SCOR Working Group Proposal

TRACE element SAMplers and sensORS, A step change to observing and understanding trace metal biogeochemistry in the ocean.

Acronym: TRACESAMORS

1. Summary/Abstract

The availability of essential trace metals (Fe, Zn, Co, Cu, Mn) controls primary productivity in up to half of the world's oceans and modulates the ecological framework of different ocean biomes. One of the biggest remaining challenges to improving our understanding of ocean biogeochemistry is the availability of accurate *in situ* techniques for the determination of the concentration and speciation of these essential trace metals. Our present understanding is constrained by limited temporal and spatial resolution observations, especially during critical seasonal and event-driven transitions in remote areas of the oceans. This is due to the absence of sensors that are suitably sensitive, selective and robust to determine elements at extremely low concentrations. Hence, the proposed topic will initiate international collaborations to foster the application and development of new samplers and sensors, for the determination of trace metal concentrations and speciation in specific parts of the ocean. The workgroup builds on the work of Grand et al. (2019) [1] OceanObs'19 paper recommendations on the creation of an international working group of trace metal sensor developers. Following a recent international meeting (TRACEAMORS, Brest 2022), our working group will focus on evaluating key analytical challenges with existing oceanographic sensors for trace metal analysis, review emerging sensing technologies in other disciplines and their potential for oceanographic use, and provide recommendations for inter-comparison with current remote samplers (target zones, deployment, maintenance). The aim is to promote collaborative international research to instigate a step change in our ability to monitor trace metal dynamics.

2. Scientific Background and Rationale

Understanding the role of trace elements and how their supply, abundance and speciation will change with projected global environmental forcings (e.g. ocean acidification, warming, global circulation, and expanding oxygen minimum zones, [2]) is a pressing research need. The international GEOTRACES program (https://www.geotraces.org) provided a step change in knowledge of the current global distributions of trace elements and their isotopes resulting from coordinated ocean section cruises through all the ocean basins. This has led to significant paradigm shifts, particularly with regards to the micronutrient iron (Fe): for example, hydrothermal inputs of Fe detected thousands of kilometers from their source in the south Pacific Ocean [3].

However, the 'tool box' of methods available to chemical oceanographers to constrain the sources, sinks, transport, residence time and internal cycling of micronutrient trace metals is limited to discrete sampling onboard ships (cornerstone of GEOTRACES observations). A limited number of autonomous systems capable of observing trace metals at subnanomolar concentrations have been deployed [4], [5] but these are generally not reliable over seasonal time periods and require some degree of regular turnaround and maintenance. Overall, these observational constraints hamper the development of a mechanistic understanding of trace metal cycling and capabilities lag behind equivalent *in situ* technologies (e.g. macronutrient sensors). Several micronutrient metals (e.g. Fe and Mn) are characterized by short oceanic residence times, highly variable source terms, and sub-nanomolar concentrations in open ocean settings. Thus, in addition to the timeliness related to a community need for Net Zero oceanographic observations, the development of in situ sampling and sensing technologies is also necessary to capture the spatial and temporal variabilities. Addressing this will lead to a step change in our understanding of seasonal and higher resolution biogeochemical cycling of essential trace elements and their role in modulating biological productivity and carbon export.

The idea of working towards novel sensors for micronutrients combining analytical advances with the gaps in marine biogeochemistry observing techniques was put forward at a Town Hall Meeting at the AGU Ocean Science meeting (Salt Lake City 2012) and ultimately led to the Collaborative on Ocean Chemistry and Analysis (COCA) meeting (http://media.journals.elsevier.com/content/files/cocameeting-30202026.pdf). While this meeting was well received by the community, few sustained collaborations emerged from it, largely because there was no long-term community or programmatic structure bridging the distinct disciplinary fields of oceanography, analytical chemistry and engineering needed to make trace metal sensors a reality. This is a drawback that TRACESAMORS proposes to address via formation of a SCOR work group.

The TRACESAMORS project was proposed to the SCOR working group call in 2020 but unfortunately not funded. Since then our project matured, and led to IFREMER hosting a hybrid workshop in Brest, France in September 2022. The total number of participants was 47 from 13 different nationalities (https://tracesamors.sciencesconf.org/) indicating the interest and the willingness of the scientific community to instigate long-term collaborations to foster a much needed step change in trace metal measurements. The working groups permitted sharing of knowledge of the methodologies currently used for *in situ* sampling and analysis of trace metals in different international laboratories and gave leads for future innovative developments. However, some key questions remained unanswered. Responding to the SCOR international Working Group call is a chance and a sustainable solution for the members of the TRACESAMORS organizing committee to continue to meet and build on the initial findings.

The key topics and questions highlighted during the TRACESAMORS workshop in Brest are as follows :

1. What are the *in situ* samplers and sensor technologies currently in use? Can the marine science community establish good routine practices and propose harmonized deployment protocols and quality control procedures for TM measurements obtained from in situ sensors?

Two possible sensor technologies have been identified as sufficiently mature to be deployed in situ for coastal or TM enriched areas. Wet chemical analysis (including spectrophotometry and chemiluminescence) [6], [7] and voltammetry [8], [9]. Both techniques fulfill the prerequisites for remote *in situ* work including high sensitivity, selectivity and robustness (Fig. 1). Samplers with (diffusive gradients in thin-films (DGT) [10]) and without [5] preconcentration are also being currently adapted to the extremely low natural concentrations of metals (nanomolar or below). However, the issue of contamination, which led trace metal geochemists to develop extreme methodologies to avoid contamination during all phases of sampling and analysis, has never been systematically investigated for existing sensors, samplers and passive sampling devices. How can we adapt these sampling protocols to avoid artifacts for in situ sensors?

We propose to bring together the main full members to plan an intercomparison exercise for the 2 sensors technologies, in situ samplers and gels in order to (i) clearly identify the limitations and advantages of these methods and (ii) provide recommendations for inter-comparison of remote sensors and samplers. Improving the level of interoperability for in situ trace metal sampling and analysis via calibration, intercomparison and harmonization of operational technologies (as performed for in situ macronutrients analysis [11] SCOR#147, Cookbook GEOTRACES (2017), [12], [13]) would be of great benefit to the marine community. This will lead to an in situ comparative evaluation of analytical challenges related to current methodologies.

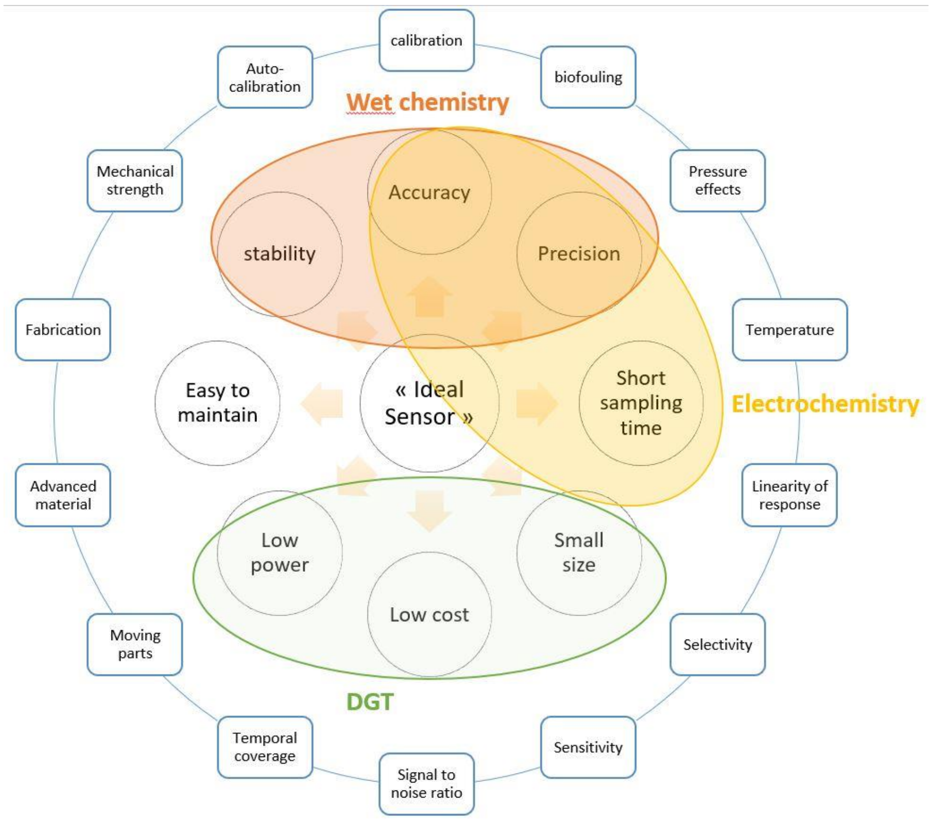

Figure 1: Performance and specification of chemical sensors and passive samplers adapted for the 3 types of analytical techniques dedicated to the TM analysis (adapted from [14])

2. What are the emerging technologies that could revolutionize the way to sample or determine trace metals *in situ*?

Analytical methods and derived sensor prototypes for TM determination have their limits in terms of detection, sensibility, versatility, size, and weight. It is essential that we explore and evaluate breakthrough technologies of future small and light sensors capable of determining metal concentration and speciation *in situ,* with the main performances described for an ideal sensor. State-of-the-art analytical detection methods and technologies (e.g., 3D printing, nanotechnologies, novel fluorescent probes) are emerging in multiple scientific fields. Therefore, it has become challenging for chemical oceanographers to keep up with all these analytical and technological developments and to anticipate potential application to oceanography. The latest trends and developments in analytical chemistry (novel ligands, biosensors, miniaturized methods) should be evaluated for their oceanographic potential. Adopting new strategies among other branches of knowledge (siderophores [15], fluorescence [16], nanoparticles [17], graphene [18] or preconcentration [19]) could help create the synergies that would facilitate new sensor development research in oceanography (figure 2).

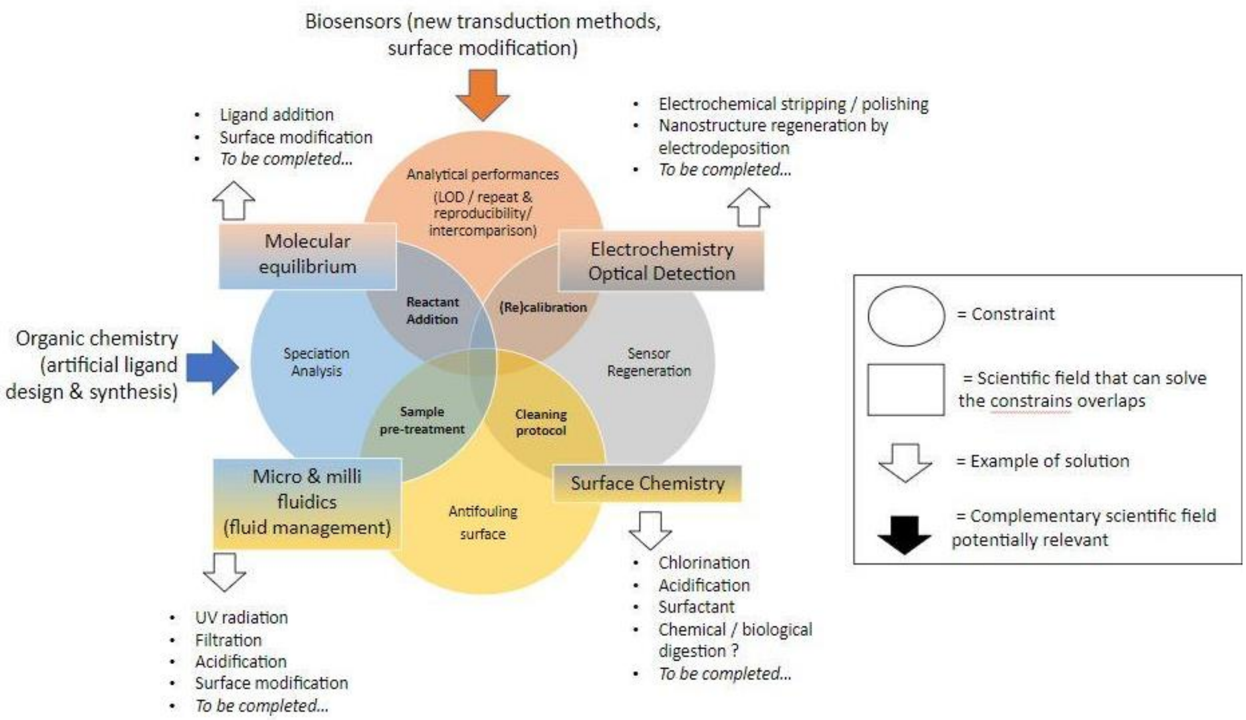

Figure 2: Mindmap for future TM marine sensors development

We propose to continue reviewing and evaluating recent techniques and to identify new promising technologies in other disciplines from the medical, engineering and other environmental research areas.

3. Where can TM sensors and samplers be best deployed?

Capturing seasonal and short-term variability of trace metals as well as the variability from specific processes, such as hydrothermal dispersal, dust deposition and shelf transport, are essential to determine their (i) supply to the euphotic zone linked to primary production, (ii) residence time and (iii) inventory in various oceanographic regimes. Repeated transects and international programmes (such as GEOTRACES) will help identify 'target zones' where biogeochemical changes and ecological sensitivity need high frequency monitoring of trace elements.

The objectives pursued by the WG will focus on assessing target zones that are the most appropriate for trace metal sensor deployment, taking into account location, facility of maintenance and maximum value of observed data. This will drive associated recommendations for future TM sensor development.

3. Terms of Reference

The TRACEAMORS work group will aim to achieve the following objectives:

Objective 1: To critically evaluate key analytical characteristics of current trace metal samplers and *in situ* sensors by intercomparing them in a controlled laboratory environment.

Objective 2: To provide recommendations for controlled inter-comparisons of remote samplers and *in situ* sensors. We will use the findings to develop a framework for the quality assessment and control standardization of these samplers and sensors, taking into account deployment location, facility of maintenance according to the analytical properties of sensors and sampling devices intercompared in the first objective.

Objective 3: To investigate new materials and analytical molecules, procedures and techniques on all aspects of trace metal sensors in industry, medicine and other environmental fields, to create new interdisciplinary collaboration and generate a critical review of promising technologies for marine biogeochemical measurements.

Objective 4: To engage the next generation of chemical oceanographers in analytical development by inviting them to the intercomparison exercises, as well as lecturing and training students.

Objective 5: To develop capacity and disseminate information resulting from the WG outcome in the form of (i) website (already created https://tracesamors.sciencesconf.org) to share results, reports (Ocean best practices), tutorials, (ii) open access journal special issue (e.g. TrAC, Frontiers in Marine Sciences) and (iii) platform for partnership collaborative proposals to generate sustained international collaborations (Capacity Building).

4. Working plan

The first TRACESAMORS meeting will be held in early 2024. Then plenary group meetings (online) will be convened to discuss with the entire WG the direction and organization of our activities (Fig. 3). These meetings (*in blue*) will be scheduled twice a year with larger conferences (*in darkest blue*). Additional online group meetings will be scheduled as needed. Training will also be organized 2 times during the time of the project (intercomparison, late 2026) and specific videos will also be available online for dissemination of knowledge.

Year 1: 2024

The first TRACESAMORS meeting will be organized online as most of the full and associated members already know each other from the first workshop organized in France. This **1st meeting** will be held in **early 2024** and from this will emerge the **working group leaders for the 5 ToRs**. A second online plenary group meeting will be scheduled during the year to conclude the discussions from the participation at the ICAAC (International Conference on Applied Analytical Chemistry) and ASLO meetings.

Interdisciplinary participation in conferences, this will be predominantly online in order to lower the traveling costs, with some on site for those committed to ToR **O3.** The idea is to **deepen the understanding and potential first primers** of new materials and analytical molecules, procedure and techniques on all aspects of trace metal sensors in industry, medicine and other environmental fields (3D printing, nanotechnologies, ligands). The TRACESAMORS project aims to establish collaborative partnerships to generate sustained collaboration during these conferences (**O5**).

At the end of year 2024, we aim to organize an **intercomparison exercise for the 2 sensors technologies and *in situ* samplers**. The objectives are to evaluate key analytical characteristics of currently employed methodologies (samplers and sensors (**O1**)). This will be done in a first step by analyzing certified reference material (NRCC, NASS–7) and GEOTRACES samples if available) in the laboratory at Stellenbosch University (South Africa). This will give the opportunity for students from Stellenbosch University to participate in practical work and to extend their knowledge of novel analytical techniques dedicated to chemical *in situ* detection. In the meanwhile, we will stream this online and/or make videos of the activities that will be posted on the TRACESAMORS website for students from other parts of the world to participate (**O4**). The second step of the intercalibration exercise will be to perform a coastal trial in order to test the 2 sensors and samplers directly in seawater. The impact of measuring problems associated with high salinity, turbidity, low / high temperature variations will be reviewed. If feasible, depth and high pressure conditions will be evaluated and discussed. Suzanne Fietz will be the lead organizer for the organization of the exercise and the link with the Stellenbosch University students. She will be assisted by the instrument and sensor managers.

Year 2 : 2025

This 2nd year will start with participation at a **targeted conference** such as the ASLO Meeting in Charlotte, North Carolina (March 2025) in order to share preliminary results obtained during the controlled inter-comparison of remote samplers and potential *in situ* sensors (**O2**, **O5**). We will also propose and lead a **TRACESAMORS dedicated session** at one of the large international ocean science meetings (AGU, OSM or ASLO, leaders Agathe Laes-Huon and Simon Ussher, **D3**) to highlight the objectives of TRACESAMORS. Discussion with other oceanographic and biogeochemist groups will help us to define the requirements for measurement conditions and assess target zones that are the most appropriate for existing trace metal sensor deployment (**O2**, lead organizer specified groups dedicated to the sensor deployment target zones). This working group will focus on the recommendations for controlled inter-comparison of remote samplers and potential *in situ* sensors and assessment to the target zones for future TM sensor deployment.

Moreover these Ocean Sciences meetings will be the right place to engage **interactions with specialized companies involved in sensor development** (Subchem Systems, Fluidion, Seabird, Systea, Hach, Clearwater sensors, Wetlabs, TRIOS **O5**). It could be an opportunity for a possible commercialization of the existing TM sampler and sensors but also to collaborate on the development of an innovative future TM sensor. The TRACESAMORS project also aims to involve potential sponsors in the development of new techniques.

Participation in oceanographic and wider field conferences (e.g. ICAAC Tokyo, June 2024, IEEE SENSORS meeting, Goldschmidt meeting Chicago, August 2024, Ocean Sciences New Orleans, February 2024, ASLO, Euroanalysis Barcelona 2025, **O5**) will activate **the review and evaluation of recent techniques** group (**O3**) and specific online meetings will be conducted on that topic during 2025. We aim to establish collaborative partnerships to generate sustained collaboration in disciplines outside the scope of oceanography (**O4, O5**).

An online plenary group meeting will be organized at the end of year 2 to evaluate the progression in the various objectives and to put together all the resources for the deliverables achievement.

Year 3: 2026

The first meeting of year 3 will be performed online and will again focus on the deliverables achievement and delivery.

The participation in the EGU 2026 Vienna, Austria May 2026, (**O3**) will strengthen the development capacity and the dissemination of information as well as finalizing the list of promising technologies in other disciplinary fields.

Year 3 will be marked by the **publication of an Ocean Best Practice Guide (D1)** as well as **the submission of a prospective article on potential oceanographic techniques (D2).**

Activities span the entire duration of the project and rely to a large extent on communication and capacity building activities. **The dedicated website** (**D4**) will also be a gateway to the intercomparison exercise results to recommendations and related resources and will serve as a forum for exchanging useful information. The actual website (https://tracesamors.sciencesconf.org/) will be improved and updated throughout the project (mid 2024 - end 2026, and beyond) and kept in open access in order to maintain and generate new collaborations (**O5**).

A final meeting will be held at the end of 2026 (targeting an emerging / developing country, place to be confirmed).

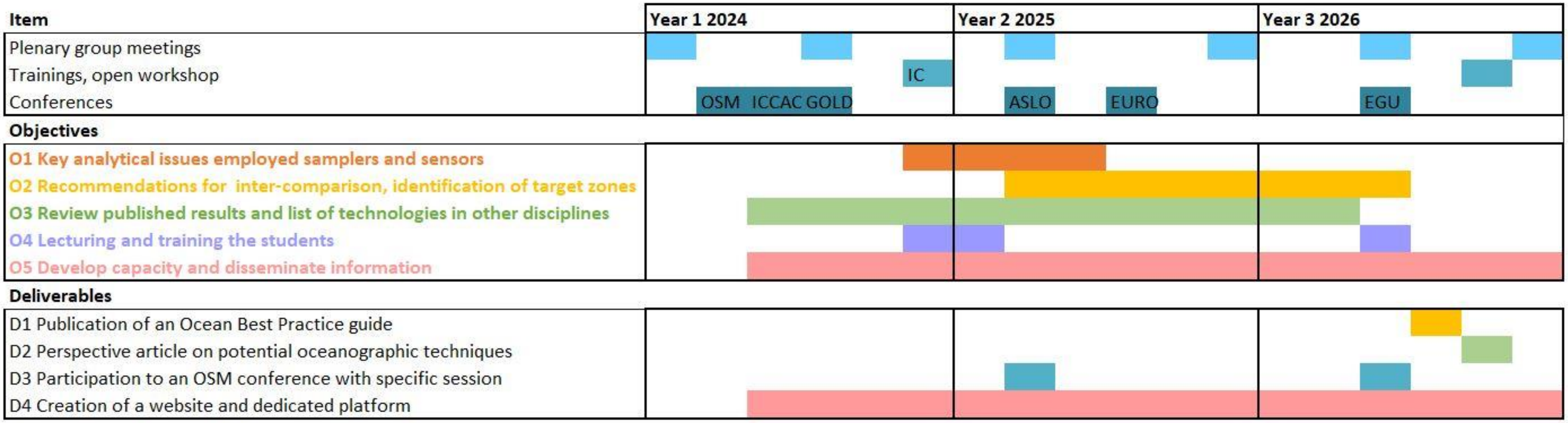

Figure 3. Plan for TRACEAMORS activities (2024-2026)

ICAAC: International Conference on Applied Analytical Chemistry, Tokyo, Japan June 2024
GOLD: Goldschmidt meeting, Chicago, USA, August 2024
OSM: Ocean Sciences New Orleans, USA, February 2024
ASLO meeting Charlotte North Carolina,USA, March 2025
EURO: Euroanalysis Barcelona, Spain, August 2025
EGU: EGU 2026 Vienna, Austria, May 2026

5. Deliverables

D1. Ocean Best Practice Guide for in situ trace metal sensors and samplers. The guide will combine the 2 current sensors technologies deployed in the field: wet chemical analysers, voltammetry, as well as *in situ* samplers (with or without preconcentration step, DGT) employed during the **intercalibration exercise (O1)** methods, their related figures of merits, key analytical and technical issues and provide recommendations for intercomparison assays and potential areas of deployments for maximum scientific impact **(O1, O2, O4)**

D2. Submission of a perspective review article on potential oceanographic techniques (open access journals e.g. Trends in Analytical Chemistry or Frontiers in Marine Science) will be completed, reviewing the potential for all aspects of trace metal sensors used in industry, medicine and environmental monitoring (3D printing, nanotechnologies, novel ligands, fluorophores) with a list of promising technologies for automated remote marine biogeochemical measurements. This information will be made publicly available **O3**).

D3. Participation and specific session at an international ocean science meeting (ASLO March 2025 Town Hall) to present the general objectives and progress of the TRACEAMORS WG (**O4, O5**) and communication on the first intercomparison results with participation of university students and companies

D4. Creation of a website and a partnership platform (**O4, O5**) for the generation of new sustained collaborations and dissemination of findings and resources.

6. Capacity Building

The aim of capacity building within TRACEAMORS will be to form and support a new international cohort of early-career scientists with the skills, knowledge and professional interdisciplinary network to tackle the challenges of applying *in situ* sensors and samplers of trace elements. The urgency of training scientists to enable transitions to autonomous samplers and sensors is pressing, with nations aiming to conduct remote observations, relying less on manned vessels. Furthermore, we have highlighted the demand for future scientists and international programmes to have robust and accurate sensors and reliable remote sampling platforms for observing event driven and seasonal biogeochemical changes in the oceans. The interdisciplinary nature of the TRACESAMORS project will enable individuals and research groups from across the world to obtain new knowledge and advanced analytical skills to develop new marine sensors and equipment urgently needed to advance the global networks. These new collaborations are critical to move this field forward, with interactions of this kind often impeded by the lack of common language and fora.

Our vision is to expand the views of Early Career marine scientists (ECRs) to look beyond their immediate disciplines to analytical scientists, chemists and engineers in order to make a significant leap in how biogeochemical cycling can be observed in the marine environment. This will open up a new network and catalyze discussion and idea sharing between marine chemists conducting trace metal observations in the field and analysts/engineers. Moreover, as we will include more advanced aspects that are linked to working group members, there will be clear opportunities for mentorship and further developing understanding through shared tasks.

We will work towards expanding the inclusion of project members from developing countries to build capacity in new technologies from other countries. Anticipated barriers to involvement are (i) economic costs associated with travel and technological development, marine infrastructure (ship time, instruments), (ii) low national critical mass of marine researchers (iii) closer link of a nations' research support towards subject areas with some economic return rather than blue skies focused research.

To address these barriers and bring researchers together to focus on the scientific challenges we will focus on:

(i) Value-added for ECRs by additional funding and linking to other activities and networks. The project will seek to boost and sustain capacity for *in situ* analytical trace techniques into the future by securing other funds with a focus on supporting developing countries. We will also encourage and actively support developing country students and scientists to apply for other funds to attend intercalibration activities and meetings (e.g. SCOR-NSF travel support funds, UK Newton Mobility Grants, French ISblue funding). The leads of this WG have already shown a capability to raise separate funds for the community, during a meeting held in France in 2022.

We will advertise and communicate via our website and email dissemination lists and news from other international organizations (GEOTRACES, SCOR, AGU, ASLO, SOLAS, POGO) and look for opportunities to link with the UN's Decade of Ocean Science for Sustainable Development. The TRACEAMORS forum will ensure close links to international ECRs to capitalize on other international programmes and SCOR activities, particularly those topics relating to the Ocean Science Infrastructure programme (see *relationships to other international programs section*).

(ii) TRACEAMORS Working Group meetings. ECR students and post-doctoral fellows or students will be invited to participate in working group meetings. All meetings will be in a hybrid format to ensure participation, even if funding cannot be obtained. To provide opportunities for associated members and early-career scientists who are not members of the WGs to attend the SCOR workshop, the second year meeting will occur in combination with the ASLO Meeting. TRACESAMORS will apply for travel funds from SCOR and the AGU, for the travel and subsistence of students and scientists from developing countries to the third year meeting. Moreover, the final meeting (2026) will take place in an emerging/developing country to allow networking, contribute to the local economy, and to share and exchange expert knowledge.

(iii) TRACEAMORS Training Workshops (O4). We will organize workshops focusing on the training of scientists in the use of resources, including raising awareness of new sensors and samplers, calibration of *in situ* sensors and data analysis. One of our objectives is also to develop skills and pedagogical innovation by opening sessions to students from local universities and enhancing interaction between the expert and the graduate communities by conducting a training workshop during the intercomparison exercise and explore ways to generate sustained collaboration in networks including involvement of the POGO programme (NF-POGO Alumni Network for Oceans). In order to optimize the use of the SCOR fundings, extra funding will be requested from ISBlue (France) through their permanent call for invited professors and researchers. Workshops will be in a hybrid format to be inclusive and broaden participation, and materials will be made available on the website.

(iv) TRACEAMORS Web-resources (O5). The dissemination and sharing of information through a website (https://tracesamors.sciencesconf.org/) and a platform for partnership collaborative proposals (already on google drive) will be built up by partners co-responsible for the production, ambition and impacts of the project. Live and recorded Powerpoint-type presentations from the meetings, videos showing innovative technologies selected for the future sensors, recommendations for the use of remote samplers will be part of the website content in order to facilitate productive, effective and stimulating face-to-face or remote knowledge exchange.

Our webpage will work to producing on-line talks, tutorials, presentations, literature and data bases around this topic. To make the knowledge from this work group available internationally and reducing bias from paid subscriptions and software charges, we will produce recorded presentations, highlight associated publications. The webpage is especially important to ensure the continuation of the project and this practical aspect will be discussed at working group meetings throughout the project.

(v) TRACEAMORS Good practice guides from intercomparisons (O2). Due to the Technical Readiness Level for many automated and sensor technologies in this field being in their early stage, the long-term aim of the project for the community will be to develop best-practice manuals of sensor methodology development, calibration of trace metal analysis *in situ* and sampling with eventual publication in open access international dissemination (e.g. UNESCO Technical Papers and Monographs). The progression and framework for doing this will follow the GEOTRACES model and link closely and consult this community when appropriate.

(vi) Engagement with field studies/sites, technology companies and future research funding (O3). During meetings and workshops TRACEAMORS members will initiate discussion on future international funding that would have ECR opportunities at the centre of the proposals. Examples of funding could include the EU COST programme which would facilitate short visits to conduct intercomparisons or learn new techniques. We will also investigate funding for future fellowships for TRACEAMORS students (e.g. Royal Society FLAIR Fellowships, Marie Skłodowska-Curie Actions Fellowships and Doctoral Networks program).

The **intercalibration exercise** is planned to take place in an emerging/developing country (South Africa) to contribute to the local economy, allow networking and to share and exchange expert knowledge. We hope this will be an opportunity for young researchers and graduate students from sub-Saharan Africa to participate and to deepen their knowledge in operational assays.

Coordinating with programmes via national funding can also be capitalised on to test new ideas, sensors and technologies (e.g. EMSO-Azores, AMT, BATS, HOTS programmes). Beyond the scope of the SCOR funding, successful ideas and collaboration will ultimately lead to major infrastructure development for the oceanographic community. The latter will also help strengthen the skill base of marine biogeochemistry and engineering communities to achieve global future goals towards understanding marine elemental cycles.

Members will be engaged with information and discussions with specialized companies involved in sensors development (Subchem systems, Fluidion), which will also be an opportunity for a possible commercialization of the existing TM sampler and sensors but also to collaboration on the development of an innovative future TM sensor. Discussions with companies dedicated to the marine environment (MacArtney, Satlantic) will also help the working group to evaluate the constraints associated to deep sea measurements and how to break through in a niche market of chemical marine sensors. There is a need to create a long-term community and programmatic structure bridging the distinct disciplinary fields of oceanography, analytical chemistry and engineering from academic and industries in order to make trace metal sensors an unmissable tool for ocean observations in the next decades.

Beyond the scope of the SCOR funding, successful ideas and collaboration will ultimately lead to infrastructure development for the oceanographic community. The collaboration will help strengthen the skill base of marine biogeochemistry and engineering communities to achieve global future goals towards understanding marine elemental cycles and ecological controls.

7. Working Group composition

Full Members

Name	Gender	Place of Work	Expertise relevant to proposal
1- Simon Ussher (co-chair)	M	University of Plymouth, United Kingdom	Flow injection techniques (FIA), fluorescence and chemiluminescence detection simon.ussher@plymouth.ac.uk
2- Agathe Laës-Huon (co-chair)	F	IFREMER, Brest, France	Development FIA for nutrients, trace metal analysis, deep sea automated analysers Agathe.Laes@ifremer.fr
3- Maxime Grand	M	Moss Landing Marine Laboratories, USA	Development of autonomous micro and mesofluidic analyzers for trace metals flow based methods and LOC maxime.grand@sjsu.edu
4- Andrew Bowie	M	University of Tasmania, Australia	Analytical chemical oceanographer, former chair of of the Scientific Steering Committee of GEOTRACES andrew.bowie@utas.edu.au
5- David Point	M	IRD GET, France	Autonomous *in situ* preconcentration devices for trace metals (DGT) david.point@ird.fr

6- Mustafa Yucel	M	Institute of Marine Sciences, Middle East Technical University, Turkey	Chemical oceanography, biogeochemical cycles, engineering and technology myucel@ims.metu.edu.tr
7- Nicolas Layglon	M	University of Geneva, Switzerland	Submersible electrochemical probe for *in situ* detection of bioavailable fraction of metals Nicolas.Layglon@unige.ch
8- Ruchi Gupta	F	School of Chemistry, University of Birmingham, UK	Sensors, microfluidics, electrophoretic sample preparation r.gupta.3@bham.ac.uk
9- Jian Ma	M	Xiamen University, China	Trace analysis using flow techniques, environmental-water metals Analyzer (*i*SEA) jma@xmu.edu.cn
10- Susanne Fietz	F	Department of Earth Sciences, Stellenbosch University, Stellenbosch, South Africa	Biogeochemist, links between phytoplankton and trace metals sfietz@sun.ac.za

Associate Members

Name	Gender	Place of work	Expertise relevant to proposal
1- Marco Bonizzoni	M	Univ. of Alabama, USA	Supramolecular chemistry of non-covalent interactions marco.bonizzoni@ua.edu
2- Wen-Hsuan Liao	M	National Cheng Kung University, Taiwan	Trace metal and their isotopic compositions (ICP-MS) whliao@gs.ncku.edu.tw
3- Hugo Oliveira	M	INL – International Iberian Nanotechnology Laboratory, Portugal	Development of flow-based analytical methods, integration of optical sensors hugo.oliveira@inl.int
4- Edem Mahu	F	University of Ghana, Africa	Geochemical cycling of trace elements and nutrients in nearshore marine systems emahu@ug.edu.gh
5- Naoya Kanna	M	The University of Tokyo, Japan	Flow injection determination of Mn and Fe in the ice-covered sea

			kanna@aori.u-tokyo.ac.jp
6- Rebecca Zitoun	F	GEOMAR, Germany	Voltammetry and FIA analysis of trace metals Young Ambassador of the European Marine Board and Chair of SCOR Committee for Capacity Development rzitoun@geomar.de
7- Juan Santos	M	Spanish Institute of Oceanography (IEO,CSIC), Spain	Use of passive samplers for trace metal inputs to coastal systems juan.santos@ieo.es
8-Sasa Marcinek	F	Ruđer Bošković Institute, Croatia	Development and improvement of electrochemical methods, DGT samplers smarcin@irb.hr
9- Monica Sanden	F	Norway department institute of marine research, Norway	Monitoring of seafood safety and environmental conditions, measurement of mercury, lead and cadmium Monica.Sanden@hi.no
10- Fiona Regan	F	Professor of Chemistry at Dublin City, Ireland	Expertise in development of sensors and separation techniques. Lab-on-chip (LOC) for water quality monitoring and citizen science. fiona.regan@dcu.ie

8. Working Group contributions

Agathe Laës-Huon is involved in analytical chemistry dedicated to seawater analysis and development of in situ instrumentation for monitoring marine chemicals and pollutants in coastal and deep-sea waters (FIA, electrochemistry, extraction and water sampling). She is in charge of the *in situ* chemical analyzers CHEMINI project.

Simon Ussher has >23 years of research experience as an analytical chemist and marine biogeochemist. His research has advanced our understanding of trace metal biogeochemistry in the Atlantic Ocean, including basin scale processes of iron (Fe) biogeochemistry from the atmosphere to the deep ocean. He employs expertise in techniques (including FIA and ICP-MS) to analyse Fe and trace elements in aerosol and marine samples.

Maxime Grand has pioneered the application of micro-Sequential Lab-On-Valve techniques to trace metal analysis at the sub-nanomolar level and worked on the development of the first generation in situ Lab-On-Chip phosphate analyzers at the NOC, UK. His research interests are focused on the biogeochemical cycling of Fe and Al in open-ocean settings such as the Indian Ocean.

Andrew Bowie is a chemical oceanographer and analytical chemist whose research investigates the biogeochemistry of trace elements in Southern Ocean and Antarctic environments. He has developed novel analytical techniques and instrumentation to probe trace element cycling in remote marine environments. He was former co-chair of the GEOTRACES program.

Susanne Fietz is a biogeochemist studying the dust deposition and the links between trace metals and phytoplankton in the Atlantic sector of the Southern Ocean. She is a current national representative of the GEOTRACES programme.

Jian Ma is an environmental analytical chemist dedicated to trace analysis using flow techniques. He has developed a robust integrated Syringe-pump-based Environmental-water Analyzer (iSEA) for real-time analyzing the nutrients, metals and carbonate parameters in seawater.

Ruchi Gupta is an Associate Professor and Global Engagement lead in the School of Chemistry, University of Birmingham, UK. Dr Gupta's area of expertise is sensors, microfluidics, acoustophoresis, electrophoretic sample preparation and analytical platforms. She has received grants from Cancer Research UK, Leverhulme Trust, Research Councils UK, Royal Society of Chemistry (RSC), and industry. She is a member of RSC's Analytical Division Council, permanent steering committee member of the Europtrode conferences, and Associate Editor of RSC Advances.

Nicolas Layglon holds a Ph.D. degree in geochemistry from the University of Toulon, France. He is a specialist in trace metal cycling in coastal areas. He has developed and optimized electrochemical sensors that can be integrated into a submersible probe to *in situ* measure the bioavailable fraction of metals for phytoplankton.

David Point is specialized in the development of fast and easy to use in situ dynamic preconcentration passive samplers (DGT). He is actually working on *in situ* automated deployment platforms for passive/dynamic samplers for continuous/sequential monitoring of trace metals

Mustafa Yucel is specialized in biogeochemistry of redox sensitive metals and sulfur across pelagic and benthic low-oxygen marine environments, hydrothermal vents and deep-sea chemosynthetic ecosystems. His skills combine electrochemical and microfluidic marine chemical sensor development and in situ validation.

9. Relationship to other international programs and SCOR Working groups

TRACESAMORS will be closely linked to a broad variety of programmes and networks:

As explained in the Capacity building section, the link to international ECRs will be ensured on other international programmes and SCOR activities, particularly those topics relating to the Ocean Science Infrastructure programme. These will include (i) Current knowledge on marine biogeochemistry of trace elements and isotopes, through the GEOTRACES programme (ii) Chemical speciation, linking researchers to IAPWS/SCOR/IAPSO Joint Committee on Seawater Thermodynamic Equation of State and the MARSPEC SCOR WG145, (iii) Systems thinking approach to Marine Science, through connection to the Changing Ocean Biological Systems (COBS) to integrate those in our network studying trace micronutrients and analytical techniques to the interdisciplinary approach working with biologists and physicists, (iv) Latest robust observation field platforms, technology and communications, through connections to the Southern

Ocean Observing System (SOOS).

Association with national and European programmes via national funding would also be created to test new sensors and technologies (e.g. EMSO-RI (Laes-Huon), TNA JERICO-RI (Laes-Huon), AMT and BATS (Simon Ussher), HOT programmes). A close link with GEOTRACES programmes and planned successor programme BioGeoSCAPES will also be maintained as some of the full members are already leaders in this trace metal community (Bowie, Fietz).

Concerning the TRACEAMORS Training Workshops, we would like to link up with the POGO programme and in particular the NANO alumni programme (NF-POGO Alumni Network for Oceans past networks of students). Moreover, the POGO-SCOR Fellowship Program will help for the participation of scientists from developing countries to TRACESAMORs activities (Zitoun)

For D1: Ocean Best Practice Guide for in situ trace metal sensors and samplers, we will take advantage of the SCOR International Nutrient Working Group #147 who delivered the GOSHIP manual for best practice in performing nutrient measurements at sea.

Finally, we will advertise and communicate via our website and email dissemination lists and news from other international organizations (GEOTRACES, SCOR, AGU, EGU, ASLO, SOLAS, POGO) and look for opportunities to link with UN's Decade of Ocean Science for Sustainable Development.

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11. Appendix

For each Full Member, indicate 5 key publications related to the proposal.

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12. ACRONYMS

AGU: American Geophysical Union

AMT: Atlantic Meridional Transect

ASLO: Association for the Sciences of Limnology and Oceanography

AtlantOS: Optimizing and Enhancing the Integrated Atlantic Ocean Observing Systems

BATS: Bermuda Atlantic Time-series Study

CHEMINI: Chemical MINIaturised analyser

CLIVAR : Climate and Ocean -Variability, Predictability, and Change

COBS: Changing Ocean Biological Systems

COCA: Collaborative on Ocean Chemistry and Analysis

DGT: Diffusive Gel Thin film

ECRs: Early Career Researchers

EGU: European Geophysical Union

EMSO: European Multidisciplinary Seafloor and water column Observatory

EU-COST: European Cooperation in Science and Technology

FIA: Flow Injection Analysis

FLAIR Fellowship: Future Leaders – African Independent Research

GOOS: Global Ocean Observing System

GOSHIP: Global Ocean SHIP based hydrographic investigation program

HOT: Hawaii Ocean Time-series

IAPSO: International Association for the Physical Sciences of the Oceans

IAPWS: International Association for the Properties of Water and Steam

ICAAC: International Conference on Applied Analytical Chemistry

ICP-MS Inductively coupled mass spectrometry

IOC: Intergovernmental Oceanographic Commission

ISblue : Interdisciplinary School for the blue planet

JERICO: Joint European Research of Coastal Observatory

LOC: Lab On Chip

MARSPEC: Marine Chemical Speciation SCOR Working Group

NERC: Natural Environment Research Council

NOC: National Oceanography Center

NRCC: National Research Council Canada

NSF: National Science Foundation

OSM: Ocean Science Meeting

POGO: Partnership for the Observation of the Global Ocean

RSC: Royal Society of Chemistry

SOLAS: Surface Ocean - Lower Atmosphere Study

SOOS: Southern Ocean Observing System

TM : Trace Metals

TNA: TransNational Access

TrAC: Trends in Analytical Chemistry

US NSF: National Science Foundation