GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2019/2020

April 1st, 2019 to March 31st, 2020

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1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

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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

Preparing the release of the third Intermediate Data Product, GEOTRACES sustains a very favourable implementation as shown in the following sections:

2.1 Status of GEOTRACES field programme

During the past year (April 1st, 2019 to March 31th, 2020), the GEOTRACES programme has progressed excellently. It is of particular importance that a new country, China, has successfully completed its first GEOTRACES section cruise (in the North West Pacific see map below, section in orange). Additionally, 4 process studies were also completed: 1 process study from USA (with 3 cruises), 2 process studies from Brazil and 1 from France. In total 7 new cruises were completed.

Overall 120 cruises have been completed, corresponding to 31 GEOTRACES sections (with 41 cruises), 38 process studies (with 59 cruises) and 9 compliant data sets, as well as, 11 cruises completed as a GEOTRACES contribution to the International Polar Year (IPY).

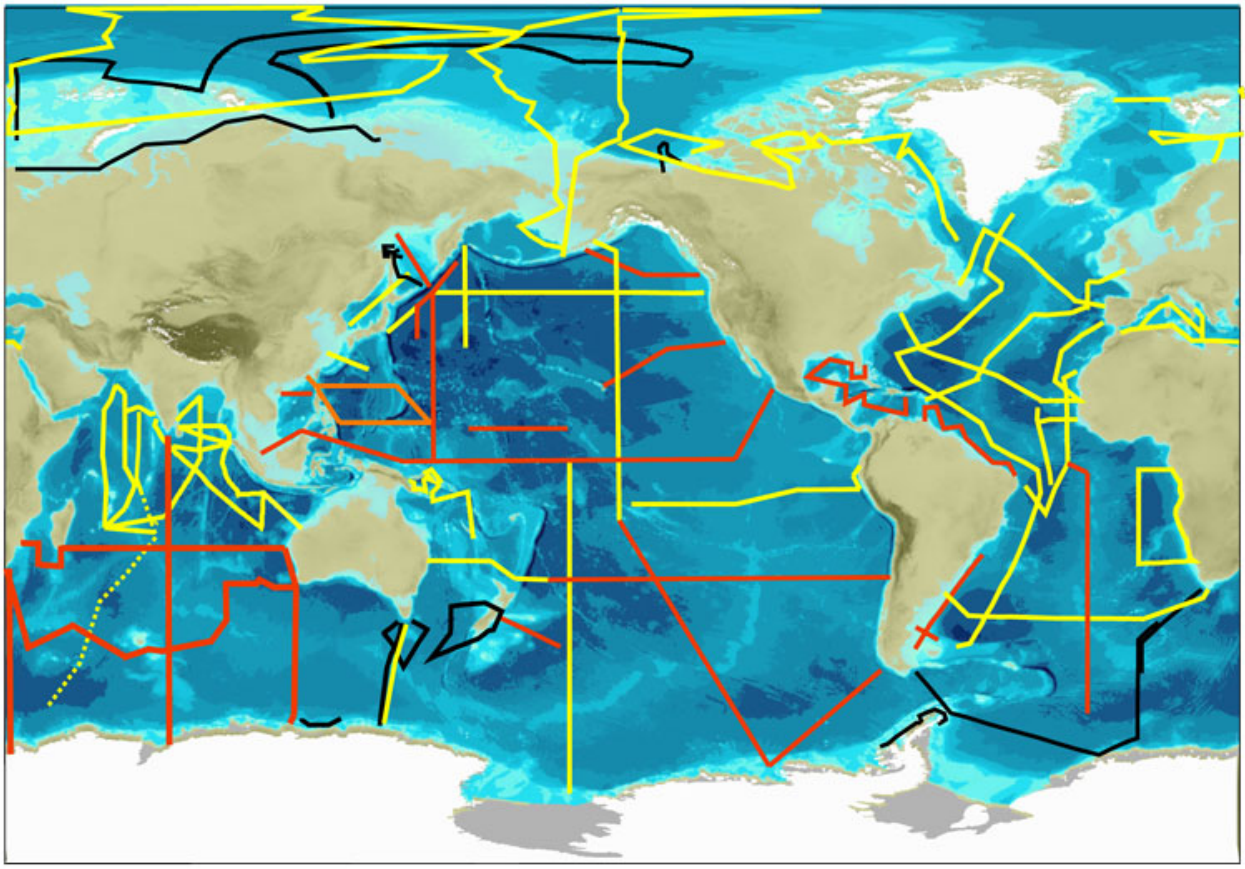


Figure 1: *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past year.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

Planned release of Intermediate Data Product 2021

Following from the release of two Intermediate Data Products in 2014 and 2017 GEOTRACES announced, in December 2019, the release of the third intermediate data product in July 2021 (IDP2021). To ensure timely release of the IDP2021, two deadlines for data submission have been established: one deadline that guarantees data inclusion on April 1, 2019 (extended to May 15, 2020 due to the COVID-19 situation) and a final deadline in December 15, 2020 (see data management section in this report for further details).

Assistance to researchers in registering data in IDP

In order to help researchers in submitting data to the IDP, several actions have been planned or completed during the reporting period:

1. Completing the GEOTRACES Data for Oceanic Research portal (DOoR) which is a new interface where researchers can register and submit their data sets for intercalibration and potential inclusion in IDP2021 as well as obtain all templates for submission of their data (see GEOTRACES International Project Office section in this report for further details). This has been a huge task that involved the coordinated work of all components of the GEOTRACES programme. The portal it is available at: https://geotraces-portal.sedoo.fr/pi/

2. **Providing guides** to researchers on how to use the DOoR and submit data to the IDP including:
   - a *how to document* available at:
   http://www.geotraces.org/images/GEOTRACES_DOoR_User_Guide.pdf
   - *a video guide* available at:
   https://youtu.be/KZHZ8MffV98 and,
   - *improved interactive guides and flowcharts* for researchers available at:
   https://www.geotraces.org/how-to-ensure-that-your-data-are-in-idp-flow-chart/

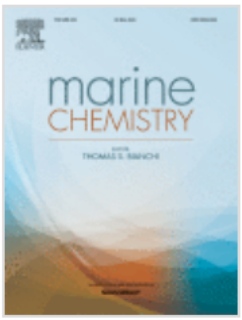
3. **Organising several drop-in events** at various conferences and workshops in 2020 to demonstrate the use of the DOoR portal and to register datasets with PIs if desired. The first of these occurred at the **SCOR booth** during the Ocean Sciences Meeting in February 2020 where GEOTRACES committee members and Mohamed Adjou, the leader of the GEOTRACES Data Assembly Centre (GDAC) provided demonstrations of the DOoR Portal.
   Thanks to those committee members and Mohamed Adjou for all their assistance and to SCOR for the opportunity to participate in the booth.

Fair Use Agreement

An important change with IDP2021 is that GEOTRACES moves away from the formal registration step (the "Download Agreement") towards adherence to a fair use agreement (available at: https://www.geotraces.org/idp2021-fair-use-document/), to cover appropriate recognition of data generators in the subsequent usage of IDP2021. All data in IDP2017 will be rolled over to IDP2021 under this fair use agreement. Researchers who do not wish their data to be rolled over from IDP2017 to IDP2021, should inform the GEOTRACES International Project Office.

2.3 GEOTRACES publications

During the reporting period, 123 new peer-reviewed papers have been published. This includes the publication of one special issue (two more are currently in preparation):



ASIAN GEOTRACES: Interaction between the North Pacific and its marginal seas
Editors: Greg Cutter, Jing Zhang and Pinghe Cai
Marine Chemistry
April 2019
https://www.sciencedirect.com/journal/marine-chemistry/special-issue/10ZN2NDLMVP

It also includes the publication of a comprehensive review of the GEOTRACES international programme published at the *Annual Review of Marine Sciences* by Bob Anderson (see the GEOTRACES Science Highlight section in this report for further details):

Anderson, R. F. (2020). GEOTRACES: Accelerating Research on the Marine Biogeochemical Cycles of Trace Elements and Their Isotopes. *Annual Review of Marine Science*, *12*(1), annurev-marine-010318-095123. DOI : https://doi.org/10.1146/annurev-marine-010318-095123

In total, the GEOTRACES peer-reviewed paper database includes 1,353 publications.

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.

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

- GEOTRACES peer-reviewed papers database: https://www.geotraces.org/geotraces-publications-database/
- GEOTRACES special issues: https://www.geotraces.org/category/scientific-publications/geotraces-special-issues/
- List of GEOTRACES promotional articles: https://www.geotraces.org/category/library/publicity/

2.4 GEOTRACES science highlights

The GEOTRACES International Project Office regularly generates science highlights of notable published articles, which are posted on the GEOTRACES website (https://www.geotraces.org/category/science/newsflash/). So far, about 217 highlights have been published. Among the numerous highlights published since last year's report, we selected the following seven:

A review constituting the half-way mark of GEOTRACES

After a brief reminder on the motivation and foundation processes of the international and ambitious programme GEOTRACES, Bob Anderson (2020, see reference below) proposes an overview of many results of GEOTRACES activities related to the three guiding themes of the programme: (1) fluxes and processes at ocean interfaces (2) internal cycling of TEIs, and 3) the development of proxies for past change. It is beyond the scope of a highlight to summarise the main results obtained with the programme so far, knowing that most of them are already covered as highlights in this website!

Thus your favourite International Project Office (IPO) encourages colleagues, teachers and students who wish to discover how fruitful modern marine geochemistry is to open this review. As an example we propose the illustration below: the contrasting distributions of phosphate (PO_4), aluminium (Al), iron (Fe), cobalt (Co) and zinc (Zn) along a meridional Atlantic section. These data illustrate how the acquisition of clean and reliable data at high resolution questions established paradigms. Although each is a micronutrient, Fe, Zn and Co fates appear to be governed by different processes. Similarly, while both Al and Fe have lithogenic origins, their distributions are quite different, due to their different chemistries, residence times, and additional boundary sources. Among these brief examples, there are many new questions to explore!

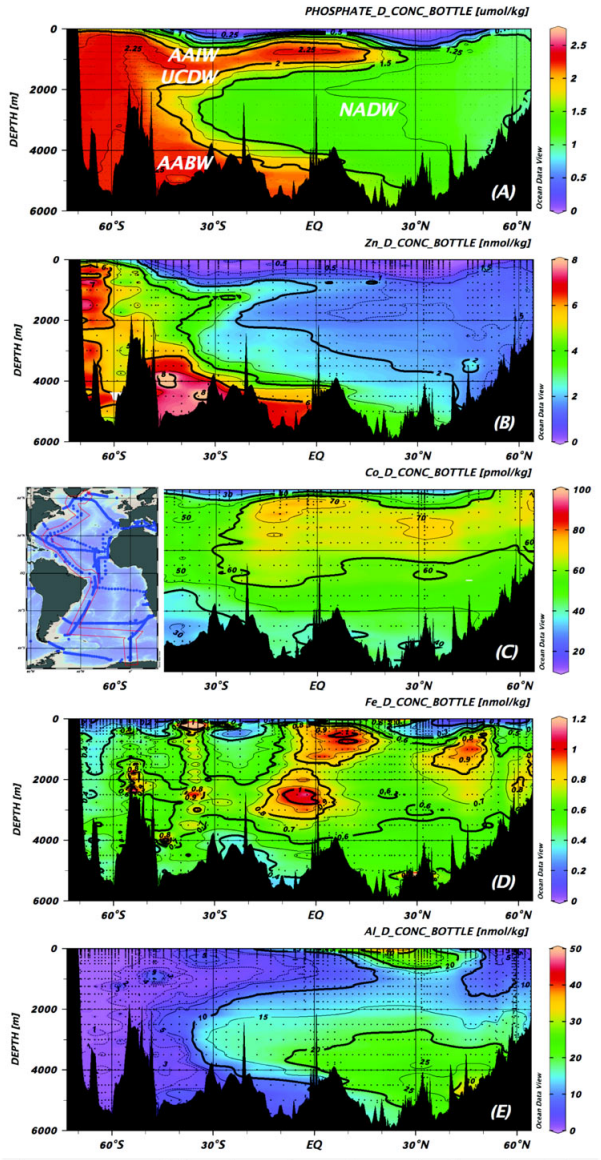


Figure 2: *Meridional sections down the length of the Atlantic Ocean created by splicing data from multiple GEOTRACES sections (see inset in panel C). Data are available in the GEOTRACES Intermediate Data Product IDP2017. A) Phosphate data from IDP2017. B) Dissolved Zn (Middag et al 2019) and unpublished data from P. Croot, available in IDP2017. C) Dissolved Co (Dulaquais et al 2014a, Dulaquais et al 2014b) and unpublished data from M. Boye available in IDP2017. D) Dissolved Fe (Klunder et al 2011, Rijkenberg et al 2014). E) Dissolved Al (Middag et al 2015, Middag et al 2011) and unpublished data from Peter Croot available in IDP2017. Figure produced using Ocean Data View <http://odv.awi.de>.*

References:

Anderson, R. F. (2020). GEOTRACES: Accelerating Research on the Marine Biogeochemical Cycles of Trace Elements and Their Isotopes. Annual Review of Marine Science, 12(1), DOI: https://doi.org/10.1146/annurev-marine-010318-095123

Dulaquais G, Boye M, Middag R, Owens S, Puigcorbe V, et al. (2014a). Contrasting biogeochemical cycles of cobalt in the surface western Atlantic Ocean. Glob. Biogeochem. Cycles 28:2014GB004903

Dulaquais G, Boye M, Rijkenberg MJA, Carton X. (2014b). Physical and remineralization processes govern the cobalt distribution in the deep western Atlantic Ocean. Biogeosciences 11:1561–80

Klunder MB, Laan P, Middag R, de Baar HJW, Ooijen JV. (2011). Dissolved iron in the Southern Ocean (Atlantic sector). Deep-Sea Res. II 58:2678–94

Middag R, van Hulten MMP, Van Aken HM, Rijkenberg MJA, Gerringa LJA, et al. (2015). Dissolved aluminium in the ocean conveyor of the West Atlantic Ocean: effects of the biological cycle, scavenging, sediment resuspension and hydrography. Mar. Chem. 177:69–86

Middag R, van Slooten C, de Baar HJW, Laan P. (2011). Dissolved aluminium in the Southern Ocean. Deep-Sea Res. II 58:2647–60

Rijkenberg MJA, Middag R, Laan P, Gerringa LJA, van Aken HM, et al. (2014). The distribution of dissolved iron in the West Atlantic Ocean. PLOS ONE 9:e101323

Neural network as tools to replace oceanic data deficiencies

The importance of the cycle and speciation of nitrate and its isotopes (δ15N) in the ocean does not have to be demonstrated anymore. In an attempt to overcome the difficulty to compare the results of N/δ15N cycle models to a sparse set of data, Rafter and co-workers propose an original approach, based on artificial intelligence (AI) methods.

They use a compilation of 12,277 published δ15N measurements together with climatological maps of physical and biogeochemical tracers to create a surface to-seafloor map of δ15N using an ensemble of artificial neural networks (EANN). In other words, they train the seawater parameters to deduce a δ15N value at a given location and depth taking into accounts the climatological values. The strong correlation ($R2 > 0.87$) and small mean difference (< 0:05 ‰) between EANN-estimated and observed nitrate δ15N indicate that the EANN provides a good estimate of climatological nitrate δ15N without a significant bias. This climatology reveals large-scale spatial patterns in nitrate δ15N and allows the quantification of regional and basin-average oceanic values of nitrate δ15N. This work demonstrates how AI tools could help to address the unavoidable deficiency of data inherent to oceanic studies, keeping in mind that they require ab initio reasonable data coverage and mostly a good understanding of the parameter fate.

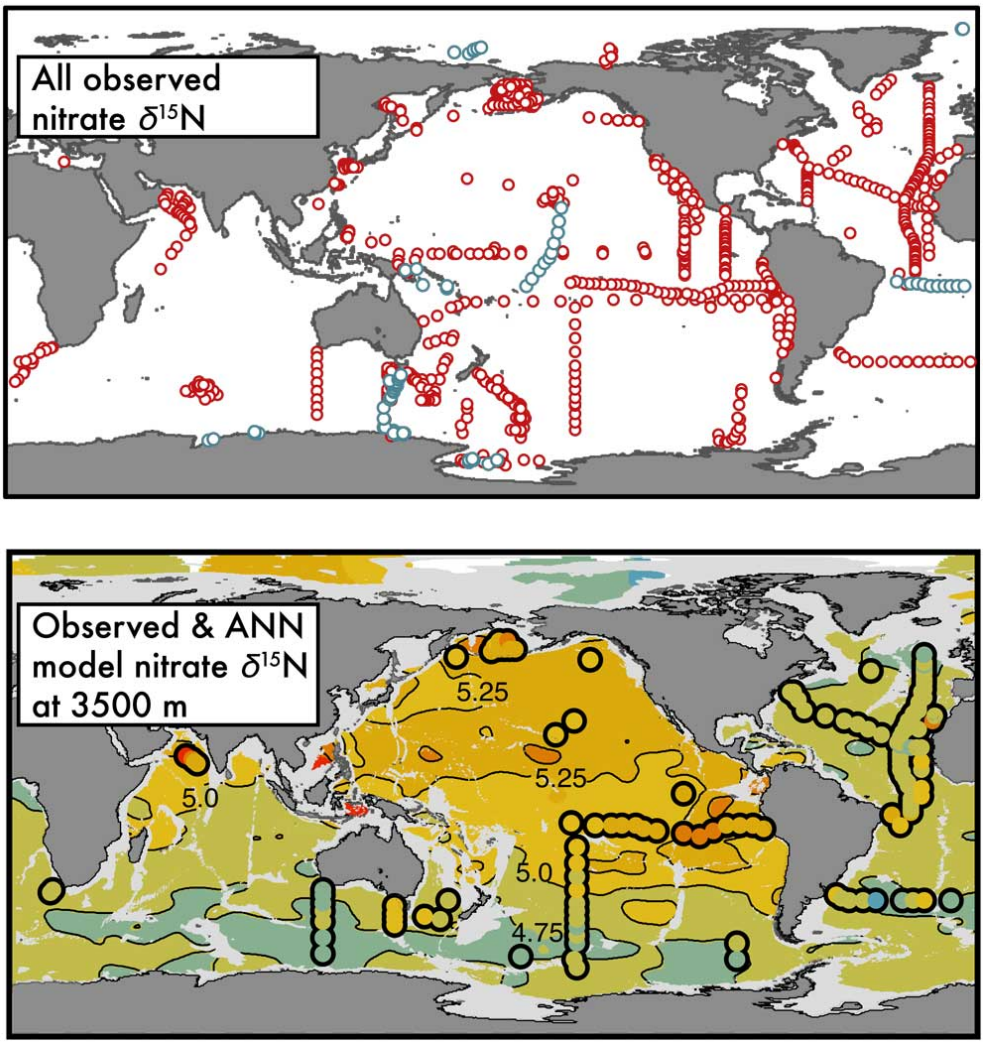


Figure 3: *(Top) Available nitrate δ15N (N isotopic composition) measurements at the time of publication. (Bottom) View of nitrate δ15N at 3500 m from two perspectives: the observed value (circles) and the model value (the contours).*

Reference:

Rafter, P. A., Bagnell, A., Marconi, D., & DeVries, T. (2019). Global trends in marine nitrate N isotopes from observations and a neural network-based climatology. Biogeosciences, 16(13), 2617–2633. https://doi.org/10.5194/bg-16-2617-2019

Welcome to the first Korean participation in GEOTRACES

Thanks to the newly launched research vessel (R/V) *Isabu* of the Korea Institute of Ocean Science and Technology (KIOST), and the acquisition of a contamination-free PRISTINE (NIOZ, NL) ultraclean seawater sampling system for trace elements, the Korean marine geochemists are pleased to published their first reliable trace metal (TM) results. Two cruises conducted in the Indian Ocean together with an intercalibration conducted at a GEOTRACES cross over station allowed them to assess their data quality. Thanks to these very positive results, researchers from KIOST and other academic institutes of Korea are currently conducting and planning *R/V Isabu*-based long-term research in offshore areas (Korean marginal seas) and the open ocean. Welcome to GEOTRACES!

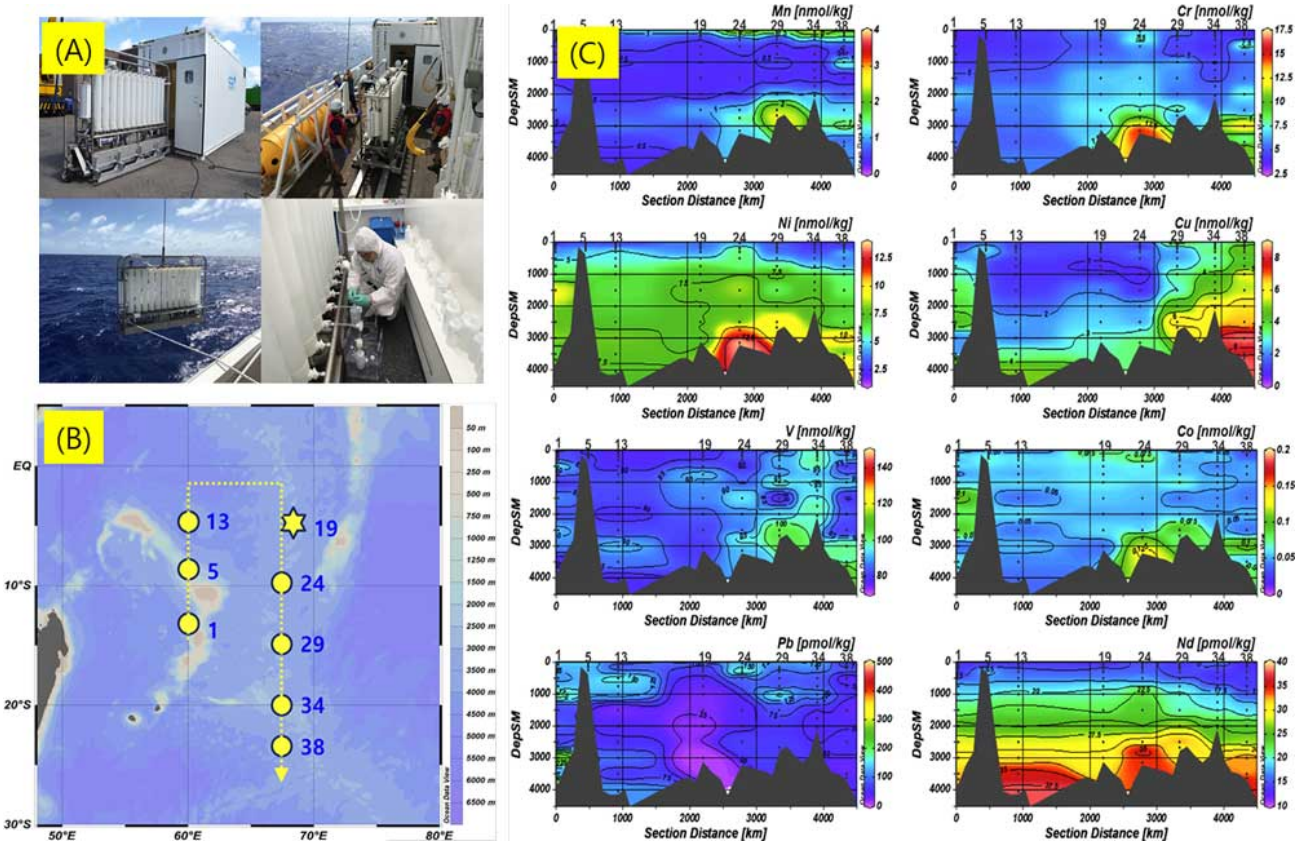


Figure 4: *A) Photographs of operating the PRISTINE ultra-clean sampler at sea and of subsampling (Upper left). B) Sampling station in the Indian Ocean in Apr. 2018 (yellow dots of lower left). Yellow star (station 19) indicates the GEOTRACES crossover station (69.54°E–5.16°S) where samples were also collected in 2017. Yellow dotted arrow line denotes the cruise track. C) Contour maps of some dissolved trace element along the western Indian Oceans (60°E and 68°S). The direction of contour (left to right) is the same as the cruise track in Fig. B. Modified from Ocean Science Journal.*

Reference:

Kim, S. H., Ra, K., Kim, K.-T., Jeong, H., Lee, J., Kang, D.-J., Rho, T., Kim, I. (2019). R/V Isabu-Based First Ultraclean Seawater Sampling for Ocean Trace Elements in Korea. Ocean Science Journal, 1–12. https://doi.org/10.1007/s12601-019-0030-x

Upwelled hydrothermal iron stimulates massive phytoplankton blooms in the Southern Ocean

Joint Science Highlight with US-Ocean Carbon & Biogeochemistry (US-OCB).

In a recent study, Ardyna et al (2019, see reference below) combined observations of profiling floats with historical trace element data and satellite altimetry and ocean color data from the Southern Ocean to reveal that dissolved iron (Fe) of hydrothermal origin can be upwelled to the surface. Furthermore, the activity of deep hydrothermal sources can influence upper ocean biogeochemical cycles of the Southern Ocean, and in particular stimulate the biological carbon pump.

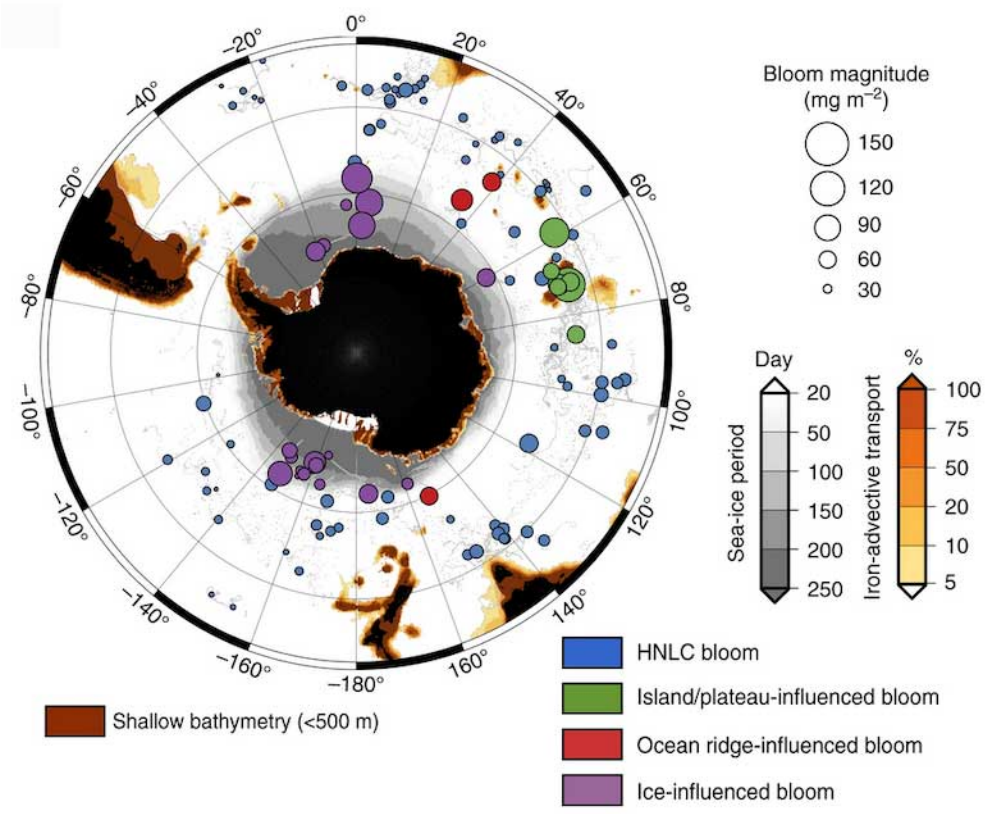


Figure 5: *Southern Ocean phytoplankton blooms showing distribution, biomass (circle size) and type (color key). Adapted from Ardyna, et al., 2019.*

Reference:

Ardyna, M., Lacour, L., Sergi, S., d'Ovidio, F., Sallée, J.-B., Rembauville, M., Blain, S., Tagliabue, A., Schlitzer, R., Jeandel, C., Arrigo, K.R., Claustre, H. (2019). Hydrothermal vents trigger massive phytoplankton blooms in the Southern Ocean. Nature Communications, 10(1), 2451. DOI: https://doi.org/10.1038/s41467-019-09973-6

About the decoupled fates of aluminium, manganese, cobalt and lead in the North Pacific Ocean

Did you know that each of these tracers could follow its own marine story, quite decoupled from the others?

This is what is shown and discussed by Zheng and co-workers (2019, see reference below) after having analysed about 500 samples for aluminium (Al), manganese (Mn), lead (Pb) and cobalt (Co) along three sections in the North Pacific Ocean. They demonstrate that the distribution of each element is uniquely related to ocean circulation; that the subsurface Pb maximum has been sustained in the North Pacific Ocean through the growth of anthropogenic sources in Asia and Russia, contrasting with the decrease observed in the Atlantic Ocean (please also read the science highlight from Bridgestock et al., 2016 here: https://www.geotraces.org/testament-of-environmental-policies/); that the labile fraction of particulate Al is larger than that of particulate lead; and finally that while the Pb enrichment factor confirms its predominant atmospheric origin, those of Mn and Co clearly attest that sources other than the aerosol deposition are more significant contributors to the concentrations of these two tracers.

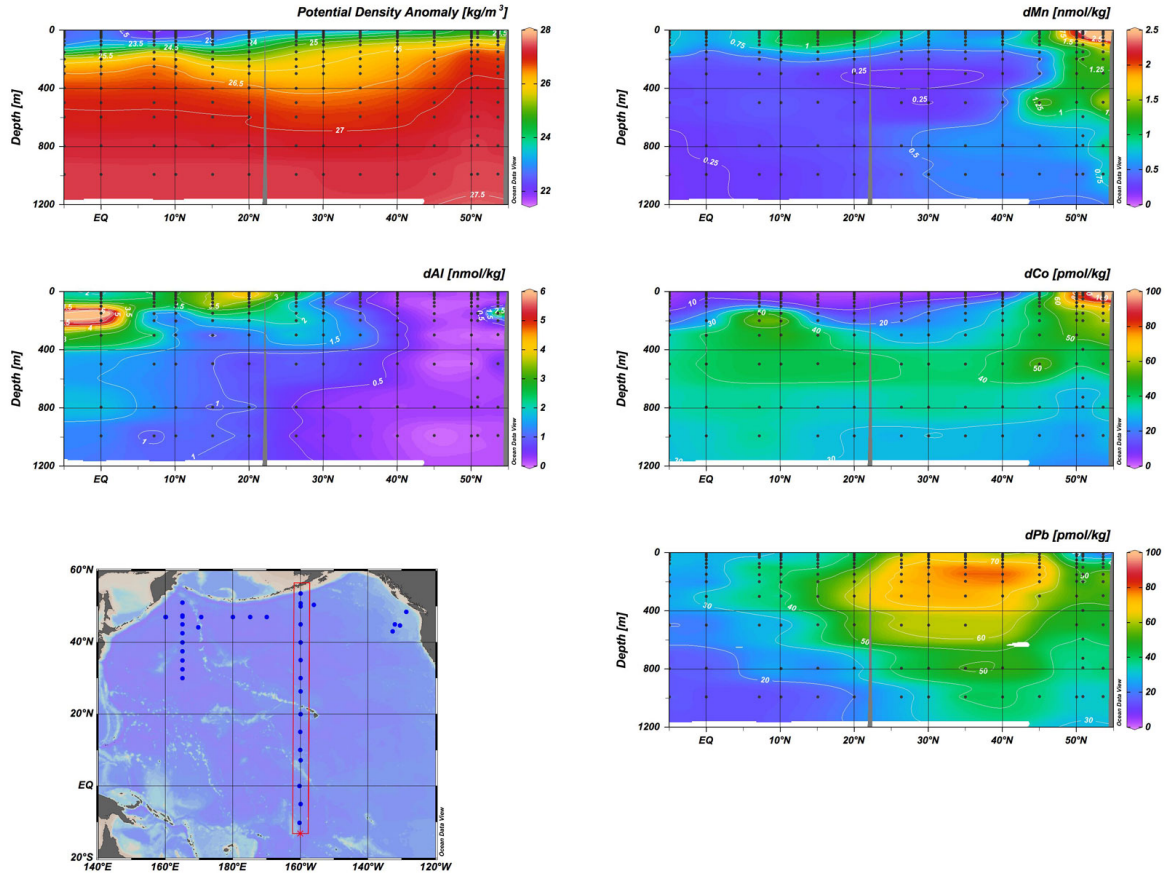


Figure 6: *Sectional distributions of dissolved metals (dM) and potential density anomaly at depths of 0–1200 m along 160°W (section highlighted in red in the map). Dissolved aluminium (dAl) is high in Equatorial Under Current (EQ, 175 m depth) and North Equatorial Current (20°N, surface). Although dissolved manganese (dMn) and dissolved cobalt (dCo) have a concurrent source at the continental shelf of the Aleutian Islands, dCo is more widely distributed via North Pacific Intermediate Water (NPIW, ~600 m). Dissolved lead (dPb) is concentrated in Subtropical Mode Water and Central Mode Water above the NPIW. Adapted from Zheng et al., 2019.*

References:

Zheng, L., Minami, T., Konagaya, W., Chan, C.-Y., Tsujisaka, M., Takano, S., Norisuye, K., Sohrin, Y. (2019). Distinct basin-scale-distributions of aluminum, manganese, cobalt, and lead in the North Pacific Ocean. Geochimica et Cosmochimica Acta, 254, 102–121. DOI: http://doi.org/10.1016/J.GCA.2019.03.038

Bridgestock, L., van de Flierdt, T., Rehkämper, M., Paul, M., Middag, R., Milne, A., Lohan, M.C., Baker, A.R., Chance, R.,, Khondoker, R., Strekopytov, S., Humphreys-Williams, E., Achterberg, E.P., Rijkenberg, M.J.A., Gerringa, L. J.A., de Baar, H. J. W. (2016). Return of naturally sourced Pb to Atlantic surface waters. Nature Communications, 7, 12921. doi: http://doi.org/10.1038/ncomms12921

A treasure of geochemical data to trace ocean circulation, ventilation, mixing, biogeochemical and hydrothermal processes

This treasure is made of approximately 60,000 valid tritium measurements, 63,000 valid helium isotope determinations, 57,000 dissolved helium concentrations, and 34,000 dissolved neon concentrations, including their metadata (geographic location, date and sample depth). It was compiled by Bill Jenkins and co-workers (2019, see reference below) who describe the nature of the data, discuss their quality, list the contributors and pioneers, and of course are giving free access to this huge dataset (https://doi.org/10.25921/c1sn-9631). They also provide some figures illustrating how powerful this new tool is as for example the figure below.

Authors invite anyone with knowledge of additional tritium, helium, or neon data that has not been included, to please contact wjenkins@whoi.edu with details for inclusion in future versions of the data set.

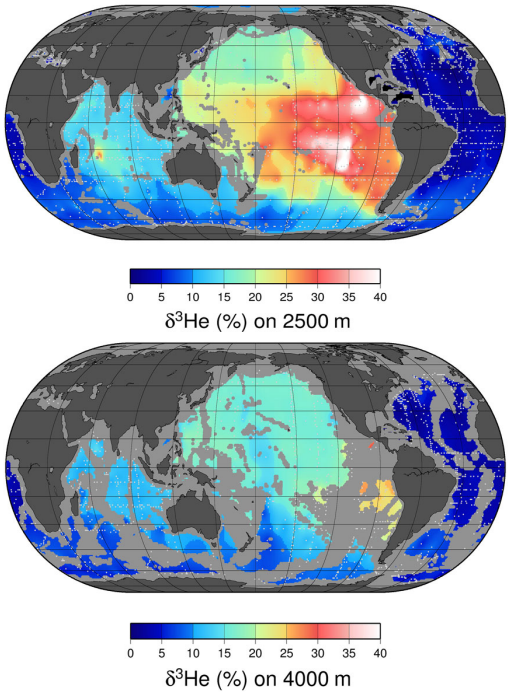


Figure 7: *(top) A map of helium values at approximately 2500 m depth. (bottom) A map of helium values at approximately 4000 m depth. The values plotted are simply an average of all measurements within a 1' square between 3750 and 4250 dbar. Depths shallower than 4000 m are masked in gray, and sampling locations are indicated by light gray dots. ^{3}He is an extremely rare isotope that is a sensitive tracer of hydrothermal processes. Since it is both stable and chemically inert, it is detectable over great distances in the ocean. The two maps shown above are of the distribution of δ^3He, a tracer of hydrothermal activity, at two levels in the deep ocean. The shallower one roughly corresponds to the depth of the mid-ocean ridge system, where the bulk of this hydrothermal injection takes place. One can see the dominant role of the fast-spreading ridges in the eastern Pacific, which drive two massive, westward reaching plumes north and south of the equator. The deeper horizon shows the spreading of δ^3He-impoverished bottom waters from the northern and southern polar regions into the deep ocean basins.*

Reference:

Jenkins, W. J., Doney, S. C., Fendrock, M., Fine, R., Gamo, T., Jean-Baptiste, P., Key, R., Klein, B., Lupton, J. E., Newton, R., Rhein, M., Roether, W., Sano, Y., Schlitzer, R., Schlosser, P. Swift, J. (2019). A comprehensive global oceanic dataset of helium isotope and tritium measurements. Earth System Science Data, 11(2), 441–454. DOI: http://doi.org/10.5194/essd-11-441-2019

South Pacific particulate organic carbon fate challenges Martin's Law

Joint Science Highlight with US-Ocean Carbon & Biogeochemistry (OCB).

Carbon storage in the ocean is sensitive to the depths at which particulate organic carbon (POC) is respired back to CO_2 within the twilight zone (100-1000m). For decades, it has been an oceanographic priority to determine the depth scale of this regeneration process. To investigate this, GEOTRACES scientists are deploying new isotopic tools that provide a high-resolution snapshot of POC flux and regeneration across steep biogeochemical gradients in the South Pacific Ocean.

A recent paper in *PNAS* reported on particulate organic carbon (POC) fluxes throughout the water column (focusing on the upper 1000 m) along the GP16 GEOTRACES section between Peru and Tahiti (Figure 1A). POC fluxes (Figure 1B) were derived by normalising concentrations of POC to ^{230}Th following analysis of samples collected by in situ filtration. This work builds on a research theme initiated at the GEOTRACES-OCB synthesis workshop held at Lamont-Doherty Earth Observatory in 2016.

The study results show that POC regeneration depth is shallower than anticipated, especially in warm stratified waters of the subtropical gyre. Regeneration depth—expressed in terms of the Martin-curve power-law exponent "b" (Figure 1C)—is shown to be greater than previous estimates (horizontal dashed lines), but similar to values obtained using neutrally buoyant sediment traps at the Hawaii Ocean Time-series Station Aloha. In contrast to the rapid regeneration of POC in warm stratified waters, POC regeneration within the oxygen deficient zone (ODZ) is below our detection limits. Models have shown that shallower regeneration of POC leads to less efficient carbon storage in the ocean, making the authors speculate that global warming, yielding expanded and more stratified gyres, may induce a reduction of the ocean's efficacy for carbon storage via the biological pump.

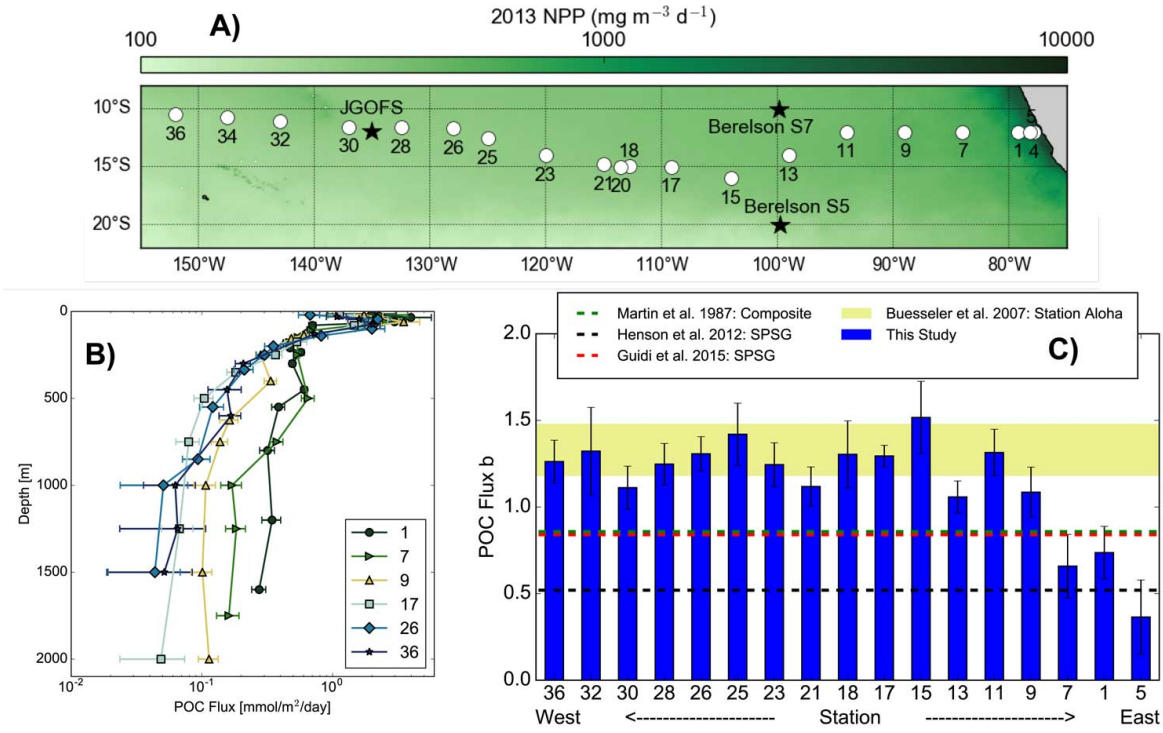


Figure 8: *Site map and POC flux characteristics from [GEOTRACES GP16 section](). Plot A) shows the GP16 station locations as white circles, with nearby sediment trap deployments as black stars, with 2013 MODIS satellite-derived net primary productivity in the background. Plot B) shows POC fluxes from particulate ^{230}Th-normalization from selected stations spanning the zonal extent of the GP16 section. Plot C) shows power law exponent b values for each GP16 station (blue), compared to estimates from bottom-moored sediment traps in the South Pacific (black and red dashed lines), a compilation of sediment traps in the North Pacific (green dashed line), and neutrally buoyant sediment traps in the subtropical North Pacific (yellow shaded band). GP16 regeneration length scales from ^{230}Th-normalization agree most closely with the estimates from neutrally buoyant sediment traps.*

Reference:

Pavia, F. J., Anderson, R. F., Lam, P. J., Cael, B. B., Vivancos, S. M., Fleisher, M. Q., Lu, Y., Zhang, P., Cheng, H., Edwards, R. L. (2019). Shallow particulate organic carbon regeneration in the South Pacific Ocean. Proceedings of the National Academy of Sciences of the United States of America, 116(20), 9753–9758. https://doi.org/10.1073/pnas.1901863116

2.4 GEOTRACES Statement of Values and Behaviours

In October 2019, GEOTRACES has released a Statement of Values and Behaviours which reflects GEOTRACES common understanding of respectful values, acceptable behaviour, and cooperative interaction as an international scientific programme. This document was prepared by Andrew Bowie and Phoebe Lam, co-chairs of the GEOTRACES Scientific Steering Committee.

The GEOTRACES Statement of Values and Behavious is available to download at: https://www.geotraces.org/statement-of-values-and-behaviours/

3. Activities

3.1 GEOTRACES intercalibration activities

The 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 12th and 13th June 2019 in Norfolk, Virginia, hosted by Peter Sedwick.

The focus for the past reporting period was again on the preparation of our procedures for the upcoming intermediate data product (IDP2021), and on implementing improvements of the S&I report submission procedure. The focus of the meeting in Norfolk was on testing the new system for registering datasets and submitting intercalibration reports (DoOR).

With the new functionalities offered by the electronic system, it is possible to track individual criteria for intercalibration and reporting back to the submitting PIs is simplified. Supported by the well-structured parameter names, unique identifiers, and the portal software, PIs now select the parameters to be submitted and intercalibrated themselves, which is anticipated to greatly reduce the potential for discrepancies between intercalibration and data submission.

Since the release of the portal, the submission system has been used by a number of PIs, but in anticipation of the upcoming 1st deadline for the IDP2021, no meeting of the S&I committee has taken place as of 31st of March. An in-person meeting that had been scheduled for summer 2020 had to be canceled in March 2020 at the onset of the Covid-19 pandemic.

- Laboratory intercomparisions & Consensus Materials

  We also report the status and progress on initiatives to produce consensus materials and lab intercomparisons.

- Seawater Consensus materials

  Consensus values for a suite of trace elements in the GSP and GSC seawaters were established last year by Jim Moffett and made available on the GEOTRACES web page:
  https://www.geotraces.org/standards-and-reference-materials/

- Mercury

  About 800 bottles of offshore Mediterranean Sea water, 400m-depth, unfiltered seawater are left from the 2017 Hg intercalibration cruise, in precombusted 125mL glass bottles, teflon seal crimped, stored in a cold chamber at 4°C.
  About 15kg Mediterranean Sea sediment, dried at 60°C, sieved at 300um, batch tested for Hg are available, on which so far no other trace metal has been measured.

- Next Meeting

  The date for the next meeting of the S&I committee is currently not set as the duration of the travel restrictions due to the Covid-19 is unclear.

3.2 Data management for GEOTRACES

The GEOTRACES Data Assembly Centre (GDAC) is hosted by the British Oceanography Data Centre 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. 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 answer issues/questions relating to GEOTRACES;
- Input of metadata and data into the BODC database and compilation of documentation to include originator's methodology
- Collation of data and metadata for the future IDP;
- Answering requests from GEOTRACES community and assisting on IDP download.

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

Cooperation with the IPO: The IPO is in regular 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 to project participants.

Contribution to DOoR portal design and release: Preparing and releasing DOoR portal by Sedoo colleague (Toulouse) was one of the main event in GEOTRACES during 2019. DOoR will ensure an efficient tracking of single data set submitted for intercalibration process. GDAC contributed actively in developing the specifications and the testing before the release. GDAC also adapted its data workflow to match this new change in data submission. This work comes in addition to GDAC delivering GEOTRACES' cruise metadata to the portal through a webservice (described in last year's report).

GDAC website updates: GDAC website update is planned on a bi-weekly basis to ensure up-to-date information.

DMC and SSC meetings: During DMC and SSC meetings (Hobart, September 2019), the accent was put on IDP2021 preparation and timeline was proposed with DMC.

Liaison with national data centres: Liaison with national marine data centres (BCO-DMO, CYBER-LEFE, NIOZ and SKLMES) was maintained during the whole 2019 and information on the new GEOTRACES data submission including DOoR portal edited templates was approved.
Data and cruise metadata overview New data submission are constantly received. Over 1500 data sets from 51 different cruises have been registered with about half of these data sets already submitted to GDAC on May 2020.

Deadlines for inclusion in IDP2021: The first deadline which guarantees inclusion in IDP2021, for the submission of datasets to GDAC or national data centres via DOoR and using DOoR templates and intercalibration reports was the 1st of April 2020. It was extended to 15th May 2020 as a response to the pandemic's potential impact on PIs' work conditions. GDAC also provided support by answering questions, in a relative record time, and assisted with the preparation of data and metadata submission.
Details of the data received before the first data submission deadline will be provided during the next DMC and SSC meetings expected in September 2020.

Summary of GEOTRACES cruises, which have taken place in the period April 2019-April 2020:

Cruise	**Chief scientist(s)**	**GEOTRACES scientist(s)**	**Type**	**Period**	**Location**
PROVOCCAR I (GApr15)	Borges Mendes Carlos Rafael	Hatje Vanessa	Process Study	20200202 20200308	South West Altantic-North Antarctic Peninsula
AE1930 (BAIT-IV, GApr13 Leg4)	Johnson Rod	Sedwick Peter	Process Study	20191114 20191120	Sargasso sea
TONGA (GPpr14)	Guieu Cecile & Bonnet Sophie	Sarthou Géraldine, Bressac Matthieu & Planquette Hélène	Process Study	20191031 20191206	Western Tropical South Pacific
Explorer AE1921 (BAIT-III, GApr13 Leg3)	Johnson Rod	Sedwick Peter	Process Study	20190816 20190822	Sargasso sea
SAMBAR_A2 (GApr14, SAM-18)	Campos Edmo	Hatje Vanessa	Process Study	20190615 20190701	South West Atlantic

AE1909 (BAIT-II, GApr13 Leg2)	Johnson Rod	Sedwick Peter	Process Study	20190511 20190517	Sargasso sea
KK1903 (GP09)	Cai Yihua & Zhou Kuanbo	Zhimian Cao, Minhan Dai & Liping Zhou	Section Cruise	20190425 20190610	North West Pacific

Other GDAC activities: During the last year Mohamed Adjou contributed to two key communication events:
1) GEOTRACES (Meta-) data management course provided to students during GEOTRACES summer school (Cadiz, September 2019).
2) SCOR booth in Ocean Sciences meeting (San Diego, February 2020) for a demonstration of new GEOTRACES procedure to register and submit data and Intercalibration reports using DOoR portal.

In summary
Preparing the data reception at GDAC under the new DOoR procedure was the most notable event this year in GDAC work. The achievement of this new procedure to efficiently track single data set submitted for intercalibration process, is the result of a synergetic collaboration between GEOTRACES working parties.

The collation and processing of data to be included in the IDP2021 will be the focus of GDAC's activities after the 1st data submission deadline has passed. GDAC continue to provide useful information on GDAC web pages for scientists and to 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 Elena Masferrer Dodas, the IPO Executive Officer and it has very recently recruited Katherine Brownlie as part-time assistant although due to the COVID-19 situation she has not been able to start on her duties. 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 DOoR portal
  The management of the development of the GEOTRACES Data for Oceanic Research (DoOR) on-line portal has been an important task conducted by the IPO during this reporting period. The portal was officially released on 22 December 2019, and it is available at the following link: https://geotraces-portal.sedoo.fr/pi/

  The GEOTRACES IPO has guided and overseen the technical development of the portal - carried by François André, Arnaud Miere and Guillaume Brissebrat (in the earlier stages of the development) from the Observatory Midi-Pyrenées Data Center (SEDOO, Toulouse) - in close liaison with the GEOTRACES Executive Committee, the Standards Intercalibration Committee, the Data Management Committee, the Parameter Definition Committee and GDAC.

  The DOoR portal has been designed to streamline the preparation of IDP2021, both for the PIs and those who work behind the scenes to assemble the data product. Indeed, following the success of the GEOTRACES Intermediate Data Products 2014 and 2017, the amount of data to be reviewed, managed and processed has increased considerably making necessary the development of an on-line management tool for the assessment of the IDP.

The DOoR portal consists of 4 on-line portals, so far: (1) one portal for GEOTRACES scientists, (2) one portal for the Standards and Intercalibration Committee, (3) one portal for the GDAC and (4) one portal for DOoR administrators.

The DOoR portal for GEOTRACES scientists is where principal investigators (PI) can: (1) register datasets for inclusion in GEOTRACES Data Products and track its status, (2) generate and download templates needed to submit intercalibration reports, submit the intercalibration reports to the S&I Committee for processing and tracing their progress, (3) generate and download data templates to be used for data submission to the appropriate data centre and track the status of inclusion in IDP, (4) link publications that must be cited when using the data, (5) associate scientists (students, postdocs, etc.) with each dataset to ensure they are duly acknowledged and (6) give permission for the release in IDP2021 for each dataset registered.

The other 3 portals are management tools designed to facilitate the work for each specific group that works assembling the Intermediate Data Product.

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

  A major overhaul of the GEOTRACES website has been successfully undertaken. The redesign of the website was motivated by the need to: (1) move the website from Institut de la mer de Villefranche in France to a new host the SEDOO Data Centre where the GEOTRACES DOoR is hosted and (2) migrate the site to a new content management system, WordPress instead of Joomla!. About 85% of the migration process is completed this stage.

  We want to thank Olivier Boebion (IT system administrator at Institut de la Mer de Villefranche, France) for all his technical assistance with the GEOTRACES website during the last 10 years and Pierre Vert (IT system administrator at SEDOO) for all this technical assistance in migrating the GEOTRACES website.

- Assistance during the SCOR review of GEOTRACES

  The IPO has compiled the necessary information and prepared the first draft of the GEOTRACES report requested by the SCOR review panel.

- Logistics for meetings

  The IPO has hosted the GEOTRACES DOoR Portal Meeting (January 2020) and organised multiple virtual meetings with committee's members during the preparation of the GEOTRACES DOoR. It has also provided assistance in the organisation of the GEOTRACES Data Management Meeting (7-8 September 2019, Hobart, Australia) and the GEOTRACES SSC Meeting (9-11 September 2019, Hobart, Australia), the GEOTRACES Summer School (23-28 September 2019, Cadiz, Spain).

- Some statistics

  26 new highlights published (217 in total)
  6 eNewsletters published, including one special issue (bimonthly 39 in total)
  123 new peer-reviewed papers included in the GEOTRACES Publication Database (1,353 in total)
  104 new articles published on the GEOTRACES website
  86 new announcements sent through the GEOTRACES mailing list
  1,447 followers (top tweet reached 3.1K) and 647 followers in Facebook (top post reached 1.6K)
  97 new subscribers on the GEOTRACES mailing list

Featured outreach activity: *New educational materials for improving science literacy in students*

Timothy Kenna and Margie Turrin from Columbia University, New York, have made available a new set of educational materials in English and Spanish for developing science literacy in students. They have produced three educational activities which all have a focus on understanding radioactivity in the environment.

The first is a lab designed to introduce the topic of radioactivity and dispel myths around its presence and impact. The second activity does not have an associated lab but works well as an introductory piece to analysing what is provided through news outlets. It can be used introducing a phenomena building into the longer lab around critical reading and article analysis. The third activity is a lab designed to introduce students to critically reading and analysing environmental articles to be able to discern what is real and what is hype.

These materials are available on the GEOTRACES website: https://www.geotraces.org/developing-science-literacy/

3.4 GEOTRACES workshops

A list of completed GEOTRACES Workshops is available below:

Second Russian GEOTRACES seminar, 7 February 2020, Moscow, Russia.

The 2nd Russian GEOTRACES seminar was held on February 7, 2020 in Moscow at the Shirshov Institute of Oceanology, Russian Academy of Sciences (https://ocean.ru). Prof. Dr. Eric Achterberg initiated the GEOTRACES seminar during his visit as part of the Helmholtz team. About 50 people attended the seminar in Moscow and some people listened to the presentation remotely in Sevastopol, Kaliningrad, and Arkhangelsk. The presentation aroused a great interest among the seminar participants.

The GEOTRACES seminar commenced with a short introduction and welcome by Prof. Dr. Piotr Zavyalov. Dr. Marina Kravchishina reported about GEOTRACES activity in Russia and highlighted the main purposes of the study of the marine biogeochemical cycles of trace elements and their isotopes (TEIs) and the need for international collaboration. Prof. Dr. Eric Achterberg gave the opening speech entitled 'International GEOTRACES Programme: Observations across ocean gradients provide insights into biogeochemical cycles'. This was followed by a round table discussion on the TEIs clean sampling systems and analyses organised by Prof. Dr. Eric Achterberg (GEOTRACES SSC member), Dr. Marina Kravchishina (GEOTRACES SSC member) and Dr. Ludmila Demina (Past GEOTRACES SSC member).

For further details about the 2nd Russian GEOTRACES Workshop are available on the GEOTRACES website: https://www.geotraces.org/2nd-russian-geotraces/

Southern Ocean Biogeochemistry Workshop, 12-13 September 2019, Hobart, Australia

A workshop on Southern Ocean Biogeochemistry was organised by Zanna Chase, Andy Bowie and Phil Boyd (University of Tasmania) from 12th to 13th of September at the Institute for Marine and Antarctic Studies (IMAS) in Hobart, Australia. The workshop was aimed at bringing together national and international scientists as well as local students and researchers in biogeochemical oceanography, modelling and paleoceanography focused on the Southern Ocean's response to climate change. During the workshop the development of collaborative projects including GEOTRACES process studies was also discussed.

The programme of the workshop is available here:
https://geotracesold.sedoo.fr/images/stories/documents/workshops/2019_SouthernOcean/Southern%20Ocean%20Biogeochemistry.pdf

Exploring GEOTRACES Data with Ocean Data View Workshop, 5-6 September 2019, Hobart, Australia

Reiner Schlitzer (AWI, Bremerhaven) gave a 2-day workshop on exploring GEOTRACES and other environmental data with Ocean Data View (ODV) in Hobart, Australia, in September 2019. This very successful hands-on workshop was attended by 40 participants.

Figure 9: *Participants at the ODV Workshop at IMAS, University of Tasmania.*

Fourth Asia GEOTRACES Workshop: Sources/sinks and internal cycling of mercury and other TEIs in the Northwest Pacific Ocean, 8-10 December 2019, Qingdao, Shandong, China

The Asia GEOTRACES Workshop: Sources/sinks and internal cycling of mercury and other TEIs in the Northwest Pacific Ocean, organized by Ocean University of China (OUC), was held during December 8-10, 2019, Qingdao, China. More than 50 participants from 9 countries, including China, Japan, Korea, India, Singapore, Canada, Germany, United States, and France (remote) attended the workshop. The aim of the workshop is to evaluate a full picture of the current status of the studies on the major sources/sinks and internal cycling processes of mercury and other TEIs in seawater in the

Northwest Pacific Ocean (NWPO), and to generate a future regional collaboration and action plan for Asia GEOTRACES. During the workshop, two major topics were focused: 1) The distribution, speciation, sources, and internal cycling of mercury and its isotope in the NWPO; 2) TEls fluxes and processes at ocean interfaces, e.g. atmospheric deposition, sediment-water boundary, continental run-off as well as interaction between marginal seas and Kuroshio water. In addition to normal sessions, a student session was co-chaired by Profs. Greg Cutter and Eric Achterberg, 6 graduate students gave oral presentations. Moreover, the international inter-calibration for TEIs, particularly Hg were addressed, the discussed details include sample collection, storage, intercalibration, and data management. The capability of marine Hg analysis and study in the Asia is expected to be strengthened by the scientific exchange and communication during the workshop. Furthermore, some participants visited the new R/V "Dongfanghong III" (5,000 tons) and discussed the possible crossover stations with other international cruises (e.g. Germany and Japan) and the potential contribution for the international GEOTRACES collaboration, e.g., sharing cruise and performing inter-calibration in its near future cruise. Finally, per discussion, bio-GEOTRACES was considered one of the potential research fields. The future collaboration in research and possible joint grant applications were discussed and preliminary agreements were reached. The importance and possibility of regional collaboration to study marine pollution, e.g. Hg and Pb were also emphasized.

For further information please check the GEOTRACES website: https://www.geotraces.org/event/asia-geotraces-workshop-sources-sinks-and-internal-cycling-of-mercury-and-other-teis-in-the-northwest-pacific-ocean/

3.5 GEOTRACES summer school

The second GEOTRACES Summer School was held from 23 to 28 September 2019 in Cadiz, Spain and it was hosted by the International Campus of Excellence of the Sea (CEI-Mar) on board the Spanish school vessel *'Intermares'*.

The summer school aimed at teaching the skills and knowledge necessary for a good understanding of the biogeochemical cycles of trace metals and it brought together 39 students from 15 different countries and 10 world-leading international scientists, including: Bob Anderson (LDEO, Columbia University – USA); Catherine Jeandel (LEGOS, France); Reiner Schlitzer, Alfred Wegener Institut (AWI), Germany; Susanne Fietz (Stellenbosch University, South Africa); Eric Achterberg (GEOMAR, Germany); Maite Maldonado (British Columbia, Canada); Mohamed Adjou (Brtish Oceanographic Data Center,UK); Géraldine Sarthou (CNRS – France); Rob Middag (NIOZ, The Netherlands); José Antonio López (Universidad de Cádiz); and Antonio Tovar (ICMAN/CSIC Spain).

Particular objectives of the summer school were:

- 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.

Among the most exciting experiences of the summer school were the field sampling workshops on board of the 'Intermares' vessel. Every morning, after the master lecture, the vessel was heading to a point away from the Bay of Cádiz looking for 100 meters deep to submerge a rosette including eight

bottles from which seawater samples were extracted. Each pair of students took a bottle and brought it to the laboratory installed on the 'Intermares' school vessel. In there they continued learning how to follow the strict GEOTRACES protocols that allows getting uncontaminated seawater samples. Trace metals are available in very low concentrations in the ocean so any accidental addition may ruin the entire process. First, and dressed for the occasion, they entered in the "bubble"; a clean environment of particles and metals for a first extraction. Next, they went to the laminar flow hood, where the air was filtered in order that the samples were not contaminated with other particles when it is manipulated. From there, to the laboratory where marine students usually work whatever the place of the world in which his/her research institution is located.

Despite the intensity of the summer school, the strength of these young scientists made it possible to achieve the second objective of the course: establishing a working network that will last and become strong over time.. The 'International Summer School GEOTRACES Spain' has been a great and very successful experience!

GEOTRACES greatly acknowldege the work done by all co-organisers: the University of Cádiz (UCA), the Andalusian Institute of Marine Sciences of the Spanish National Research Council (ICMAN-CSIC), the Ministry of Agriculture and Fisheries, the Ministry of Defense, the International Campus of Excellence of the Sea (CEI·MAR). As well as the funding provided by the Scientific Committee on Oceanic Research (SCOR)/GEOTRACES, the General CSIC Foundation, the International Doctorate School of Marine Studies (EIDEMAR), and the CEI·MAR.

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

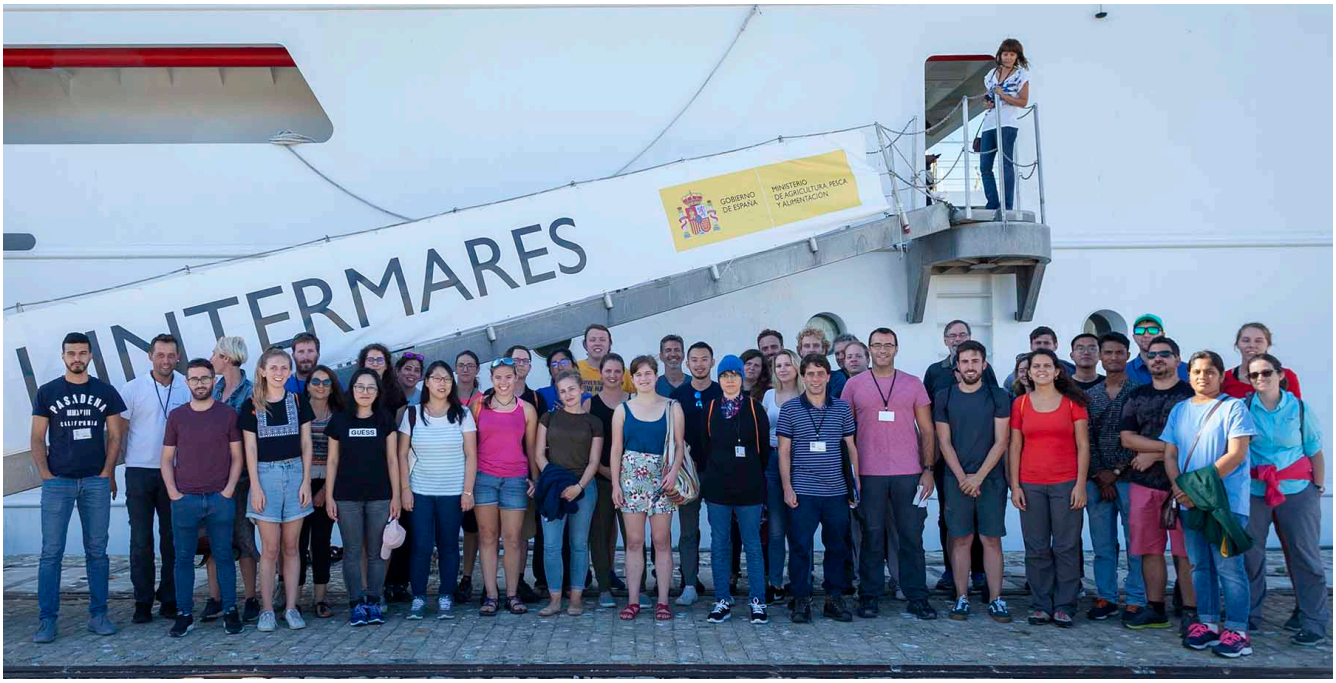


***Figure 10**: 2019 GEOTRACES Summer School participants*

3.6 Special sessions at international conferences featuring GEOTRACES findings

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

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
>
> *08m: Wally Broecker: A Scientific Celebration of a Life in Geochemistry
> Conveners: Sidney Hemming, Edouard Bard, Sigurdur Gislason, Roberta L. Rudnick

It included the GEOTRACES talk:
GEOTRACES: Inspired by GEOSECS to Investigate Trace Elements and their Isotopes in the Ocean, Anderson R, Francois R, Frank M, Henderson G, Jeandel C & Sharma M

*08f: The Role of Carbon in Regulating Climate States: Lessons from Earth's Past
Conveners: Kate Littler, Gerhard Kuhn, Norbert Frank, Thomas Chalk, William Gray
Keynotes: Jessica Tierney (University of Arizona), Robert (Bob) Anderson (LDEO - Columbia Univ.)

*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

2020 Ocean Sciences, 16-21 February 2020, San Diego, California, USA.
For further information: https://www.agu.org/Ocean-Sciences-Meeting

GEOTRACES or GEOTRACES-related sessions:

*Revealing Biogeochemical Processes on Basin Scales through Ocean Transects
Primary Chair: Gregory A Cutter, Old Dominion University.
Co-chairs: Phoebe J Lam, University of California Santa Cruz; Karen L Casciotti, Stanford University; Rob Middag, Royal Netherlands Institute for Sea Research.

*Linking the biology, geochemistry, and circulation of the Gulf of Mexico
Primary Chair: Angela N Knapp, Florida State University.
Co-chairs: Alan M Shiller, University of Southern Mississippi; Heather M Benway, Woods Hole Oceanographic Inst.; Juan Carlos Herguera, Center for Scientific Research and Higher Education at Ensenada.

*Controls on trace metal biogeochemistry and physicochemical speciation in seawater
Primary Chair: Hannah Whitby, IUEM Institut Universitaire Européen de la Mer.
Co-chairs: Randelle M Bundy, University of Washington; Jessica N Fitzsimmons, Texas A & M University College Station; Andrea Koschinsky, Jacobs University Bremen.

*Biogeochemical cycles in oxygen minimum zones: mechanisms, drivers, and change
Primary Chair: David Janssen, University of Bern.
Co-chairs: Daniele Bianchi, University of California Los Angeles; Thomas S Weber, University of Rochester.

*Autonomous observing systems for macronutrients and bioactive trace metals in coastal and open ocean settings: present status, challenges and emerging technologies
Primary Chair: Maxime Grand, Moss Landing Marine Laboratories.
Co-chairs: Andrew R Bowie, University of Tasmania; Agathe Laes-Huon, IFREMER; Alexander Beaton, National Oceanography Center, Soton.

*Towards BioGeoSCAPES: Exploring molecular drivers of ocean metabolism and biogeochemistry
Primary Chair: Benjamin S Twining, Bigelow Lab for Ocean Sciences.
Co-chairs: Erin Marie Bertrand, Dalhousie University; Martha Gledhill, GEOMAR Helmholtz Centre for Ocean Research; Naomi Marcil Levine, University of Southern California.

*The role of micronutrient cycles in global-scale dynamics
Primary Chair: Andy Ridgwell, University of California Riverside.
Co-Chair: Alessandro Tagliabue, University of Liverpool

*Understanding Rare Earth Element (REE) distributions and isotopic ratios and the mechanisms behind their use as tracers of (paleo)oceanic processes
Primary Chair: Brian A Haley, Oregon State University
Co-chairs: Torben Stichel, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven; Johan Schijf, University of Maryland Center for Environmental Science; Vanessa Hatje, Universidade Federal da Bahia.

Forthcoming:

Virtual Goldschmidt 2020, 21-26 June 2020
For further information: https://goldschmidt.info/2020/

GEOTRACES session:

*14m: Biogeochemical Cycling of Trace Elements and their Isotopes in the Oceans (GEOTRACES)
Conveners: Tim Conway, Mariko Hatta, Nick Hawco
Keynote: Brandy Toner
Invited Speakers: Jun Nishioka, Sam Wilson

3.7 Capacity building

Activities GEOTRACES continues to apply its strategy to organise training workshops the day or the two-days immediately before or after a SSC meeting in order to increase the local impact of these meetings. During the reporting period, two of such worhsops have been organised: the Worshop Exploring GEOTRACES Data with ODV and the Southern Biogeochemistry Workshop, see GEOTRACES Workshops above for further details). 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. GEOTRACES is thankful to SCOR for the funding received.

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 (in blue new additions since last reporting period). 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 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
Australia (Marine National	Complete (backup system)	Polyurethane powder-coated aluminium autonomous Seabird	12 x 12-L Teflon-lined OTE external-	1750 m 9mm Dyneema rope or 200 m 6 mm

Facility)		rosette with CTD and other sensors, auto-fire module, and all titanium housings and fittings	spring Niskin-style bottles	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
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	Six 5-L Niskin-X	1000m steel conducting cable
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
Republic of Korea	Complete	Titanium frame PRISTINE	24 × 12L PVDF	10,000 m; conducting Kevlar
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	Sea-Bird GEOTRACES Powder-coated aluminium	12 X 12-L GO-FLO	1500 m; conducting Vectran cable
USA - GEOTRACES	Complete	Seabird GEOTRACES Powder-coated aluminium with titanium pressure housings and fittings	24 X 12-L GO-FLO	7000 m conducting Vectran cable

USA-University of Alaska Fairbanks	Complete	Sea-Bird GEOTRACES 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 – University of South Florida	Complete	Sea-Bird GEOTRACES Powder-coated aluminium with Ti parts and pressure housing. Fires at pre-programmable depths	12 X 12-L OTE Niskin-X	3000 m 0.25" Amsteel wire
USA-Old Dominion University	Complete	Sea-Bird GEOTRACES 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	Sea-Bird GEOTRACES Powder-coated aluminium with titanium pressure housings and fittings	12 X 12-L Niskin-X	3500 m; conducting Vectran cable
USA – Scripps Institution of Oceanography	Complete	Sea-Bird painted aluminium with stainless pressure housing (standard system). Fires at pre-programmable depths	12 X 10-L Niskin-X 12 X 5-L Niskin-X	2000 m Amsteel cable and 2000 m Space-Lay coated metal cable
USA – Woods Hole Oceanographic Institution	Complete	Sea-Bird painted aluminium with stainless pressure housing (standard system). Fires at pre-programmable depths	12 X 8-L Niskin-X	4000 m Amsteel cable

4. Plans for the coming year

Towards Intermediate Data Product 2021

Major GEOTRACES effort will be devoted to the release of the third GEOTRACES IDP in July 2021. In parallel, the GEOTRACES DOoR interface will continue to evolve to add new services for the GEOTRACES community.

Also, GEOTRACES plans to continue advancing the GEOTRACES field programme, although the COVID-19 pandemic that has perturbed cruise plans for the coming reporting period. In this sense, all the cruises scheduled for 2020 that had to be cancelled have been or will be re-scheduled to another date in 2021 or 2022.

Capacity building through GEOTRACES Summer Schools

Following the successful GEOTRACES Summer Schools organised in 2017 and 2019, GEOTRACES plans to pursuit its two-year strategy and hold its third summer school in 2021 (tentatively in 28 June – 2 July 2021) in Bremerhaven, Germany, organised by Walter Geibert (AWI-Bremerhaven). The preliminary estimate is that this summer school could host about 50-60 participants.

Scientific 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 at Hanse-Wissenschaftskolleg Institute for Advanced Study (HWK) in Delmenhorst, Germany. This workshop will be driven by Walter Geibert, and it 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 continue to provide advice and recommendations, as appropriate, to help launch this new programme. A complete report on the activities completed by the BioGeoSCAPES is available in the annex of this report.

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Once more, we wish to express our immense gratitude to SCOR, and very especially to Ed Urban on his role of Executive Director during the past years. His continuous support and valuable advice generously given has been essential for the successful implementation of the GEOTRACES programme. At the same time, GEOTRACES warmly welcomes Patricia Miloslavich as new SCOR Executive Director and greatly thanks her for the SCOR continuous support. We wish Patricia plenty of success in this new position.

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