GEOTRACES SCIENTIFIC STEERING COMMITTEE
ANNUAL REPORT TO SCOR 2022/2023

May 1st, 2022 to April 30th, 2023

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1. SCOR Scientific Steering Committee (SSC) for GEOTRACES

Co-Chairs
Karen Casciotti, USA
Maeve Lohan, UK

Members
Jay T. Cullen, Canada
Susanne Fietz, South Africa
Jessica Fitzsimmons, USA
Walter Geibert, Germany
Vineet Goswami, India
Yoshiko Kondo, Japan
Marina Kravishina, Russia
Rob Middag, Netherlands
Taryn Noble, Australia
Haojia (Abby) Ren, China-Taipei
Yeala Shaked, Israel
Dalin Shi, China-Beijing
Kazuyo Tachikawa, France
Alessandro Tagliabue, UK
Rodrigo Torres, Chile
Antonio Tovar-Sanchez, Spain

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

The GEOTRACES programme continues to enjoy a very successful implementation, with three Intermediate Data Products successfully released (a new version of the GEOTRACES Intermediate Data Product 2021 to be released in July 2023) and the next Intermediate Data Product already planned for release in November 2025.

2.1 Status of GEOTRACES field programme

The GEOTRACES field programme is progressing excellently with 144 cruises completed, corresponding to 38 GEOTRACES sections (with 50 cruises), 41 process studies (with 65 cruises), 18 compliant datasets, as well as, 11 cruises completed as a GEOTRACES contribution to the International Polar Year (IPY).

During the past year (May 1st, 2022 to April 30th, 2023), 3 new section cruises from Japan, Germany and USA (marked in orange in the Figure 1) and 3 process studies (1 from Australia, 1 from Germany (with 2 cruises) and 1 from USA (one of the two cruises is sailing when the report is being written) have been undertaken (see Data Management section below for further details). In addition, 5 new compliant datasets have been endorsed.

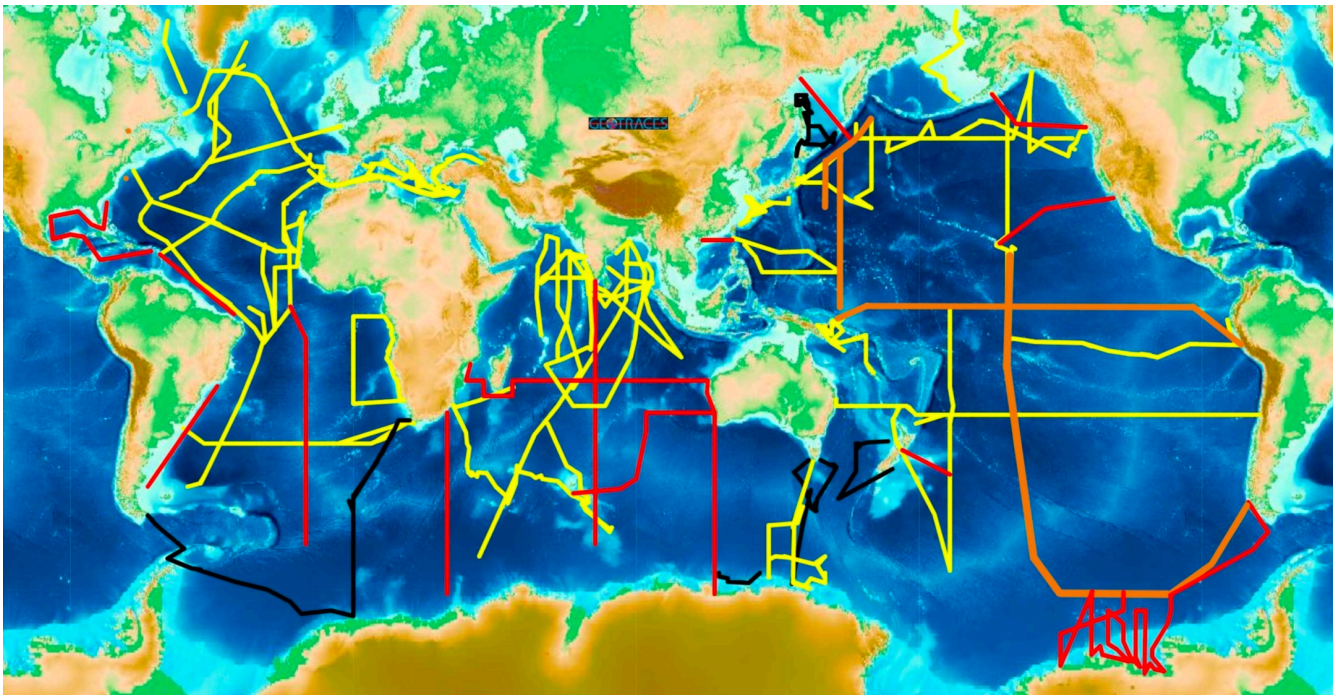

Figure 1. *Status of GEOTRACES global survey of trace elements and their isotopes. In black: Sections completed as the GEOTRACES contribution to the International Polar Year. In yellow: Sections completed as part of the primary GEOTRACES global survey. In orange: Sections completed during the past year. In red: Planned Sections. An interactive cruise map is available at the following website: https://www.bodc.ac.uk/geotraces/cruises/section_maps/interactive_map/*

2.2 GEOTRACES Intermediate Data Product

Intermediate Data Product 2021 version 2

The GEOTRACES Intermediate Data Product 2021 (IDP2021; https://www.geotraces.org/geotraces-intermediate-data-product-2021/) was successfully released on 17 November 2021. The product includes hydrographic and marine geochemical data from 77 cruises and 3191 stations. An updated and corrected version of the IDP2021 is planned to be released on 7th July 2023. This product will contain 9 cruises and 211 more stations than version 1. A detailed document including the changes from version 1 will also be released.

The **IDP2021 digital data** is available at:

***Bulk download:** https://www.bodc.ac.uk/geotraces/data/dp/
***WebODV online for data subsetting, extraction and visualisation:**
https://geotraces.webodv.awi.de/
***WebODV online for data analysis, exploration and visualisation**: https://explore.webodv.awi.de/

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

GEOTRACES reiterates its gratitude to all data submitters and all those who had created the product.

Timeline for next Intermediate Data Product

GEOTRACES plans to release the fourth Intermediate Data Product (IDP) in November 2025.

Deadlines for inclusion in next IDP are as follows:

***15th May 2024 – First deadline** for the submission of datasets to GDAC (or national data centres for US, Dutch and French PIs) using DOoR templates and completed intercalibration reports via DOoR (https://geotraces-portal.sedoo.fr/pi/) to guarantee inclusion in IDP2025. After this date the inclusion of the data submitted cannot be guaranteed.

***15th of December 2024 – Final deadline** for submission of datasets to GDAC (or national data centres for US, Dutch, French and Chinese PIs) using DOoR templates and the complete intercalibration reports via DOoR (https://geotraces-portal.sedoo.fr/pi/).

Because of the very large number of datasets that are being submitted for the IDP, GEOTRACES is encouraging early submission of the datasets to improve the chances that the datasets are included in the IDP. Further information about the submission process is available at: https://www.geotraces.org/timeline-for-next-geotraces-intermediate-data-product/

2.3 GEOTRACES publications

During the reporting period, 186 new peer-reviewed papers have been published. In total, the GEOTRACES peer-reviewed paper database includes 2,192 publications.

Publicity documents: 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: https://www.geotraces.org/category/library/publicity/

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 318 highlights have been published. Among the numerous highlights published since last year's report, we selected the following five:

Do you want to know more about iron and its isotopes? This review is for you!

Jessica Fitzsimmons and Tim Conway (2023, see reference below) present a comprehensive review of iron and iron isotope sources, internal cycling, and sinks in the ocean, including the history of the field and the role that GEOTRACES has played in driving development of this exciting oceanic tracer. They summarise the end-member isotope signatures of different iron sources (dust, sediments, hydrothermal venting). Then, they review how the use of these isotopes contributes to improving our understanding of marine iron biogeochemistry and oceanic iron distributions: disentangling multiple iron sources, identifying the redox state of the sedimentary sources, distinguishing anthropogenic versus natural dust sources, and investigating different hydrothermal processes. They also review ways in which iron isotope fractionation might be used to understand the internal oceanic cycling of iron, including speciation changes, biological uptake, and particle scavenging. In the end, the authors propose an overview of future research needed to expand the utilisation of this cutting-edge tracer.

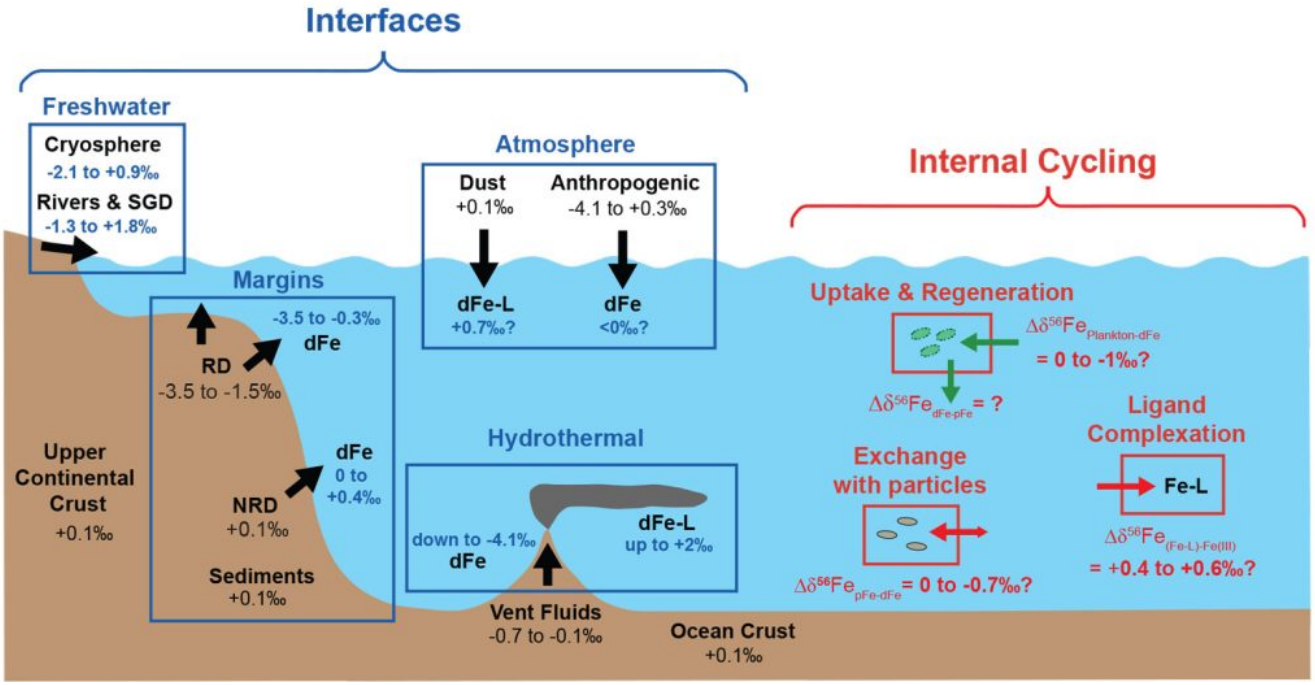

Figure 2. *Summary schematic of oceanic iron isotope source signatures and fractionation during marine cycling of iron, based on the GEOTRACES interfaces and internal cycling schematic (adapted from GEOTRACES Group 2006, with permission). Abbreviations: dFe = dissolved Fe, pFe = particulate Fe, L = ligand, NRD = nonreductive Fe dissolution, RD = reductive Fe dissolution, SGD =submarine groundwater discharge.*

Reference:

Fitzsimmons, J. N., & Conway, T. M. (2023). Novel Insights into Marine Iron Biogeochemistry from Iron Isotopes. Annual Review of Marine Science, 15(1). Access the paper: 10.1146/annurev-marine-032822-103431

Decline of the anthropogenic lead imprint to the ocean confirmed by data from the South West Atlantic Ocean

Olivelli and co-authors (2023, see reference below) present total dissolvable lead (Pb) concentrations and isotope compositions for 23 surface waters collected in 2011 along a latitudinal transect offshore of the South American coast from Punta Arenas to the Equator (Leg 3 of the Dutch GEOTRACES GA02 section). They reveal that the mean Pb concentrations in the surface waters of the western South Atlantic Ocean decreased by 34 % between the 1990s and 2011. Pb isotope compositions also show a shift towards a more natural Pb isotope signal: 2011-samples show that natural Pb sources contributed 36 ± 6 % of the Pb present in western South Atlantic surface waters, while it was 24 ± 4 % in 1996.

As for the preceding work of the same team in the North Atlantic Ocean (Bridgestock and al, 2016 – read the science highlight here) these results evidence the positive effect of environmental and health policies that banned the use of leaded gasoline in South America since the 1990s.

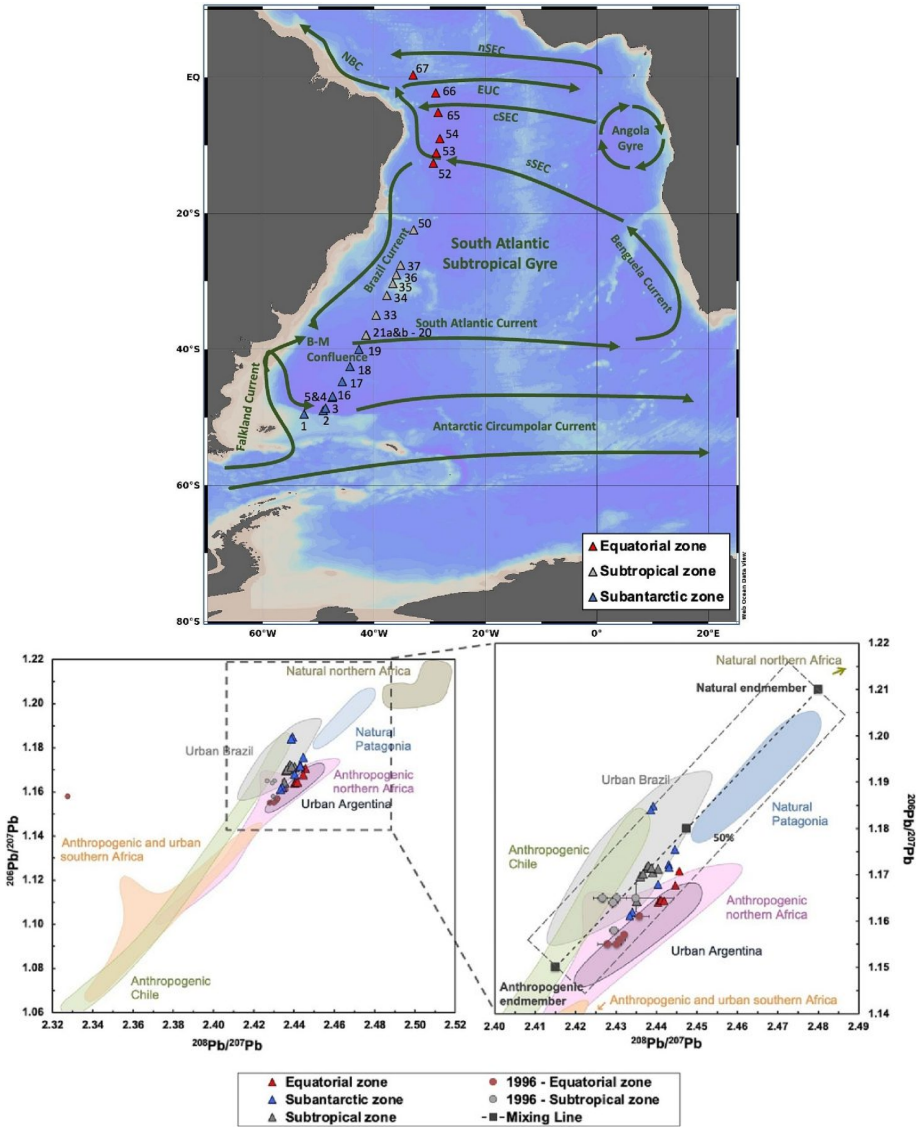

Figure 3. *Top panel: Map of sampling locations (triangles) along GEOTRACES GA02 Leg 3, and surface currents (green arrows) in South Atlantic Ocean. Bottom panel: three-isotope plot showing the Pb isotope composition of the samples analysed in this study (triangles), historical samples (circles) and potential sources of Pb from Africa and South America (coloured fields). The mixing envelope between the inferred anthropogenic and natural endmembers shows that anthropogenic Pb is still predominant, but there is relatively more natural Pb in the 2011-samples than in those from 1996.*

References:

Olivelli, A., Murphy, K., Bridgestock, L., Wilson, D. J., Rijkenberg, M., Middag, R., Weiss, D. J., van de Flierdt, T., & Rehkämper, M. (2023). Decline of anthropogenic lead in South Atlantic Ocean surface waters from 1990 to 2011: New constraints from concentration and isotope data. Marine Pollution Bulletin, 189, 114798. Access the paper: 10.1016/j.marpolbul.2023.114798

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. Access the paper:10.1038/ncomms12921

A vivid picture of particle distribution and sources in the Arctic Ocean

Gardner and co-workers (2022, see reference below) proposed an extensive description of particle concentrations and chlorophyll-a fluorescence (Chl-a) distribution along GEOTRACES sections across the Arctic Ocean. The optical data in the sections were paired with particle composition on filtered samples through the whole water column. Particle distributions in the Arctic are affected by currents, stratification, ice coverage and thickness, nutrient and light availability, and biological processes. The combination of cp (a proxy for particular matter and particulate organic carbon) sections plotted with salinity, temperature, and Chl-a contours, adds a background and baseline across the entire Arctic Ocean that is useful in deciphering some of the particle dynamics of the Arctic.

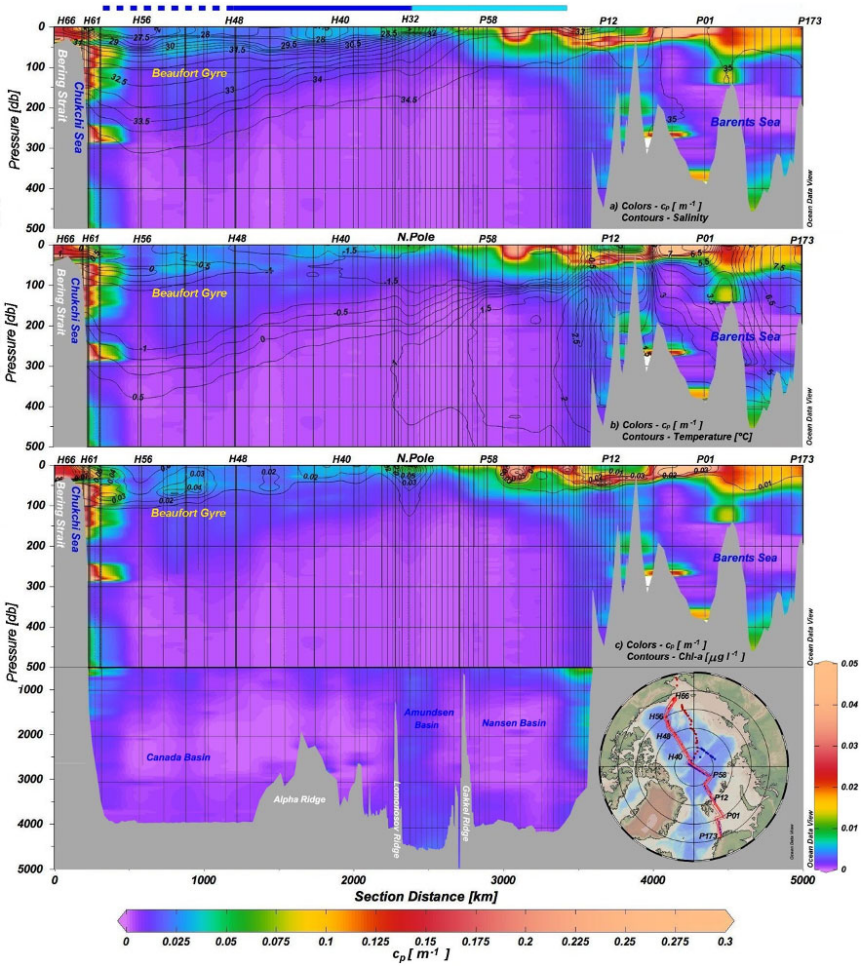

Figure 4. *Sections of cp (m^{-1}, a proxy for PM or POC) from the Bering Strait to Norway. Contours: a) salinity; b) temperature, °C ; and c) Chl-a, µg l^{-1}. Range of cp is 0-0.3 m^{-1} in 0-500m layer (horizontal bar) and 0-0.05 m^{-1} in 500-5000m layer (vertical bar) to enhance cp changes at depth. Blue lines at the top – ice cover: dashed – 20% to 80%, dark blue – >80%, light-blue – ice reported from R/V Polarstern. No line ~ ice-free. Orange line on map – stations included in these sections.*

Reference:

Gardner, W. D., Richardson, M. J., Mishonov, A. V., Lam, P. J., & Xiang, Y. (2022). Distribution, Sources, and Dynamics of Particulate Matter Along Trans-Arctic Sections. Journal of Geophysical Research: Oceans, 127(6). Access the paper: 10.1029/2021jc017970

Shedding light on Arctic Mercury

Arctic biota contain higher mercury levels than elsewhere. The Arctic Ocean is key to understand the drivers because bioaccumulating neurotoxin methylmercury is formed from inorganic mercury within the ocean itself. Based on the recent Arctic Monitoring and Assessment Programme (www.amap.no) and new observations, the mercury budget in the Arctic Ocean was revised (Dastoor et al, 2022). The revised Arctic Ocean mercury budget (~1,870 Mg) is lower than previous estimates (2,847–7,920 tons) and this implies a higher sensitivity to climate change and anthropogenic emissions. Particulate mercury settling (122 ± 55 tons per year) from surface waters to the shelf sediments is the largest mercury removal mechanism in the Arctic Ocean. The revised Arctic Ocean mass balance suggests that mercury burial in shelf sediments (42 ± 31 tons per year) may be underestimated by over 100% (52.2 ± 43.5 tons per year).

New research is now shining a light on mercury cycling on the Arctic shelf. On Arctic oceanographic cruises in August and December 2019, PhD candidate Stephen G Kohler and coworkers collected seawater samples for mercury, lead and manganese measurements. In the illuminated Arctic summer, surface seawater has elevated concentrations of mercury. As the seasons change and the Arctic descends into its long, dark winter, little is known about mercury and its behavior during the polar night. In a new publication, Kohler et al. (2022, see reference below) find that mercury concentrations on an Arctic Ocean shelf sea decrease about 33% from summer to winter. They propose an additional transport mechanism where manganese released from the shelf actively scavenges mercury from the water column. Methylmercury concentrations did not change with seasons. The persistent methylmercury concentrations are likely driven by a lower affinity for particles and the presence of gaseous species. The results update the current understanding of Arctic mercury cycling and require budgets and models to be reevaluated with a seasonal aspect. The residence time of methylmercury is longer (25 years) compared to inorganic mercury (3 years), and high methylmercury levels can be expected in the future.

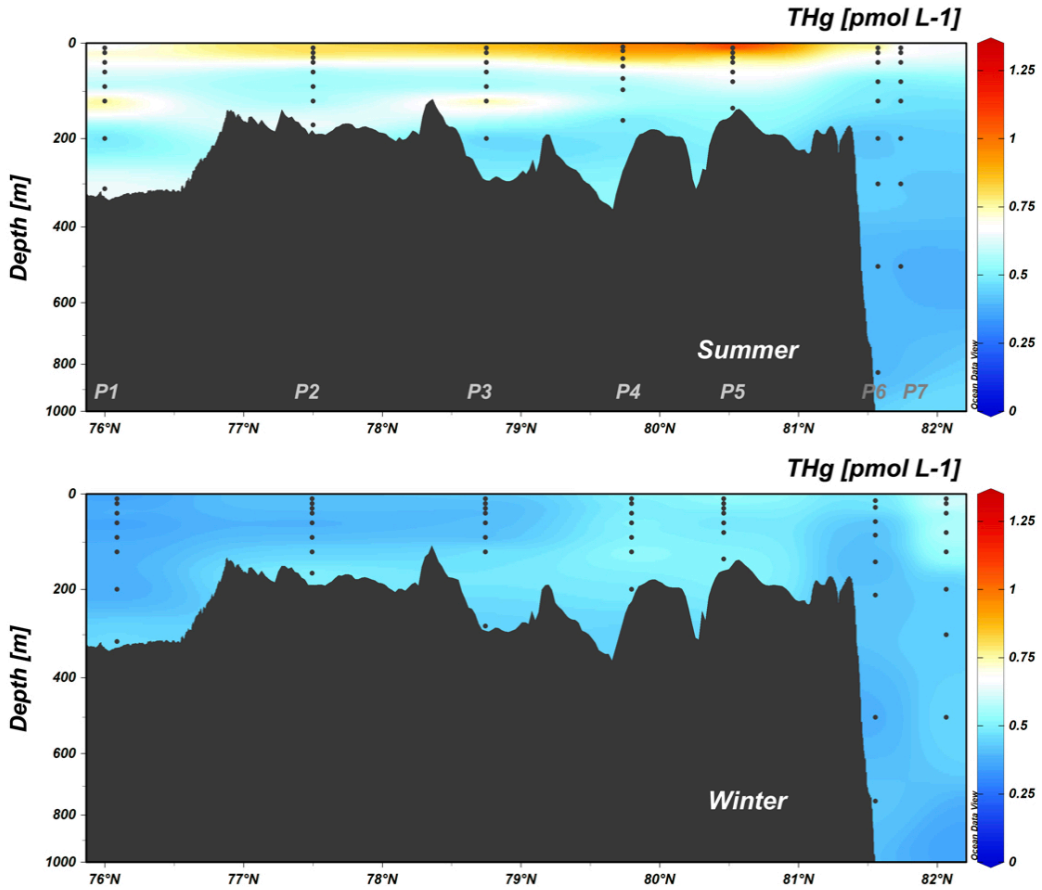

Figure 5. *Total mercury concentrations mesured in summer (top panel) and winter (bottom panel). Stephen G. Kohler and his colleagues find that mercury concentrations on an Arctic Ocean shelf sea decrease about 33% from summer to winter.*

References:

A Dastoor, H Angot, J Bieser, J Christensen, T Douglas, LE Heimbürger-Boavida, M Jiskra, R Mason, D McLagan, D Obrist, P Outridge, M Petrova, A Ryjkov, K St. Pierre, A Schartup, A Soerensen, O Travnikov, K Toyota, S Wilson, C Zdanowicz. Arctic mercury cycling. Nature Reviews Earth & Environment 3 : 270-286, (2022). 2022-03-22. https://www.nature.com/articles/s43017-022-00269-w – https://hal.archives-ouvertes.fr/hal-03619231

SG Kohler, LE Heimbürger-Boavida, MV Petrova, MG Digernes, N Sanchez, A Dufour, A Simic, K Ndungu, MV Ardelan. Arctic Ocean's wintertime mercury concentrations limited by seasonal loss on the shelf. Nature Geoscience (2022). 2022-07-18. Access the paper: https://www.nature.com/articles/s41561-022-00986-3

3. Activities

3.1 GEOTRACES intercalibration activities

The S&I Committee met in Brest, France on 8-9 September prior to the next SSC meeting. During this meeting, the functioning of the committee was presented and discussed with the new appointed members, several reports were reviewed and intercalibrated, and a good portion of the meeting was spent reviewing and discussing improvements for website pages, intercalibration report template and the DOoR portal.

***Figure 6**. First in person meeting for the new committee held in Brest (France). From left to right: Peter Sedwick, Julie Granger, Ana Aguilar-Islas, Hélène Planquette, Christopher Hayes, Yeala Shaked, Luke Bridgestock. Yoshiko Kondo and Tim Conway joined online. Lars-Eric Heimbürger-Boavida was excused.*

- modifying the intercalibration template to help improve the intercalibration process: this updated template was approved at the international SSC meeting and is now available online, along with a model example of a correctly filled report (courtesy of A. Shiller)
- updating the cookbook: S&I committee members are heading different chapters of the cookbook in collaboration with previous contributors. The process is in place and a new version of the cookbook is expected to be submitted during the DMC meeting next September 2023 for review and approval
- improving website pages and DOoR portal: request for improvements were communicated to Elena Masferrer Dodas and Francois André by the co-chairs. Co-chair Planquette went to Toulouse and discuss these modifications in on December 16th, 2022. Various updates, which allow a smoother use of the portal were implemented, and the co-chairs thank warmly E. Masferrer Dodas and F. André for the time spent.

Table 1: Standard and Intercalibration Committee Members

Member	**Institution**	**Preliminary Assignments**
Ana Aguilar-Islas (Co-Chair)	University of Alaska Fairbanks (U.S.)	Polar parameters, aerosols
Hélène Planquette (Co-Chair)	LEMAR Laboratory, CNRS (France)	Particulate TEs
Luke Bridgestock	University of Cambridge (U.K.)	Other stable of isotopes of TEs, Pb isotopes, Ba isotopes, REES and some radiogenic isotopes (Hf, Nd, Os, Sr)
Tim Conway	University of South Florida (U.K.)	Water column dissolved TEs + Fe, Zn, Cu isotopes
Julie Granger	University of Connecticut (U.S.)	Isotopes of N and C, pH, DIC, TALK, macronutrients
Christopher Hayes	University of Southern Mississippi (U.S.)	Natural and artificial radiogenic isotopes
Lars-Eric Heimbürger-Boavida	Mediterranean Institute of Oceanography (France)	Mercury species
Yoshiko Kondo	Nagasaki University (Japan)	Dissolved ligands and inorganic elements, dissolved oxygen peroxide
Yeala Shaked	Institute of Marine Science, Eilat (Israel)	Biogeotraces related parameters

The S&I met virtually on December 5th, 2022 then on April 3rd, 2022 during which other reports were looked at. All members attended, with the exception of L.-E Heimburger-Boavida (field trip).

Peter Sedwick resigned from the committee due to upcoming demanding responsibilities. We thank him for his service. Co-chair Aguilar-Islas will take over the expertise on aerosol reports because we were unable to find a member of the aerosol community willing to commit to the committee.

The co-chairs, Hélène Planquette and Ana Aguilar-Islas participated in one virtual Executive meeting on April 23rd, 2023. The co-chairs also reported on S&I activities at the GEOTARCES SSC meeting (26-30 September 2022).

The 2023 in-person meeting will take place in San Jose, California (USA), next September 21-22, prior to the DMC and SSC meetings (in Palo Alto, California). In preparation for IDP 2025, co-chairs will communicate the dates of scheduled meetings to the international community to encourage early intercalibration report submissions.

3.2 Data management for GEOTRACES

The British Oceanography Data Centre (BODC), at the National Oceanography Centre (UK) hosts the GEOTRACES Data Assembly Centre (GDAC, https://www.bodc.ac.uk/geotraces/). Donna Cockwell, is the lead GEOTRACES Data Manager, working in collaboration with Samantha Blakeman and Charlotte Dempster. The GDAC benefits from additional BODC expertise, when required.

The GDAC is responsible for the entirety of the GEOTRACES data activities. This involves the following components:

- Interaction between principal investigators (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 the Standards and Intercalibration Committee to answer issues/questions relating to GEOTRACES;
- Input of metadata and data into the BODC databases and compilation of documentation, including the originator's methodology;
- Collation of data and metadata for future IDPs;
- Answering requests from the GEOTRACES community and assisting on IDP downloads.

The main GDAC tasks over the last year were:

IDP2021v2 data reception, archiving and processing: Over the last year work has focussed on identifying gaps in the core CTD hydrology (i.e. CTDTMP, CTDSAL and CTDOXY). With the assistance of the DMC and IPO, data submitters were contacted and encouraged to supply the missing CTD hydrology data. As a result, hydrography data for 23 cruises have been added or expanded in the IDP.

IDP2021_v2 DOI: The GEOTRACES IDP2021v2, to be released on July 7th 2023, continues to offer users as an open access data release of the GEOTRACES IDP, with a DOI released by NERC EDS British Oceanographic Data Centre NOC (doi:*10.5285/ff46f034-f47c-05f9-e053-6c86abc0dc7e*).

Enhancing of proof-checking: New dynamic html files have been added to the DOoR portal, further enhancing the proof-checking capabilities, this is an improvement from the previously used static jpeg files.

Development of standardised hydrography profile workflow: GDAC have focused efforts on developing a workflow for the hydrography (CTD, oxygen, transmissivity, fluorescence, etc.) profile data that accompanies GEOTRACES samples data. We used standard BODC ingestion processes, as well as automating metadata population and document writing, to provide standardised ODV files which will simplify integration in future IDPs.

Cruises: The summary of GEOTRACES cruises, which have taken place in the period May 2022-April 2023 is shown in Table 2.

Table 2. Cruises completed during the reporting period.

Cruise	Chief Scientist(s)	GEOTRACES scientist(s)	Type	Period	Location
Sonne SO298 (GP11)	Achterberg Eric	Achterberg Eric	Section Cruise	2023-04-09 to 2023-05-28	Pacific section along the Equator
RV Atlantic Explorer AE2305 (GApr18, STING)	Angela Knapp	Tim Conway, Kristen Buck, Rene Boiteau	Process Study	2023-02-20 to 2023-03-06	Gulf of Mexico
RV Roger Revelle RR2214 (GP17, OCE)	Twining Benjamin	Twining Benjamin, Fitzsimmons Jessica, Cutter Gregory	Section Cruise	2022-12-02 to 2023-01-25	South Pacific and Southern Ocean (Amundsen Sea)
FS Polarstern PS133_2 (GApr17)	Sabine Kasten	Scarlett Trimborn	Process Study	2022-11-19 to 2022-12-19	South Georgia and Southern Ocean, ACC
FS Polarstern PS133_1 (GApr17)	Christine Klaas	Scarlett Trimborn	Process Study	2022-10-01 to 2022-11-17	South Georgia and Southern Ocean, ACC
Hakuho Maru KH22-07 (GP22)	Obata Hajime	Obata Hajime	Section Cruise	2022-06-30 to 2022-08-21	Western North Pacific
RV Investigator IN2022_V03 (GIpr08, SOTS)	Shadwick Elizabeth	Chase Zanna, Bowie Andrew	Process Study	2022-05-03 to 2022-05-15	Southern Ocean (East Indian sector)

In summary: The past year was marked by the release of the GEOTRACES IDP2021v2, a crowning achievement of the hard work of the whole GEOTRACES community. The GDAC work was central in preparing and processing all the GEOTRACES (meta-)data, and closely collaborating with all the acting parties. Beyond the GEOTRACES data work, the GDAC released enhanced proof-checking, which was added to the DOoR portal and made improvements to hydrography profile workflows in preparation for IDP2025.

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. 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, Twitter, YouTube 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;
- ensuring the development and maintenance of the DOoR portal;
- 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:

- Maintenance of the GEOTRACES DOoR portal and building the IDP2021

  The IPO has continued to manage the development and maintenance of the GEOTRACES Data for Oceanic Research (DOoR, https://geotraces-portal.sedoo.fr/pi/) on-line portal that has proved to be an excellent tool which has enormously facilitated the building of the IDP2021. The technical work is assured by François André from the Data Centre of the Observatoire Midi-Pyrenées (SEDOO, https://www.sedoo.fr/) in Toulouse, France.

  The main developments completed during the reporting period include:

  - Improve the GDAC Interface to make possible the addition of dynamic html files (instead of the previous used static jpeg files) in order to ameliorate the proof-checking capabilities.
  - Major overhaul of the S&I Interface following the demands from the S&I Committee.
  - Add a feature to regularly update all user names in the database based on their ORCID.
  - Improve the management of the compliant data submissions through DOoR.
  - Simplification of the management of non-intercalibrated parameters (new status created "approved by default") through DOoR.

In addition, the IPO and the SEDOO have assisted GDAC, the S&I committee and the Parameter Definition Committee (PDC) in the creation of the IDP2021 version 2, reviewing registered datasets and creating new parameters when needed.

- Intermediate Data Product 2021 version 2 release

The IPO has greatly helped the GDAC in their work of preparing the IDP2021 version 2 by: contacting data submitters to compile the data needed for the release of IDP2021 version 2, organising virtual meetings to advance the work, registering or managing the necessary changes in the DOoR datasets and providing assistance and guidance as needed.

- GEOTRACES endorsed as Ocean Decade Action

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

In June 2021, GEOTRACES was endorsed as contribution by the UN Decade of Ocean Science for Sustainable Development. In May 2023, the IPO has been submitted the annual report of activities as requested by the UN Ocean Decade. The IPO informs the UN communication officers about the GEOTRACES activities so that they can relay the information in their media (this has been particularly useful for the videos produced by the IPO which are described below).

- Outreach

The IPO is working with Adrian Artis (graphical designer) in preparing a suite of short videos presenting the science of GEOTRACES for the general audience. Starting early 2023 until July 2023, a video is being released each month. Each of these videos is focused on a topic or category of trace element. This project will be presented at the Goldschmidt 2023 conference on a session proposed and co-convened by Elena Masferrer. The list of videos to be released are:

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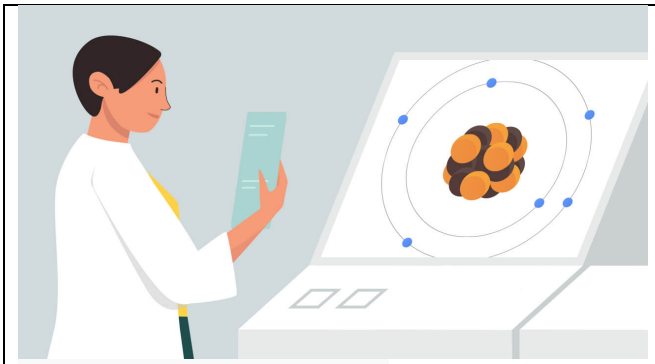
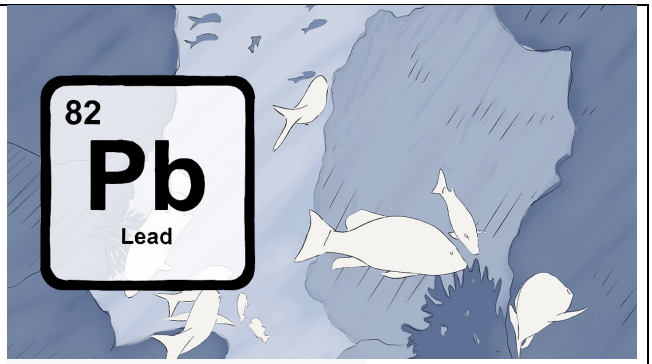
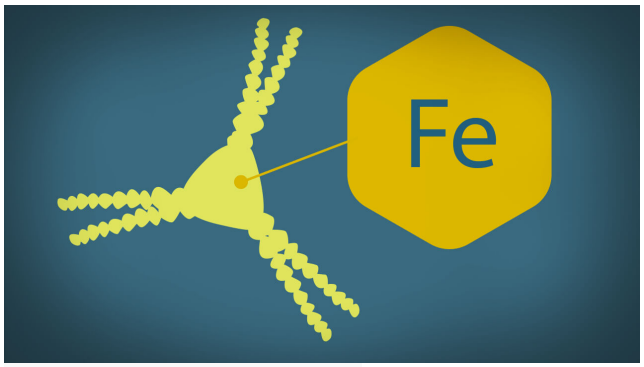
<td> 
https://youtu.be/5fVbGVwu78s
Isotopes, tracers of origines & chronometers
Watch this video to learn what isotopes are and why they have revolutionised our knowledge and understanding of the oceans. (Subtitles in 7 languages) Watch it in Youku</td>
<td> 

https://youtu.be/LmPe5bsjB0o
Lead, humans and oceans
Discover how scientists have found that lead pollution in the marine environment has been reduced… (Subtitles in 5 languages) Watch it in Youku</td>
</tr>
</table>

https://youtu.be/u9KkyTMRNXk

Neodymium, the element that attracts us

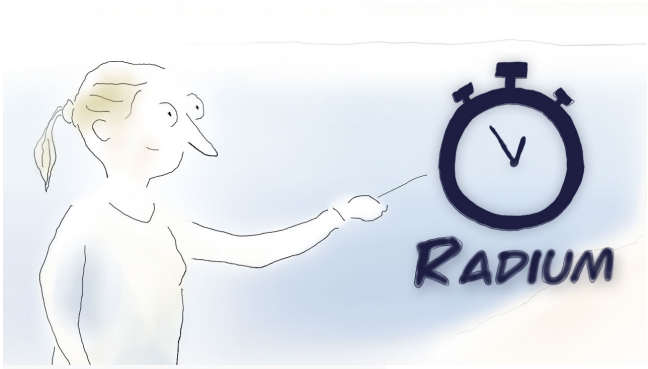
Not only is it omnipresent in our daily lives (phones, cars, etc.), in the ocean neodymium has important powers… (Subtitles in 5 languages) Watch it in Youku



https://youtu.be/EpzEv0H4lvg

Iron, essential for life in the ocean

Iron plays a fundamental role in marine ecosystems… however, detecting it in the ocean is like finding someone in a crowd of a hundred billion people… (Subtitles in 4 languages) Watch it in Youku



https://youtu.be/V3U8D6Cmaxc

Radium, a chronometer of ocean currents

Discovered by Marie and Pierre Curie, radium is now used as a chronometer to deduce the rate of water mass transport… (Subtitles in 4 languages) Watch it in Youku

https://youtu.be/RxKunSn4kW4

Thorium, a luminous element

This mysterious chemical element is used as a chronometer by scientists… (Subtitles in 4 languages) Watch in in Youku

- Some statistics for the period May 1st, 2022 to April 30th, 2023

  37 new highlights published (318 in total)
  6 eNewsletters published, including one special issue (bimonthly 45 in total)
  186 new peer-reviewed papers included in the GEOTRACES Publication Database (2,192 in total)
  179 new articles published on the GEOTRACES website
  2,685 followers in Twitter and 892 followers in Facebook

3.4 Special sessions at international conferences featuring GEOTRACES findings

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

Hybrid Virtual Goldschmidt 2022, 10-15 July 2022
For further information:https://2022.goldschmidt.info

GEOTRACES sessions:

*12a – The interplay between terrigenous fluxes and the biological pump as reflected by trace elements and their isotopes in the oceans
Conveners: Adi Torfstein and Zanna Chase

*12d – The Role of Trace Metal Speciation (Physical and Chemical) At Marine Geochemical Interfaces
Conveners: Catherine Jeandel, Rebecca Zitoun, Hélène Planquette, Sylvia Sander, William M. Landing and Andrea Koschinsky

*14b – Transport of particle-reactive elements from estuaries to open ocean: role of boundary exchange and oceanic internal cycling
Convenors: Kai Deng, Milena Horvat, Jianghui (JD) Du, Igor Živković, Jožef Stefan Institute and Jennifer L Middleton

The Challenger Society Conference 2022, 6-8 September 2022
For further information: https://www.nhm.ac.uk/our-science/science-events/the-challenger-society-conference-2022-in-london.html

GEOTRACES session:

*T3 – Chemistry of nutrients, trace elements and their isotopes in the Ancient, Modern and Future Oceans
Convenors: Rhiannon Jones, Arianna Olivelli, Suzanne Robinson, Dr Amber Annett, Dr Oscar Branson, Dr Hana Jurikova

EGU General Assembly 2023, 23–28 April 2023
For further information:https://meetingorganizer.copernicus.org/EGU23/session/45681

GEOTRACES session:

*OS3.1, Response of ocean biogeochemical cycles to past, present and future climate change
Convenor: Alessandro Tagliabue
Co-convenors: Charlotte Laufkötter, Christopher Somes, Camille Richon

Forthcoming:

ASLO 2023, Aquatic Science Meeting, 4-9 June, 2023
For further information: https://www.aslo.org/palma-2023/

GEOTRACES and GEOTRACES-related sessions:

**SS014 Atmospheric Supply of Soluble Trace Elements and Isotopes: Advances and Challenges
Conveners: Rachel Shelley, Susanne Fietz, Alex Baker, Morgane Perron,

**SSO38 Trace Metal and Macronutrient Behaviour in Large Rivers and Estuaries
Conveners: Adrienne Hollister, Hannah Whitby, Rebecca Zitoun, Juan Santos-Echeandía.

Town Hall

SCOR Working Group 167, RUSTED Town Hall
Further information about RUSTED is available here:https://www.geotraces.org/new-scor-working-group-rusted/

Goldschmidt 2023, 9-14 July 2023

List of GEOTRACES or GEOTRACES-related sessions:

*Theme 13, Chemistry and physical processes of the oceans and atmosphere: now and through time:

13c – Marine trace element cycling from the estuaries to the open ocean (GEOTRACES)
Co-conveners: Kai Deng, Helene Planquette, Anh Le-Duy Pham, Jennifer L Middleton, Pierre Damien, Marion Anne Fourquez,

13h – Emerging insights into processes controlling elemental and non-traditional stable isotope paleoproxies in past and present oceans
Co-conveners: David J Janssen, Adina Paytan, Susan H Little, Jiawang Wu, Gert J. De Lange and Ruifang Xie.

13d – Hydrothermal vents from discharge to biogeochemical impacts
Co-conveners Zvi Steiner, Anna Lichtschlag, David González-Santana, Ziming Yang and Natascha Riedinger.

*Theme 14, Science and Society:

14a – Use of GEOTRACES data to understand biogeochemical processes in the oceans
Co-conveners: William M. Landing and Angela Milne.

14d – Lessons learned in communicating geochemistry to non-scientific audiences
Co-conveners: Elena Masferrer Dodas and Chrissy Wiederwohl.

3.5 Capacity building

GEOTRACES Summer Schools The third GEOTRACES summer school took place from 10th to 15th July 2022 at the Helmholtz-Centre Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany, organised by Walter Geibert and Claudia Hanfland. One of the products of this summer school is a series of training videos introducing the cleanroom and the ICP-MS. These videos are currently being finalised and they will be available on the GEOTRACES site in Autumn 2023.

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. In this sense, a document including "Recommendations for nations developing a trace metal-clean sampling system" prepared by Greg Cutter (Old Dominion University, past S&I co-chair) is available on the GEOTRACES web site. This document summarises 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 along with other materials is available on the GEOTRACES Capacity Building web page https://www.geotraces.org/geotraces-capacity-building-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 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	24 X 12-L GO-Flo	3000 m; Kevlar cable

		sampler for use with modem equipped 911plus CTD		
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 (GEOMAR)	Complete	Two titanium rosette frames (built by KUM, Kiel) with titanium pressure housings and fittings	27 x 12-L OTE GO-Flo and 27 x 12-L OTE Niskin	8000 m; conducting Kevlar
Germany (AWI)	Complete	Titanium frame with 911 plus CTD; all sensors with titanium housing	24 x 12-L OTE GO-Flo	8000 m; conducting Vectran cable
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-Flo	Kevlar
Italy - National Research Council of Italy, CNR	In progress	Seabird GEOTRACES Powder-coated aluminium with titanium pressure housings and fittings	24 X 12-L C-Free bottles	6000 m, steel conducting cable
Japan	Complete	Powder coated aluminium	12-L Niskin-X	7000 m; Vectran conducting Cable
Japan	Complete	Powder coated aluminium	12-L Niskin-X	10000 m; Aramid yarn conducting cable
Netherlands	Complete	Titanium frame	24 X 24-liter ultraclean	10000 m; conducting

			polypropylene	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
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 2022–2024)	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

GEOTRACES field work programme

GEOTRACES will continue to advance the implementation of the field work programme with section cruises already planned by US, Germany and Australia supplemented by process studies (US, Canada, Australia, the Netherlands and UK have already cruises scheduled) that will investigate particular physical, chemical, and biological processes regulating the distributions of these TEIs. These new data will enrich future intermediate data products.

Towards a new Intermediate Data Product

As mentioned in section 2.2. above, GEOTRACES plans to release a new Intermediate Data Product in November 2025 and a timeline has been already announced. Nevertheless, thanks to the DOoR portal the submission and review of data can now be done on a continuous basis. Indeed, PIs are encouraged to provide data as soon as available so that the S&I Committee and GDAC can review and process them as soon as possible to facilitate the integration of these data in the next IDP.

Scientific workshops

GEOTRACES still plans to undertake the synthesis workshop on "Changing marine elemental cycles" which was initially planned for 2021 but that had to be postponed due to the COVID-19 pandemic. The plans for this workshop will be re-discussed at the SSC meeting in September 2023. At the same time, an initiative to create a working group to produce state estimates was initiated at last SSC meeting and it will be discussed again at next meeting with a scientific workshop that could be planned in the future.

These initiatives will continue and complement the GEOTRACES synthesis efforts initiated by the suite of three synthesis workshops (in 2015, 2016 and 2018, http://www.geotraces.org/science/synthesis-of-results). They will also promote the efforts of bringing together the observational and modelling communities as well as 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.

Acknowledgements

We wish to express our gratitude to SCOR, and to both, Patricia Miloslavich on her role of former Executive Director, and Emily Twigg on her role of new Executive Director, for providing support and valuable advice for the successful implementation of the GEOTRACES programme. A complete report on the activities completed by the BioGeoSCAPES is available in the annex of this report.

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July 2023