last year's report, we selected the following six:

### The circulation loop in the North Atlantic and Arctic oceans depicted by the artificial radionuclides

Atlantic waters have been recently recognised to play an increasing role in reducing sea-ice extent in the Arctic Ocean at a rate now comparable to losses from atmospheric thermodynamic forcing. Beyond the Arctic Ocean, the water mass transport and transformation processes in the North Atlantic Ocean substantially contribute to the Atlantic meridional overturning circulation (AMOC). Artificial radionuclides can be used as transient tracers that provide crucial information on pathways, timescales and processes of key water masses that cannot be obtained from hydrographic properties alone. In particular, radionuclides released from the two European Nuclear Reprocessing Plants, have proven to be specifically useful to trace the circulation of Atlantic waters into the Arctic and sub-Arctic oceans. Within this context, the three recent articles by Castrillejo et al. (2018), Wefing et al. (2019) and Casacuberta et al. (2018, see references below) describe the journey of the two long-lived

anthropogenic radionuclides iodine-129 ($^{129}I$; $T_{1/2}$=15.7 $\cdot 10^6$y) and uranium-236 ($^{236}U$; $T_{1/2}$=23.4 $\cdot 10^6$ y) from their sources up through the Arctic Ocean and back into the North Atlantic Ocean. Each paper corresponds to one GEOTRACES expedition that took place between 2014 and 2016 in the North Atlantic Ocean (GA01 section), Arctic Ocean (GN04 section) and Fram Strait (GN05 section). Main results show that the combination of $^{129}I$ and $^{236}U$ serves very well to identify the different Atlantic branches entering the Arctic Ocean: Barents Sea Branch Water (BSBW) and Fram Strait Branch Water (FSBW). Due to the uneven mixing of $^{129}I$ and $^{236}U$ from the two European Reprocessing Plants of Sellafield and La Hague in the North Sea, each branch brings a different $^{129}I/^{236}U$ ratio. Furthermore, this ratio allowed identifying a third Atlantic branch evolving from the Norwegian Coastal Current (NCC), that stays within the upper Polar Mixed Layer and carries a significantly larger proportion of $^{129}I$ and $^{236}U$ releases from the European reprocessing plants compared to the FSBW and the BSBW. The evolution of the NCC with a strong $^{129}I$ and $^{236}U$ signal is further observed when it returns to the Atlantic Ocean as Polar Surface Water (PSW) in the Fram Strait. This allowed estimating a transit time of 15-22 years for the PSW flowing through the Arctic Ocean. In the subpolar North Atlantic Ocean (SPNA), an increase of $^{129}I$ was observed in the deep overflow waters in the Labrador and Irminger Seas, confirming the major pathways of Atlantic Waters in the SPNA that were previously suggested by other authors: a short loop through the Nordic seas into the SPNA (8-10 years) and a longer one, which includes transport all the way through the Arctic Ocean (>16 years). The output of these works proves the potential of using $^{129}I$ and $^{236}U$ as a tool for investigations on the circulation within and exchanges between the Arctic and sub-Arctic Seas.

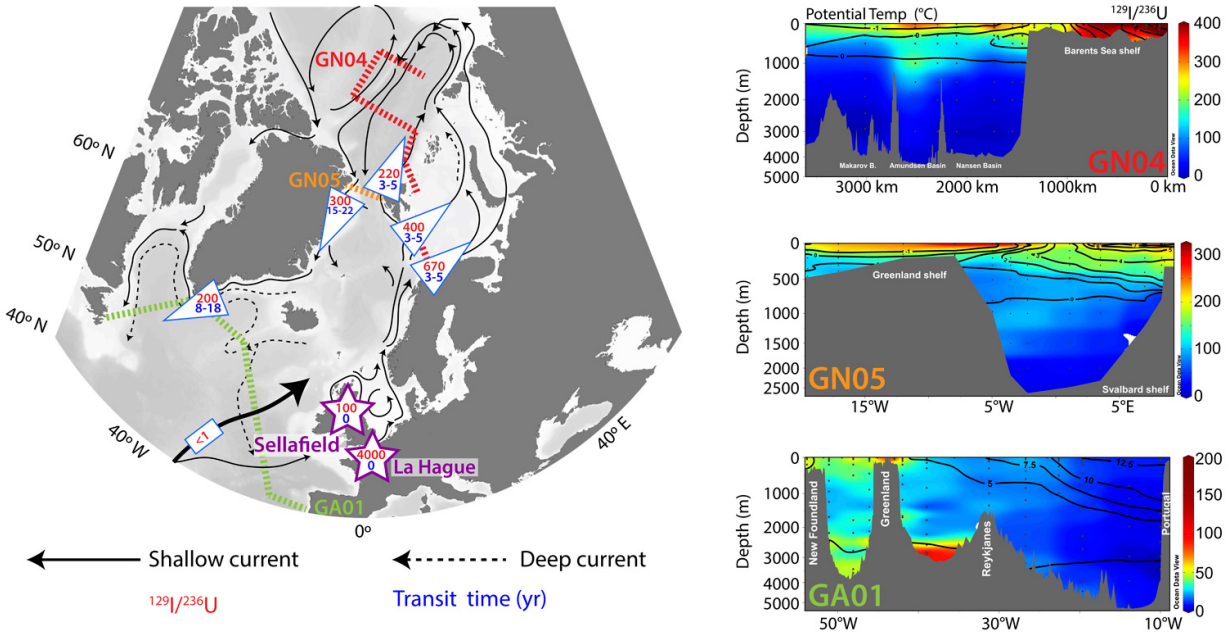


***Figure 2.*** *(Left) Map showing the main Atlantic water circulation in the North Atlantic and Arctic oceans (black arrows). Dashed lines represent the three GEOTRACES sections sampled between 2014 and 2016: North Atlantic Ocean (GA01), Arctic Ocean (GN04) and Fram Strait (GN05). Both $^{129}I$ and $^{236}U$ are released from the two European Reprocessing Plants of Sellafield and La Hague (purple stars). Blue triangles represent the $^{129}I/^{236}U$ atom ratios (in red) at sampling time and the transit time of Atlantic waters (in blue) from their source in the North Sea, to the sampling location. (Right) Section plots of $^{129}I/^{236}U$ atom ratio in the three GEOTRACES sections, with black contour lines representing potential temperature.*

References:

Casacuberta, N., Christl, M., Vockenhuber, C., Wefing, A.-M., Wacker, L., Masqué, P., Synal, H.-A., Rutgers van der Loeff, M. (2018). Tracing the Three Atlantic Branches Entering the Arctic Ocean With 129I and 236U. Journal of Geophysical Research: Oceans, 123(9), 6909–6921. DOI: http://doi.org/10.1029/2018JC014168

Castrillejo, M., Casacuberta, N., Christl, M., Vockenhuber, C., Synal, H.-A., García-Ibáñez, M. I., Lherminier, P., Sarthou, G., Garcia-Orellana, J., Masqué, P. (2018). Tracing water masses with 129I and 236U in the subpolar North Atlantic along the GEOTRACES GA01 section. Biogeosciences, 15(18), 5545–5564. DOI: http://doi.org/10.5194/bg-15-5545-2018

Wefing, A.-M., Christl, M., Vockenhuber, C., van der Loeff, M. R., & Casacuberta, N. (2019). Tracing Atlantic waters using 129 I and 236 U in the Fram Strait in 2016. Journal of Geophysical Research: Oceans. DOI: http://doi.org/10.1029/2018JC014399

## Gulf stream eddies are fertilizing the Western Atlantic Ocean

Tim Conway and co-authors (2018, see reference below) show that Gulf Steam eddies can provide an extra supply of iron, and nutrients such as phosphate and nitrate to the iron-starved Western Atlantic Ocean. Gulf stream eddies form when the northward fast-flowing Gulf Stream meanders and pinches off coastal water, spinning these 'rings' out into the ocean. This coastal water is rich in iron. The authors used satellite and ocean datasets to show that these eddies may be just as important than dust in supplying iron to this area of the ocean!

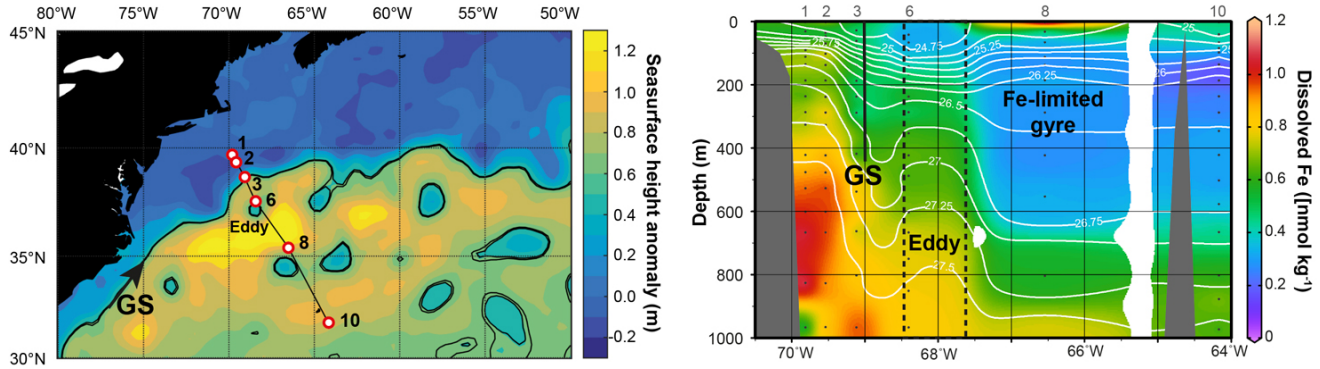


***Figure 3.*** *Cruise track (left) and dissolved iron (Fe) concentrations (right) from a North Atlantic GEOTRACES dataset (GA03). The northward flowing Gulf Stream (labelled GS) can be clearly picked out as the boundary between the coastal Slope Water which is enriched in Fe, and the open gyre which is Fe-depleted. A gulf steam eddy (labelled) was serendipitously sampled on the cruise, and can be seen as carrying a column of water enriched in Fe across the Gulf Stream and out into the gyre. The authors used this chemical dataset, together with satellite data to calculate how much iron eddies carry into the gyre each year.*

Reference:

Conway, T. M., Palter, J. B., & de Souza, G. F. (2018). Gulf Stream rings as a source of iron to the North Atlantic subtropical gyre. *Nature Geoscience*, 1. DOI: http://doi.org/10.1038/s41561-018-0162-0

## Artificial intelligence helps investigate the oceanic zinc cycle

What explains the hitherto mysterious correlation between zinc (Zn) and silicon, an element not involved in the Zn cycle?

Roshan and co-workers (2018, see reference below) used an artificial neural network (ANN, a machine learning technique inspired by biological neural systems) to produce a global climatology of dissolved Zn concentration, the first such global climatology of a trace metal. They first used an ensemble of ANNs to produce climatological maps of dissolved Zn with the same spatial resolution as the World Ocean Atlas 2013 (WOA13) and then coupled these dissolved Zn maps, and those of phosphate ($PO_4^{3-}$) and silicate ($SiO_4^{4-}$) from WOA13, to a data-constrained ocean circulation model. They then employed a restoring model to compute the biogeochemical sources and sinks of dissolved Zn, $PO_4^{3-}$ and $SiO_4^{4-}$.

The main results are:

- The Zn: $PO_4^{3-}$ uptake ratio varies by approximately tenfold across latitude and is modulated by Fe availability;
- Zn remineralizes like $PO_4^{3-}$ in the upper ocean, but its accumulation in deep waters exceeds that of $PO_4^{3-}$;
- The strong Zn-$SiO_4^{4-}$ correlation is caused by a combination of surface uptake, desorption from particles, and hydrothermal input, and is therefore completely fortuitous.

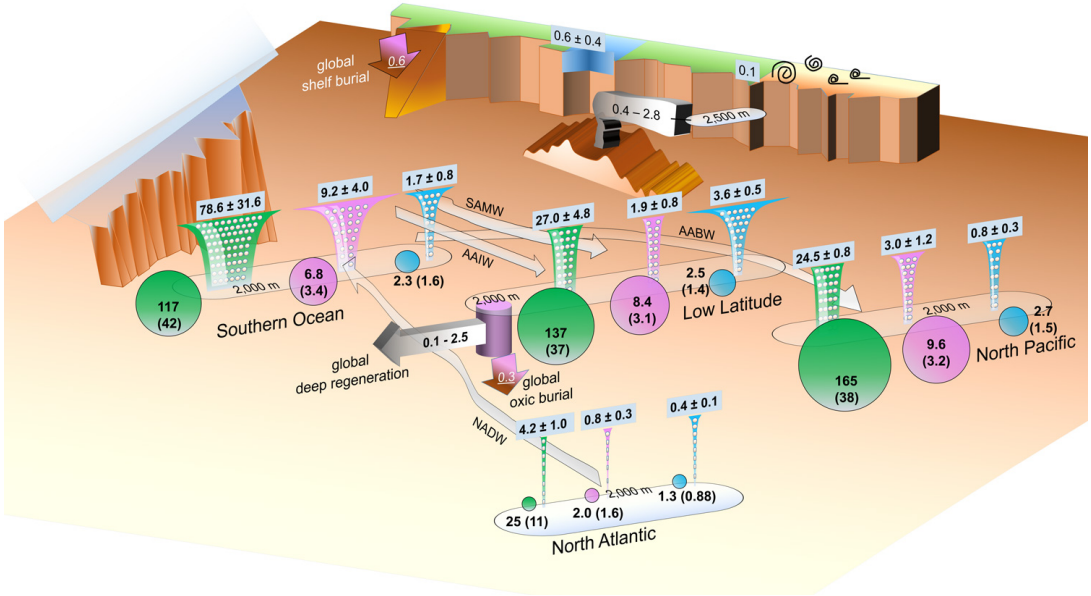


***Figure 4.*** *This schematic shows the reconstructed internal particle-associated cycling of zinc (Zn) in the ocean, as well as some recent estimates of the external sources and sinks of Zn. Funnels represent fluxes of particulate zinc (pink; in giga mol/yr), silicon (green; in tera mol/yr) and phosphorous (cyan; in tera mol/yr), which are biologically-produced in the sunlit surface ocean and exported to the subsurface. In the subsurface, the fluxes gradually attenuate due to degradation/dissolution. Particulate zinc flux attenuates quickly like particulate phosphorus, meaning that these two compounds are associated with labile soft tissues of plankton and re-enter water column at shallower depths than silicon, which is a hard-tissue compound. However, a significant amount of dissolved zinc is supplied to the deep ocean (below 2,000 m; 0.1-2.5 giga mol/yr), which is most likely resulted from a combination of seafloor hydrothermal input and desorption of the zinc ions that are passively adsorbed on the particles at shallower depths. Circles represent the mean dissolved concentrations of the above three compounds at depths below 2,000 m of different regions, which indicate that the mentioned excess input of zinc makes its deep ocean increasing trend (according to water flow arrows) more similar to silicon than phosphorous, and eventually leads to a coincidental zinc-silicon correlation in the ocean. Also annotated are some estimates of the zinc input from rivers and dust, and those of removal to deep and shelf sediments.*

Reference:

Roshan, S., DeVries, T., Wu, J., & Chen, G. (2018). The Internal Cycling of Zinc in the Ocean. Global Biogeochemical Cycles, 32(12), 1833-1849. DOI: http://doi.org/10.1029/2018GB006045

## Ever wonder how long your favourite element remains in the ocean before it's gone again?

This timeframe, sometimes called a residence time, ranges from decades for the most reactive trace elements to millions of years for the most unreactive elements such as the major components of sea salt. The residence time is often difficult to constrain and involves estimating how much of an element is presently in the ocean (i.e., the inventory) as well as the magnitude of the total supply rate or removal rate of the element. In the study published by Hayes and co-authors in *Global Biogeochemical Cycles* (2018, see reference below), a replacement time (or residence time with respect to supply) can be quantified using large synthesised GEOTRACES datasets from the North Atlantic which can precisely define the inventory of trace elements as well as their supply rate using radioactive tracers. In particular, their method suggests an ocean replacement for iron that is only 6 years, meaning this micronutrient element may be cycling much more quickly than previous estimates have suggested and will provide a target for ocean models to understand how this element is removed from the ocean in terms of biological uptake or abiotic scavenging.

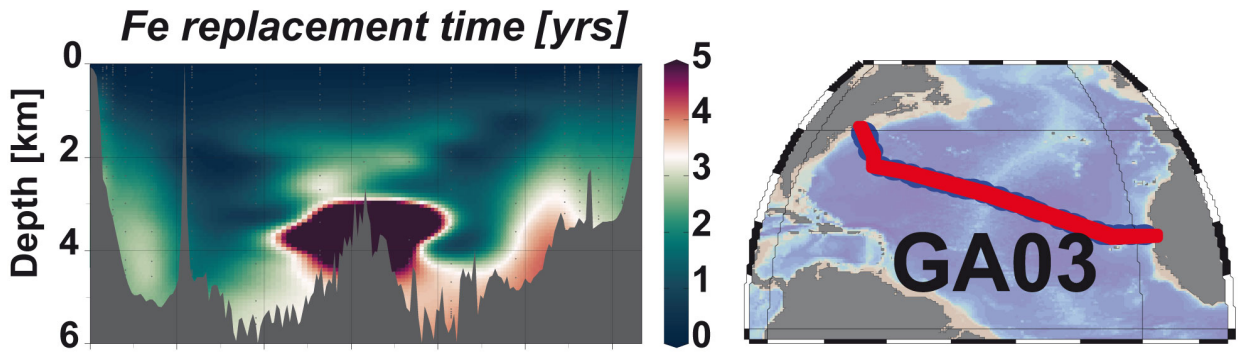


***Figure 5.*** *(Left) Replacement time of dissolved Fe across the GEOTRACES cruise section GA03. This replacement time is how long it would take to replace all of the iron in the North Atlantic Ocean with a source of iron derived from the quantifiable delivery of the crustal isotope thorium-232 to the ocean. (Right) Map showing the GEOTRACES section GA03 in the Atlantic Ocean.*

Reference:

Hayes, C. T., Anderson, R. F., Cheng, H., Conway, T. M., Edwards, R. L., Fleisher, M. Q., Ho, P., Huang, K.-F., John, S., Landing, W.M., Little, S. H. Lu, Y., Morton, P. L., Moran, S. B., Robinson, L. F., Shelley, R. U., Shiller, A. M., Zheng, X.-Y. (2018). Replacement Times of a Spectrum of Elements in the North Atlantic Based on Thorium Supply. *Global Biogeochemical Cycles*, *32*(9), 1294–1311. DOI: http://doi.org/10.1029/2017GB005839

## The role of melting-ice in driving the slowdown of circulation in the western Atlantic Ocean revealed by protactinium-thorium ratio

Abrupt climate changes in the past have been attributed to variations in Atlantic Meridional Overturning Circulation (AMOC) strength. Knowing the exact timing and magnitude of the AMOC shift is important to understand the driving mechanism of such climate variability. After a thorough selection of 13 sediment cores, the authors show that the proxy Protactinium-231-Thorium-230 ($^{231}Pa/^{230}Th$) exhibits remarkably consistent changes both in timing and amplitude over the last 25 thousand years (kyr) in the West and deep high-latitude North Atlantic. This consistent signal reveals a spatially coherent picture of western Atlantic circulation changes over the last deglaciation, during abrupt millennial-scale climate transitions. At the onset of deglaciation, an early slowdown of circulation in the western Atlantic is observed consistent with the timing of accelerated Eurasian ice melting, followed by a persistence of this weak AMOC for another millennium, corresponding to the substantial ice rafting from the Laurentide ice sheet. This timing indicates a role for melting ice in driving a two-step AMOC slowdown. This work also emphasises that $^{231}Pa/^{230}Th$, under thorough criteria, could hold as pertinent proxy of ocean circulation.

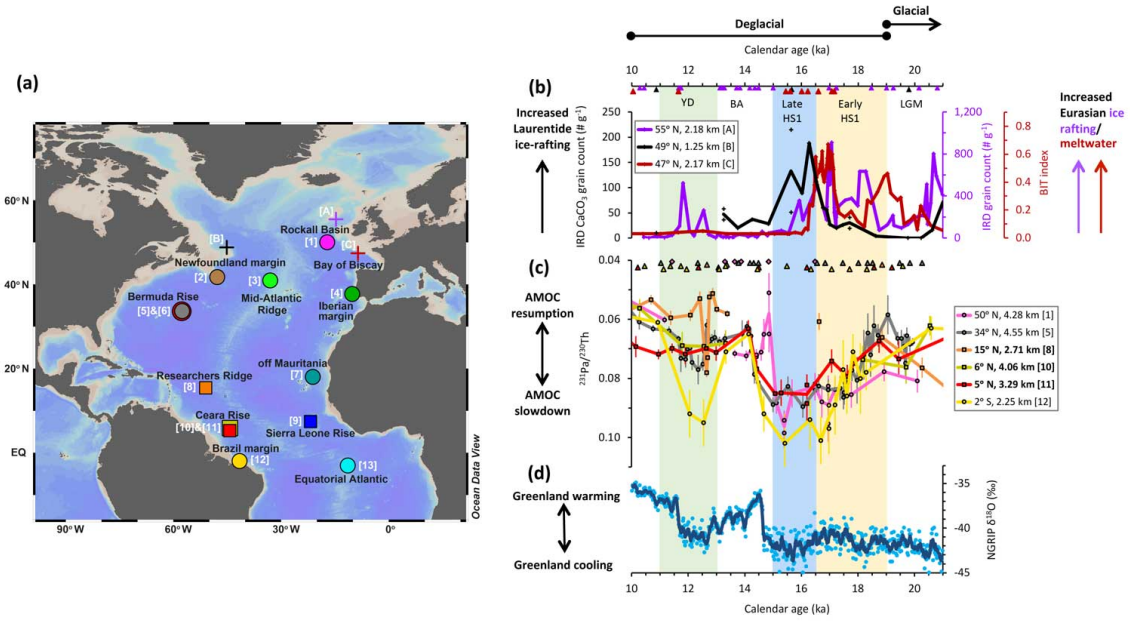


***Figure 6.*** *Use of sedimentary $^{231}Pa/^{230}Th$ to interpret changes in Atlantic Meridional Overturning Circulation (AMOC) strength and its link to climate variations over the past 25 thousand years. (a) Location map of $^{231}Pa/^{230}Th$ records [1]–[13] and ice melting proxy records [A]–[C] presented in this study, (b) North Atlantic ice rafting records (IRD) and a proxy record of Eurasian meltwater discharge (BIT index), (c) selected West and high-latitude North Atlantic $^{231}Pa/^{230}Th$ records, (d) Northern Greenland temperature proxy record. The AMOC slowdown observed (c) is consistent with the timing of an increased Eurasian ice melting (b).*

Reference:


Ng, H. C., Robinson, L. F., McManus, J. F., Mohamed, K. J., Jacobel, A. W., Ivanovic, R. F., Gregoire, L. J., Chen, T. (2018). Coherent deglacial changes in western Atlantic Ocean circulation. *Nature Communications*, *9*(1), 2947. DOI: http://doi.org/10.1038/s41467-018-05312-3

## 52 years of benthic nepheloid layer data!

A data base of 2412 profiles collected using the Lamont Thorndike nephelometer from 1964 to 1984 is used to globally map turbid nepheloid layers by Gardner and co-workers (2018, see reference below). The authors compare maps from that period with maps based on data from 6392 profiles measured using transmissometers from 1979 to 2016. Beyond this comparison, the final goal is to gain insight about the factors creating/sustaining Benthic Nepheloid Layers (BNLs). Eleven maps, including mean surface Kinetic Energy (KE), are discussed here. The similarity between general locations of high and low particle concentration BNLs during the two time periods indicates that the driving forces of erosion and resuspension of bottom sediments are spatially persistent during recent decadal time spans, though in areas of strong BNLs, intensity is highly episodic. This work confirms that topography, well-developed current systems, and surface KE and EKE play a role in generating and maintaining BNLs.

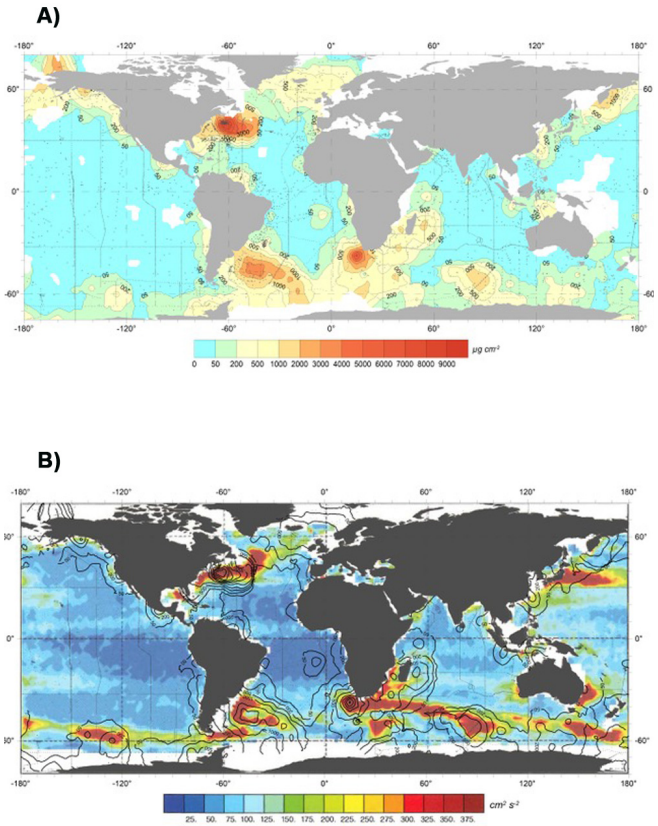


***Figure 7.*** *A) Excess particulate matter in "strong" nepheloid layers (> 20 µg $l^{-1}$) based on transmissometer (cp) and nephelometer (E/ED) profiles. B) Mean Kinetic Energy per unit mass, $cm^2 s^{-2}$, in surface waters, derived from four years of satellite altimetric data and using the geostrophic relationship (adapted from Wunsch, 2015). Black contours superimposed are Excess particulate matter in "strong" nepheloid layers (> 20 µg $l^{-1}$ from Figure A).*

Reference:

Gardner, W. D., Richardson, M. J., Mishonov, A. V., & Biscaye, P. E. (2018). Global comparison of benthic nepheloid layers based on 52 years of nephelometer and transmissometer measurements. *Progress in Oceanography*, *168*(May), 100–111. DOI: http://doi.org/10.1016/j.pocean.2018.09.008

## 3. Activities

### 3.1 GEOTRACES intercalibration activities

The Standards &Intercalibration (S&I) Committee has 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 Santa Barbara.

The complete S&I Committee is currently composed of Ana Aguilar-Islas, Karen Casciotti, Tina van de Flierdt, Walter Geibert, Lars-Eric Heimbürger-Boavida, Yoshiko Kondo, Maeve Lohan, Hélène Planquette, Peter Sedwick and Alyson Santoro. Maeve Lohan and Walter Geibert serve as co-chairs. The committee met in person on 6th and 7th December 2018 in Marseille, hosted by Lars-Eric Heimbürger-Boavida.

The focus for the past reporting period was almost completely shifted away from the intercalibration of datasets towards the preparation of our procedures for the upcoming intermediate data product, implementing improvements of the S&I report submission procedure together with the data management committee and the International Project Office. The main focus has been on the development of an on-line portal system for analysts to submit their data to be calibrated. This system will track all the data and the permissions for future IDP's. This involved the participation of the S&I co-chairs at a DMC meeting in Liverpool (17-18 April 2018) and in Toulouse on 24-26 September for the IDP data portal meeting.

During the S&I-meeting in December 2019, a key task was the introduction of the new committee members to the existing intercalibration procedures for labs, cruise data sets and materials. The existing procedures for the submission of intercalibration reports to S&I and the subsequent review and approval were discussed in detail, before agreeing on suggestions how these procedures should be reflected in the data submission portal.. The S&I committee produced a template for the portal whereby an analyst will download a form with a series of questions to be answered that will act as the intercalibration report. The analyst will then upload this back through the portal.

S&I has already received a significant number of intercalibration reports in the previous report-style IDP2017 format and approved 4 datasets for IDP 2021.

Laboratory intercomparisions & Consensus Materials:

The status and progress on several initiatives to produce consensus materials and lab intercomparisons is reported below:

Sea ice:

Ana Aguilar-Islas and Peter Sedwick led a successful exercise on trace metals in sea-ice, comparing sampling equipment and processing intercalibration and exploring ways to produce consensus materials, including artificial sea-ice. They are still awaiting results from one other group but the results look promising.

Seawater Consensus materials:

For the seawater consensus materials GSC and GSP, material has been sent out to a number of labs, 18 of which have reported back for GSP and 16 for GSC. Consensus values for this material are under development, and a request for reporting data to Jim Moffett is published on the GEOTRACES web page. Overall the data look good for most laboratories and we have enough data for consensus values for Cd, Cu, Fe, Mn, Ni and Pb but awaiting more data for Co and Al. The S&I committee are working with Jim Moffett on establishing the best way to assign errors on the data and we hope the consensus values will be on the GEOTRACES web page soon.

An additional consensus material for seawater (CAP) has been collected by E. Achterberg and C. Schlosser during GA08 in the Cape Basin. To date only 4 laboratories have reported back with their results, so S&I are encouraging more laboratories to report results for this material before consensus values can be published. The GEOTRACES web page will be updated to encourage more people to submit data and to analyse this material.

Leachable Particulate data:

Hélène Planquette led an exercise for comparing results for the Berger marine particle leach protocol for which five of seven labs had reported results by 7th December 2018.

Next Meeting:

The next meeting for the following reporting period is scheduled for 12/13 June 2019 in Norfolk, Virginia, hosted by Peter Sedwick. It is hoped that a test run of the portal submission process can be undertaken and assessed by the S&I.

## 3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanography Data Centre (BODC), with the head office located in Liverpool; Dr Mohamed Adjou, the GEOTRACES Data Manager, is based at Liverpool BODC office. He is assisted by Donna Cockwell from the Southampton BODC office. GDAC benefits from additional BODC expertise when work cases require it.

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

- Interaction between PIs and national data centres in order to encourage regular and timely data/ metadata submissions;
- 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/ );
- Liaising with the Data Management Committee and Standards and Intercalibration Committee to ensure issues/questions relating to GEOTRACES and its progress can be discussed, and deadlines can be met accordingly;
- Input of metadata and data into the BODC database and compilation of documentation to include analysis methodologies;

• Preparing for future data reception at GDAC under the recommendation of the Data Management Committee;
• Collation of data and metadata for the future IDP;
• Answering requests from GEOTRACES community and assisting on IDP download and use for all kind of users.

This year, GDAC would like to highlight and report on the following tasks:

**Cooperation with the IPO** The IPO is in permanent contact with GDAC in order to have an up-to-date cruise inventory as displayed on the GDAC website. IPO is also assisting GDAC by sending reminders to respect time-scheduled tasks.

**GDAC website updates** All basin maps have been updated. The update of the GDAC website maps was not considered as a priority task during the IDP publication year, under intense data processing work at GDAC.

**DMC and SSC meetings** The DMC meeting (Liverpool, April 2018) and SSC meeting (Taipei, July 2018) were occasions for Mohamed to meet most of the key GEOTRACES participants and country representatives.

The DMC meeting was one month after Mohamed took on the post of GEOTRACES data manager. Discussions focused on data quality control of IDP2017 and future IDP, as well as the control of datasets submission workflow and how to track the data sets approved by S&I and author permission.
During the SSC, the following points, among others, were addressed under GDAC perspectives:

1. Information and highlights on version 2 of the IDP2017
2. A comparison/ interpretation of version 1 and version 2 IDP2017 download statistics.
3. A GDAC website report
4. Proposing a new methodology to improve data quality checking and reporting.
5. Suggesting SeaDataNet flags to have a broader range of data quality flagging possibilities.
6. Proposing a proofreading step by the scientists to enable them to check the final version of their data in the IDP.

**Contribution to GEOTRACES metadata portal effort** Although GDAC is not in charge of the development and the future deployment of GEOTRACES metadata portal, GDAC contributed in defining the functional requirement of such web portal (GEOTRACES Metadata Portal meeting, 25-26 September in Toulouse, France). One of the major tasks assigned to GDAC from Toulouse meeting was to review the list of cruise identifiers, GEOTRACES cruise names and aliases, and find a way to standardise these different labels in order to avoid using free-text for cruise names in the metadata portal. This list was established and circulated in a spreadsheet, as a first step, to the Toulouse meeting participants. GDAC is working on providing this standardised cruise list through a webservice enabling “real-time" updates to be distributed instantly.

**Liaison with national data centres** National marine data centres (BCO-DMO, CYBER-LEFE and NIOZ) in charge of supplying GDAC with GEOTRACES data were contacted and short work visits are scheduled for the upcoming months of this year. GDAC also hosted Yanping Xu from Xiamen University (China) in November 2018 for a week-long training session on GEOTRACES data management prior to China’s first GEOTRACES section cruise (GP09).

**Data and cruise metadata overview** This year is a post IDP publication year and only a few datasets were submitted to GDAC. The next DMC and SSC meetings, expected in September 2019, will communicate on the future IDP2021 and this will encourage people to submit their data to GDAC.

***Summary of GEOTRACES cruises, which have taken place in the period April 2018-April 2019:***

| Cruise | Chief scientist | GEOTRACES scientist | Type | Period | Location |
|---|---|---|---|---|---|
| PS117 (GApr12) | Boebel Olaf | Middag Rob | Process Study | 2018-12-15 — 2019-02-07 | Zero meridian towards continent (Lazarev Sea) & Weddell Sea |
| RR1815 (GP15 Leg2, PMT) | Cutter G, Casciotti K & Lam P | Cutter Gregory, Casciotti Karen & Lam Phoebe | Section Cruise | 2018-10-24 — 2018-11-24 | Pacific Ocean |
| RR1814 (GP15 Leg1, PMT) | Cutter G, Casciotti K & Lam P | Cutter Gregory, Casciotti Karen & Lam Phoebe | Section Cruise | 2018-09-18 — 2018-10-22 | Pacific Ocean |
| IN2018_V04 (GIpr13) | Michael Ellwood | Michael Ellwood | Process Study | 2018-09-11 — 2018-10-08 | East Australian Current |
| M147 (AMAZON-GEOTRACES, GApr11) | Frank Martin | Frank Martin | Process Study | 2018-04-19 — 2018-05-21 | Amazon estuary & the associated plume |

***Summary of GEOTRACES cruises to take place in May 2019-April 2020:***

| Cruise | Chief scientist | GEOTRACES scientist | Type | Period | Location |
|---|---|---|---|---|---|
| TONGA (GPpr14) | Guieu Cecile & Bonnet Sophie | Géraldine Sarthou, Matthieu Bressac & Hélène Planquette | Process Study | 2019-10-31 — 2019-12-06 | Western Tropical South Pacific |
| KK1902 (GP09) | Cai Yihua & Zhou Kuanbo | Zhimian Cao, Minhan Dai & Liping Zhou | Section Cruise | 2019-04-25 — 2019-06-10 | North West Pacific |
| IN2019_V02 (GIpr08 bis) | Trull Tom | Boyd Phillip | Process Study | 2019-03-12 — 2019-04-05 | Southern Ocean (East Indian sector) |
| BAIT* (GApr13) | Rod Johnson | Peter Sedwick | Process Study | 2019-03* — 2020-03* | Sargasso Sea (BATS site) |

*(*) BAIT project will cover several cruises on-board of the RVs Endeavor or Atlantic Explorer. The first cruise 'EN631' will take place during the period 2019-03-10 —2019-03-15. During the period 2019-05-01 —2020-04-30 four other cruises are planned (cruise IDs and dates not yet known).*

**In summary**

This year, during the calm data submission period, the main task at GDAC was to review and improve data processing, with a special attention to data QC. The collection and processing of data to be

included in the IDP2021 will be the focal point of GDAC's data activities over the coming year, as DMC and SCC are expected to communicate on IDP2021 at the Hobart meeting (September 2019).
The workflow of data processing and tracking will benefit from the on-going developments of the GEOTRACES IDP portal. Meanwhile at GDAC, a new controlled data processing workflow will be launched in close consultation with S&I and DMC.

We continue to provide useful information on GDAC web pages for scientists and answer questions related to data and metadata submission though our GDAC email (geotraces.dac@bodc.ac.uk). We encourage the GEOTRACES community to contact GDAC for any question about their data or metadata submission.

### 3.3 GEOTRACES International Project Office

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

This year, we want to highlight the following activities:

- On-line GEOTRACES metadata portal

  An important activity conducted this year by the IPO is supporting the development of an on-line GEOTRACES metadata portal. Following the success of the GEOTRACES Intermediate Data Products, the amount of data to be reviewed, managed and processed has increased considerably. In order to facilitate the tasks of the core group of persons working on the construction of the product (co-chairs of S&I, DMC, PNC, GDAC, IPO and Reiner Schlitzer),

this group met in Liverpool in April 2018 on a joint DMC and GEOTRACES Executive meeting to review the lessons learned from the IDP2017 and to propose to the SSC the creation of a on-line GEOTRACES metadata portal that should allow: (1) a major participation of the data contributors in directly filling in the information necessary for the evaluation and management of their data into the portal, (2) a quick and easy access to this information for all people involved in the construction of the product, (3) a more automatic management of these data to allow easier updating and evaluation. The SCC approved the development of this portal to be charged to Guillaume Brissebrat (head) and Arnaud Mière (IT) from the Observatory Midi-Pyrenées Data Center (SEDOO, Toulouse, where the IPO is hosted), particularly as they have already successfully worked with the IPO in developing the GEOTRACES publication database. In September 2018, the IPO organised a working meeting with Guillaume and the IDP core group in order to define the structure and functional requirements of the portal (GEOTRACES Data Portal meeting, 25-26 September 2018, Toulouse, France). The IPO contributed to this meeting by proposing a working document defining a possible structure for the portal. Following the meeting, the IPO is assisting the developers (Guillaume and Arnaud) in providing input when needed, chasing the information from GEOTRACES senior scientists and pushing developers to get the portal done in time. Regular meetings between the IPO and the SEDOO (every two weeks) are held.

- GEOTRACES Publications Database (<http://www.geotraces.org/library-88/scientific-publications/peer-reviewed-papers>)

  New search functionalities have been added to the database. For instance, it is now possible to make more complex searches equivalent to using operators such as “AND”, “OR” and “NOT”.

- Guide for cruise PI (< http://www.geotraces.org/cruises/cruise-summary/cruise-guide>)

  The IPO has developed an interactive flow chart to guide cruise leaders on the overall process from getting their cruise designated as a GEOTRACES cruise or compliant data until the data resulting from the cruise is included in the IDP. A derived guide (short version) is also available for cruise leaders to distribute to cruise participants to guide them on the process to get their data in the IDP (<http://www.geotraces.org/dp/submit-data/flow-chart>.

- GEOTRACES Best Practices (<http://www.geotraces.org/about-us/geotraces-policies/geotraces-best-practices>)

  The IPO has published a list of best practices for GEOTRACES researchers with the objective of (1) informing scientists on the actions needed in order that the IPO can properly broadcast their GEOTRACES scientific results and activities and (2) reinforce the information on the process to get the cruise data included in the IDP. The best practice list covers the following topics: data: cruise information; scientific publications; special sessions and issues; outreach and educational materials and activities; national events and activities; and networking.

- New GEOTRACES Programme Brochure

  A new GEOTRACES brochure presenting the GEOTRACES programme along as the Intermediate Data Product is being developed.

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

  The main menu bar of the GEOTRACES website has been improved in order to simplify the access to the intermediate data product and GDAC web site resources. During the 2018 SSC, the IPO distributed a survey to SSC members asking for feedback and suggestions for improvement. Ninety per cent of the respondents found the web site well organised and have no suggestions for improvement. The main proposal for amelioration is to enhance the search engine. In the coming reporting period, the IPO plans to undertake a major overhaul of the web site that will imply moving the web site from Joomla! to WordPress. All the suggestions received will be taken into account during this process.

  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.

- GEOTRACES Science Highlight keyword search cloud

  The IPO has now published almost 200 science highlights on the GEOTRACES web site. In order to improve the search functionality, the IPO is currently working on setting up a GEOTRACES Science Highlight keyword cloud that will allow for users to click on a keyword and get a list of science highlights corresponding to the keyword selected. This functionality will be available on the new GEOTRACES web site.

- Logistics for meetings

  The IPO has hosted the GEOTRACES Data Portal Meeting (25-27 September 2018) and has provided assistance in the organization of the GEOTRACES Data Management Meeting (April 2018, Liverpool, UK), the GEOTRACES SSC Meeting (July 2018, Taiwan), the GEOTRACES-PAGES Workshop (November 2018, Aix-Marseille, France) and the GEOTRACES S&I meeting (November 2018, Marseille, France).

- Some statistics

  36 new highlights published (191 in total)
  6 eNewsletters published, including one special issue (bimonthly 33 in total)
  295 new peer-reviewed papers included in the GEOTRACES Publication Database (1230 in total)
  108 new articles published on the GEOTRACES website
  72 new announcements sent through the GEOTRACES mailing list
  546 likes in Facebook (top post reached 1.6K)
  780 likes and 1,007 followers (top tweet reached 3.1K)
  157 new subscribers on the GEOTRACES mailing list

***Featured outreach activity:*** *Float Your Boat Project*

The 2015 US Arctic GEOTRACES initiative participated in a novel outreach project coordinated with Dave Forcucci (US Coast Guard Marine Science Coordinator) to involve students and the public with an Arctic research cruise on the *US Coast Guard ice-breaker Healy*. GEOTRACES was a perfect match for the inaugural kick off of "Float your Boat" < https://www.facebook.com/explorethearctic/ >.

Over one thousand 8-inch (20-cm) long cedar boats were commissioned (funded by the National Science Foundation) from the Center for Wooden Boats (CWB.org) in Seattle, WA and distributed to school groups, scout troops, and science open-house events around the country. Students personalized their boats with bright colours and after returning to Seattle the boats were branded with floatboat.org and packed into the hold of the Healy for the journey to the North Pole. During the GEOTRACES cruise, four groups of boats were deployed on ice floes between 87.5 N and 80 N on the 150 W meridian, each with a small satellite buoy (deployed by the University of Washington Applied Physics Laboratory to study ice movement). The iridium satellite-linked buoys provided an opportunistic chance for high resolution, real-time tracking of the boats for about a year and a half. After drifting with the Arctic ice, it was hoped that the boats would eventually be freed from its grasp and float to a distant shore to be discovered and reported. This project is described by our teacher-at-sea, Bill Schmoker, at https://www.polartrec.com/expeditions/us-arctic-geotraces/journals/2015-09-16 and by Prof. Timothy Kenna, the scientitst who was in charge of deploying the boats: https://blogs.ei.columbia.edu/2015/09/21/arctic-magic-one-research-vessel-multiplies-to-hundreds/

In October 2018, three years after deployment, one of these small wooden boats was found by a gentleman in Iceland, Bolli Thor (in the picture). He wrote: "These are the coordinates 63.962285, -22.734055 where I found one of your little wooden boats, near small town called Sandgerði in Iceland where I live. I found it at my favorite spot, where I usually walk with my dog called Tyra.". Remarkably, we identified the pre-deployment picture, the student and school (Upper Nyack Elementary School).

The drift track data stopped in February, 2017. Two groups of boats ran aground in northern Canada, while two groups, deployed near the N. Pole, were entrained in the Trans Polar drift and travelled south, through Fram Strait, into the E. Greenland Current. A boat from these groups made it to Iceland.

### 3.4 GEOTRACES Workshops

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

GEOTRACES Taiwan Training Workshop, 26 July 2018, Taipei, China-Taipei

A GEOTRACES-Taiwan training workshop was organised the day immediately after the SSC meeting in Taipei. The workshop was organised by Tung-Yuan Ho (Academia Sinica) and attended by 62 participants from Taiwan. GEOTRACES lectures were given by 8 SSC members (Phoebe Lam, Andy Bowie, Maeve Lohan, Hajime Obata, Reiner Schlitzer, William Landing and Tung-Yuan Ho) included topics such as GEOTRACES and IDP2017 introduction; Seawater trace metal clean sampling and pre-treatment; particle sampling and analysis; TEIs on-board sampling and FIA&CSV analysis; Ocean Data View and marine biogeochemistry. The workshop was followed by a fruitful debate between GEOTRACES international scientists and local scientists.

For further information please visit the GEOTRACES web page: http://www.geotraces.org/images/stories/documents/workshops/2018-GEOTRACES-Workshop-Info.pdf

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, was 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 Paleoceanography, 3 - 5 December 2018, Aix-Marseille, France

60 researchers from the PAGES and GEOTRACES communities participated to an intensive 2.5 day workshop from the 3rd to the 5th of December in Aix en Provence, France. The aim of the workshop was to conduct open discussions on the applicability and scientific gaps regarding the use of some proxies exploited to infer past circulation, surface productivity and particle fluxes. Indeed, thanks to the GEOTRACES programme, these tracers are more and more documented in the modern ocean, raising important caveats in the understanding of their present behaviour and distributions. Fruitful confrontations and discussions conducted the two communities to identify common exciting perspectives and workshop products.

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

***Figure 8.*** *Participants at the Joint GEOTRACES PAGES Workshop.*

Biogeoscapes Workshop, 8-10 November 2018, Johnsson Center, Woods Hole, USA

In November 2018, approximately 28 international scientists from the fields of chemical oceanography, omics, physiology and modeling met to explore the need and scope of a new international programme loosely aimed around coupling the potential insight onto ocean ecosystems from new advances from different fields (primarily arising from the Tara Oceans and GEOTRACES efforts). The meeting was sponsored by the Scientific Commission on Ocean Research, the Ocean Carbon and Biogeochemistry programme and the Moore Foundation. Four invited speakers highlighted the insight and added value gained from integrating observations of micronutrients and omics. Reflection on previous programmes identified the importance of intercalibration and data management, and the need for omics intercalibration efforts and investment in novel data management and open access, user-friendly platforms. Equally, the need for new ecosystem modelling approaches, capable of integrating the mechanisms and feedbacks emerging from omics datasets was noted. Time was spent discussing the potential extent and impact of a new program, as well as choosing Biogeoscapes as the name. The role of different types of contributions from different nations, including the routes to funding Biogeoscapes activities were discussed, and the overall outcome of the meeting is summarised in the broad mission statement above. This preliminary broad mission of Biogeoscapes will be improved by further input and feedback from the international community. It is anticipated that feedback from the wider community will occur first via national meetings during 2019 and then in a larger international forum, which would shape the preliminary science plan in much more detail.

For further information please visit: www.biogeoscapes.org

BioGEOTRACES-Japan begins, 19-21 September 2018, Nagasaki, Japan

A workshop, entitled ”BioGEOTRACES-Japan begins” was held on 19-21 September 2018 in Nagasaki, Japan to evaluate the potentials of biological studies related to trace elements and their isotopes (TEI) in the ocean, and to find the future directions of these studies in Japan. For three days, 15 registered Japanese scientists took part in the workshop. Drs. Maria Maldonado (University of British Columbia, Vancouver) and Tung-Yuan Ho (Academia Sinica, Taipei) were invited as guest speakers. The workshop consisted of 3 invited talks, 3 keynote talks and 11 research topics related to GEOTRACES & BioGEOTRACES. During the workshop, recent scientific findings, and possible future collaborations among TEI chemists, biologists and modellers were discussed. It was decided to organise the BioGEOTRACES-Japan in order to promote these comprehensive studies and cooperate with the international community.

7th Kaplan Symposium: Tracers in the Sea: Trace Elements and their Isotopes in the Oceans, Future Directions and Instrumental Frontiers, 11-13 February 2019, Eilat, Israel

The 7th Kaplan Symposium was dedicated to GEOTRACES research with the title “Tracers in the Sea: Trace Elements and their Isotopes in the Oceans, Future Directions and Instrumental Frontiers”. The workshop counted with the participation of 72 scientists and it was organised by Adi Torfstein and Yeala Shaked at the Institute of Earth Sciences of the Hebrew University of Jerusalem. The symposium had 4 scientific themes: trace element cycling in seawater and marine particulates; the role of atmospheric dust in marine biogeochemistry; novel isotope systems in the oceans; and instrumental developments in marine geochemistry. It counted with several GEOTRACES senior scientists as invited speakers including: Eric Achterberg, GEOMAR, Germany; Mark Altabet, U Massachusetts

Dartmouth, USA; Bob Anderson, Lamont-Doherty Earth Observatory, Columbia University, USA; Gideon Henderson, Oxford University, UK; Catherine Jeandel, LEGOS, University of Toulouse, France; William Landing, Florida State University, USA; Claire Rollion-Bard, Institut de Physique du Globe de Paris, France; and Derek Vance, ETH, Switzerland.

For further information please visit the symposium web site: https://sites.google.com/view/7th-kaplan-symposium/home

## 3.5 GEOTRACES Summer School

The second GEOTRACES Summer School will be held from 23 to 28 September 2019 in Cadiz, Spain. It aims at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals. It will bring together 36 students and 10 world-leading international scientists.

Particular objectives of the summer school are:

- Gaining knowledge and experience on oceanographic sampling campaigns for collection of samples for the analysis of trace metals.
- Students should be capable to properly select and conduct analytical strategies for the study of trace metals in marine samples.
- Gaining knowledge on bio-geochemical cycles of metals in the ocean and their speciation.
- Data management to analyse the role of trace metals in the ocean.

The summer school is organised by the International GEOTRACES programme, the University of Cádiz (UCA), the Andalusian Institute of Marine Sciences of the Spanish National Research Council (ICMAN-CSIC), and the International Campus of Excellence of the Sea (CEI·MAR); with funding from the Scientific Committee on Oceanic Research (SCOR)/GEOTRACES, the General CSIC Foundation, the International Doctorate School of Marine Studies (EIDEMAR), and CEI·MAR.

For further information please visit the Summer School web site: https://geotraces.uca.es/

## 3.6 Special sessions at international conferences featuring GEOTRACES findings

Several GEOTRACES special sessions were held or are planned in major international conferences including:

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

Fourth Xiamen Symposium on Marine Environmental Sciences (XMAS), 6-9 January 2019, Xiamen China
For further information: http://mel.xmu.edu.cn/conference/4xmas

*GEOTRACES session:*

> *The role of trace metals in controlling structure and function of microbial communities in contemporary oceans
> Conveners: Punyasloke Bhadury, Yeala Shaked, Maria Maldonado, Yihua Cai and Chris Bowler

ASLO 2019, Aquatic Sciences Meeting, 23 February - 2 March 2019, San Juan, Puerto Rico
For further information: https://aslo.org/sanjuan2019/main

*GEOTRACES session:*

> *SS51. New views on the biological transformation of metals in the marine environment
> Conveners: Randelle Bundy, Shane Hogle, Katherine Heal, Kristen Buck and P. Dreux Chappell

***Forthcoming:***

SOLAS Open Science Conference, 21-25 April 2019, Sapporo, Japan
For further information: https://www.confmanager.com/main.cfm?cid=2778

*GEOTRACES session:*

> *Atmospheric deposition of iron, ocean biogeochemistry and marine emission of biological aerosols
> Conveners: Akinori Ito (JAMSTEC), William M. Landing (Florida State University) and Douglas S. Hamilton (Cornell University)

27th IUGG General Assembly, 8-18 July, 2019, Palais des Congrès in Montréal, Québec, Canada

*GEOTRACES relevant sessions:*

*P02 Physics and biogeochemistry of semi-enclosed, shelf seas and coastal zones
Conveners: Peter Zavialov, Jianping Gan, Osmar Moller Jr, Katrin Schroeder

*P09 Marine biogeochemistry through time: nutrient, trace metal, oxygen, and carbon cycling in the past, present and future
Conveners: Kate Hendry, Zanna Chase, Katja Fennel and Patrick Rafter

Goldschmidt 2019, 18-23 August 2019, Barcelona
For further information: https://goldschmidt.info/2019/

*GEOTRACES or GEOTRACES-related sessions:*

*10c: Arctic and sub-Arctic Large Scale Ocean Processes: What can We Learn from Tracers?
Conveners: Núria Casacuberta, Michael Karcher

*10j: Biogeochemical Cycles of Low Oxygen Zones and their Response to Ocean Deoxygenation
Conveners: Nicole Bale, Darci Rush, Ruifang Xie, Tim Conway, Insa Rapp, Laura Bristow

*10k: Trace Metal Cycling and Radioisotope Tracers of Ocean Biogeochemistry (GEOTRACES)
Conveners: Aridane G. González, Hannah Whitby, Amber Annett, Emilie Le Roy

*08j: Dynamics and Fluxes of the Exogenic Carbon Cycle and Interactions with Biogeochemical Cycling
Conveners: Gerhard Kuhn, Norbert Frank, Thomas Chalk, William Gray
Keynote: Robert Anderson

*10a: Linking Marine Silicate Alteration to Carbon Cycle and Trace Elements Budgets in the Ocean and Sediment
Conveners: Wei-Li Hong, Jianghui Du, Antoine Crémière
Keynote: Catherine Jeandel

*10h: The Oceanic Particle Flux and its Cycling within the Deep Water Column
Conveners: Maureen Conte, Rut Pedrosa Pamies, Phoebe Lam, Henry Ruhl

*12a: Hydrobiogeochemical Processes at the Sediment-Water Interface: Wetlands, River Corridors and Coastal Zones
Conveners: Dipankar Dwivedi, Xingyuan Chen, Joseph Tamborski, Valentí Rodellas, Edward O'Loughlin, Yamin Deng, Virginie Sanial
Keynote: Christof Meile

*13e: Radionuclides in the Environment: Modeling, Experimental, Scaling, Controlling Chemical/Microbial/Hydrological Processes
Conveners: Peter H. Santschi, Daniel Kaplan

*13f: Trace Elements Speciation: Novel Methodologies and Insights into Transformations Influencing their Global Biogeochemical Cycle
Conveners: Sylvain Bouchet, Adrien Mestrot

## 3.7 Capacity building

Activities It is a GEOTRACES strategy to organise training workshops the day or the two-days immediately after a SSC meeting in order to increase the local impact of these meetings (e.g. the GEOTRACES-Taiwan training workshop held in July 2019, see GEOTRACES Workshops above for further details). In this sense the capacity building benefits are considered at the time of selecting the host of the meeting. During the training workshops selected SSC members give lectures, along with local scientists, to national scientist and students. Note that SSC meetings are also an occasion for a fruitful exchange with local scientists and often-parallel scientific meetings are organised during the breaks all along the SSC meeting.

Travel Grants GEOTRACES has requested support from SCOR to enable scientists from developing countries and countries with economies in transition to participate in the second 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. At the time of writing this review, a document "Recommendations for nations developing a trace metal-clean sampling system" is being prepared by Greg Cutter (Old Dominion University, past S&I co-chair). This document will summarise the lessons learned during past guidance experiences and it will be of great resource for other countries wishing to develop trace metal-clean sampling. This document will be available on the GEOTRACES Capacity Building web page http://www.geotraces.org/science/geotraces-activities.

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 (Australia National University) | Complete | Powder coated aluminium, autonomous 1018 intelligent rosette system (General Oceanics) | 12 x 10-L Teflon-lined Niskin-1010X (General Oceanics) | 6000 m; 6 mm Dynex rope |
| Australia (Marine National Facility) | Complete | Polyurethane powder-coated aluminium autonomous Seabird rosette with CTD and | 12 x 12-L Teflon-lined OTE external-spring Niskin-style | 1750 m 9mm Dyneema rope or 200 m 6 mm Dyneema rope wth |

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| | | other sensors, auto-fire module, and all titanium housings and fittings | bottles | coupling to 6000 m CTD wire |
| Australia (Marine National Facility) | Complete (backup system) | 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 wth coupling to 6000 m CTD wire |
| Brazil | Complete | GEOTRACES WATER SAMPLER - 24-bottle sampler for use with modem equipped 911plus CTD | 24 X 12-L GO-Flo | 3000 m; Kevlar cable |
| Canada | Complete | Powder coated aluminium with titanium CTD housing, Seabird Rosette | 24 X 12-L GO-Flo | 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 aluminum with titanium pressure housings and fittings | 24 X 12-L Niskin-X | 8000 m; conducting Kevlar |
| Israel | Complete | Powder coated aluminium, SeaBird Rosette | 12 X 12-L Niskin; 8 X 12-L GO-Flo (Teflon coated) | 2000 m, steel conducting cable |
| Italy | Complete | Go-Flo bottles on Kevlar line | 5 x 20-L Go-Flos | Kevlar |

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| 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* **There is only one cable for the two systems* |
| Netherlands | Complete | Titanium frame | 24 X 24-liter ultraclean PVDF | 10000 m; conducting Kevlar* **There is only one cable for the two systems* |
| 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 |
| Russia | Complete* (although the steel cable) | Powder coated aluminium, SeaBird Rosette SBE9p occupied CTD SBE 9+ | 24 × 12-L Niskin bottles | 4000 m, steel conducting cable |
| Russia | In development (by 2021– 2024) | Powder coated aluminium, SeaBird Rosette and all titanium housings and fittings | GO-FLO, Niskin-X, 24 × 12-L | 10000 m, conducting Kevlar |
| South Africa | Complete | Powder coated aluminium, titanium housing/fittings | 24 X 12-liter GO-Flo | 6500 m; Kevlar cable |
| South Korea | Complete | Titanium frame | 24 × 12L PVDF | 10,000 m; 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 |

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| 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

***Towards Intermediate Data Product 2021***

The development of the web based metadata portal will continue over the next reporting period with the goal for it to be functional for data contributors to use for the IDP2021. GEOTRACES hopes that this data portal will not only smooth the production of the remaining intermediate and final data products for the GEOTRACES programme, but will provide a data management framework for future programmes.

Also, having completed over half of the global survey (Figure 1) GEOTRACES plans to continue to advance the GEOTRACES field programme through section cruises (with one section cruise from China scheduled so far for next reporting period), supplemented by process studies (3 already planned for next year) that have investigated particular physical, chemical, and biological processes regulating the distributions of these TEIs.

***Capacity building through GEOTRACES Summer Schools***

Following the successful GEOTRACES Summer School organised in August 2017 in Brest, France, GEOTRACES has decided to organise GEOTRACES summer schools every two years. GEOTRACES is currently preparing the second summer school to be held in September 2019 in Cadiz, Spain as reported previously. The third GEOTRACES summer school is already planned to be held in 2021 in Germany.

In addition, a workshop “Southern Ocean Biogeochemistry in a Changing World” will be held in Hobart, Australia, on 12-13 September 2019, immediately after the 2019 SSC meeting. The workshop

will bring together national and international GEOTRACES scientists as well as local students and researchers in biogeochemical oceanography, modelling and paleoceanography focused on the Southern Ocean's response to climate change.

***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 fall 2019 (initially planned for 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 workshops:*

GEOTRACES plans to continue its synthesis efforts initiated by the suite of three synthesis workshops (in 2015, 2016 and 2018, http://www.geotraces.org/science/synthesis-of-results) by organising a synthesis workshop on sensitivity to trace elements and isotopes cycles to global change to be held in 2021 (tentatively) in Germany. This workshop will combine new knowledge gained from GEOTRACES with the latest models of TEIs. The workshop should also continue the 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. In any case, the synthesis will continue to respond to the expectation that GEOTRACES results benefit other oceanographic disciplines.

***Biogeoscapes effort***

GEOTRACES investigators and the IPO will provide advice and recommendations, as appropriate, to help launch this new programme as needed.

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