Proposal for a SCOR working group on the development of new methodologies for chemical and other branches of oceanography

Abstract

The construction of large networked observing systems and the development of a variety of autonomous vehicles have provided an unprecedented opportunity to study the ocean at spatial and temporal scales that have not been previously available to the ocean research community. However, as a result of power availability, mass and size constraints, and the limited ability to service instruments on these platforms, there are only a few parameters of interest to oceanographers that can take advantage of this expensive infrastructure. SCOR WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders was created to optimize the use of existing sensors. However, there is also an urgent need to develop new methodologies in oceanography that can meet these constraints on the development and deployment of new sensors, and a need to catalyze interactions among chemical oceanographers, analytical chemists, and ocean engineers to bring new technologies into use for ocean sensors.

The proposed SCOR working group would bring together members of the analytical chemistry, oceanography and ocean engineering communities to develop long-term collaborations across disciplinary boundaries to catalyse a fundamental shift in the analytical methodology used in chemical oceanography and allied fields.

Specifically the SCOR working group over a 4-year period would achieve the following tasks:

1) Produce and publish in a peer-reviewed journal an in-depth report providing a wide-ranging critical assessment of which new technologies in analytical chemistry might be profitably applied to the development of new measurement techniques in oceanographic research that would be compatible with the newly available observational infrastructure.
2) Identify existing funding sources within the global research community that could be targeted to support short-term exchanges of personnel between analytical chemistry and oceanographic laboratories to facilitate technology transfer.
3) Develop and submit coordinated proposals from the collaborating communities to international funding groups to facilitate an ongoing series of meetings between the groups.
4) Develop a web site to act as a clearing-house for the dissemination of information arising from tasks 1-3, to encourage new ideas and entrain new individuals into the collaborative process.

Rationale

Recognition of the need to observe the response of the ocean to climate forcing at a variety of temporal and spatial scales has led to large investments globally in the infrastructure of ocean observing systems (Clark, 2001, Cowles et al., 2010) that range from networked moorings to a variety of autonomous vehicles (Rudnick et al., 2004) that can telemeter real-time data back to shore and be used to develop and constrain oceanic models. These new platforms, however, have very severe operational constraints, such as low power availability, restricted weight capacity, limited access for servicing, etc. Currently, there are few sensors or methodologies available that can actually make measurements of oceanic properties that meet these requirements. Thus, only a few of the parameters of interest to oceanographers can be determined because current methodologies used in chemical and allied fields of oceanography are inconsistent with the constraints associated with these platforms. In order to take advantage of these new platforms it is clear that new approaches are needed to making analyte determinations in the ocean. There is thus an urgent need to catalyse a fundamental improvement in the methodologies used to determine a large number of oceanographic parameters in order to take advantage of this newly developed observational infrastructure.

Timeliness and Scientific Background

As a result of the development of new instrumentation and materials, the field of analytical chemistry, at this time, is a rapidly evolving area. While many chemical oceanographers have had a basic undergraduate training in chemistry, the inexorable increase in time since that training means that few practicing oceanographers are familiar with the latest developments in the field of analytical chemistry. As a result it is difficult, if not impossible, for chemical oceanographers to remain cognizant of fundamental improvements in the field of analytical chemistry that could be applied to the development of a new class of oceanographic methodologies. There is a need to bridge the gap between chemical oceanographers and analytical chemists; this has been recognized for a long time (Goldberg, 1988) and past suggestions to improve the measurement of carbon system parameters (among others), by bringing together oceanographers and analytical chemists (NRC, 1993; Walt and Urban, 1995) have produced tangible results. However, in rapidly changing fields the connection between the fields needs to be reinforced at regular intervals or, preferably, on a semi-continuous basis. Additionally, the advent of the new oceanographic observing infrastructure imposes requirements for miniaturisation, process control, and incorporation of instruments into pressure cases that requires engineering skills that few chemical oceanographers posses. There is therefore a need to bring together skilled individuals from these fields to focus on the development of new technologies that can fully utilise these new sampling platforms.

A recent meeting, held at the University of Hawaii, and funded by the US National Science Foundation's Chemical Oceanography and Chemicals Imaging programs,

provided an initial opportunity to bring together ~ 50 people from 14 countries representing the analytical chemistry, chemical oceanography and ocean engineering communities to initiate a dialogue amongst the communities and to identify promising technologies that might be applicable to the analytical requirements in oceanography
(see http://www.soest.hawaii.edu/oceanography/faculty/chrism/COCA/Home.html).
The meeting successfully identified a critical mass of interested individuals and ideas and has been promoted in the analytical chemistry community by one of the attendees, but this was designed as a single meeting.
(http://www.soest.hawaii.edu/oceanography/faculty/chrism/COCA/Outcomes.html)
What is needed now is a continued effort to build on the foundation of connections created at the University of Hawaii meeting, continue the dialogue, and develop a longer-term association.

Reason for SCOR

SCOR is an ideal mechanism to achieve the next stage of this process as it will allow members of that original meeting, and the extended contacts that have now been made, to entrain others in those communities into a framework that will develop longer term plans that will continue after the SCOR working group completes its terms of reference. SCOR has played an important role in improving the measurements of chemical elements in seawater from SCOR's early years, starting with SCOR WG 6 on Chemical Oceanography and most recently through SCOR WG 109 on the Biogeochemistry of Iron in Seawater. The SCOR GEOTRACES project has stimulated improvements in the measurement of many trace elements and isotopes through an extensive intercalibration process for key GEOTRACES parameters.

The specific tasks that are envisaged for this working group will create a set of publications and activities that will define the success of the working group, but which will also provide a solid foundation for a self-sustaining cross-disciplinary collaboration that specifically targets fundamental problems in oceanography and that will lead to long-lasting capacity building benefits for our field. We have also approached the International Union of Pure and Applied Chemistry (IUPAC) to invite them to co-sponsor this working group

Thus the tasks that are envisaged for the working group consist of immediately reachable goals that will then be used to develop the most promising direction for future collaborations. Since the SCOR working group is deliberative in nature it is expected that the shape of the plan resulting from the SCOR working group may differ from that originally envisaged by the NSF, or this proposal, however, that is both expected and welcomed.

SCOR is also appropriate because the original Hawaii workshop attracted participants from 14 different countries as well as several representatives from manufacturers of commercial instrumentation. Although this broad international interest was gratifying, we believe that there will be interest in developing countries

and countries with economies in transition and look forward to getting SCOR input to help entrain individuals from such places so that capacity building between the disciplines can be extended across national and economic boundaries, enriching nascent oceanographic programs in other countries. It is likely that minituarised sensor technology will eventually be much cheaper than currently available methodology and this will bring the opportunity to monitor critical chemical parameters within the economic reach of countries with limited budgets for oceanographic research and will also increase their participation in important global studies.

Working group tasks and timeline

It is proposed that the WG will have a 4-year timeline with 3 meetings amongst the Full and Associate members. Since the project is cross–disciplinary, we will hold one of the group's meetings associated with an international oceanography meeting and another associated with a chemistry meeting of similar stature. This will also allow us to advertise the existence of this initiative to other members of those communities and bring new people and ideas into the process. The final meeting would be planned to coincide with a dedicated workshop. The design of the workshop and development of a funding plan for it is one of the WG tasks (**task 3, below**).

TOR #1: Produce and publish in a peer-reviewed journal a critical assessment of which analytical chemistry technologies might be newly applied to oceanographic research.

After approval, we would write a short article announcing the formation of the WG and soliciting input and submit this to *Eos* and also to a suitable forum that is seen by the analytical chemistry community. An initial meeting in the first full year would be held to develop and to assign groups of individuals to specific topics in analytical methodology that might be applied to oceanography. The NSF-funded meeting in Hawaii developed several target areas for research that now need to undergo rigorous in-depth evaluation. As part of this process the working group would identify particular topical areas of ocean science that would benefit from the individual development areas recommended. This would highlight the immediate practical benefits that would flow to understanding oceanic processes arising from the recommended development work.

It is expected that the individuals who take on this **first task** would use networks within their communities to evaluate current state of the art, inherent limitations of techniques, potential solutions to problems associated with oceanographic implementation and a list of scientific applications that the new technologies would enable. It is expected that this task will require 1 year. We would plan to publish

the report that would be assembled from this task in the peer-reviewed literature. Since there is little overlap between the analytical chemistry and oceanography literature we would probably plan to publish in the oceanography literature but arrange for simultaneous publicising of the work in the analytical chemistry journals though articles tailored to the interests of this community. This decision would be made by the working group members.

TOR #2: Identify existing funding sources within the global research community that could be targeted to support short-term exchanges of personnel between analytical chemistry and oceanographic laboratories to facilitate technology transfer.

The **second task** that members would be asked to undertake simultaneously is to identify within their disciplines and countries, sources of funding that might be approached to support exchange of individuals between laboratories to enable technology transfer and understanding between the fields. We would also identify funding that could be used to host future training workshops that could be used to enable capacity building in under-represented regions.

It is expected that at least one video conference would be scheduled during this period to deal with issues arising and to modify topics if deemed appropriate.

A second full meeting in the group's year 2 would assess progress on the first and second terms of reference.

TOR #3: Develop and submit coordinated proposals from the collaborating communities to international funding groups to facilitate an ongoing series of meetings between the groups.

The second meeting will also undertake the third task:

The **third task** of the working group would be to identify and develop collaborative proposals to a variety of funding agencies to support a series of workshops that would become the next stage of the collaboration. It would be intended that the initial workshop would be near the end of the life of the SCOR working group and the final meeting of the SCOR working group would be at this meeting, signaling a transition of the effort from a SCOR-supported working group to a self-sustaining initiative with its own goals and membership.

TOR #4: Develop a web site to act as a clearing-house for the dissemination of information arising from tasks 1-3, to encourage new ideas and entrain new individuals into the collaborative process.

The final, **fourth task** of the working group, which would proceed in tandem with the first three would be to develop a web-based resource for individuals who are interested in participating in these developments by:

1) Disseminating the results of **task 1** widely for comment and to encourage individuals to take up research in these areas,
2) Provide a forum for discussion of **task 1** ideas and suggestion of others.
3) Advertise the availability and deadlines for grant applications identified by **task 2**.
4) Act as a matchmaker where possible to bring together individuals from the various communities to develop research proposals or pursue ideas under **task 1 & 2.**
5) Advertise and develop the workshop under **task 3** that would show progress in and encourage new developments.

Working group membership

The working group membership is designed to cover all of the three disciplines and also to ensure participation by younger scientists who will eventually be the standard bearers of this initiative. At this stage we have identified individuals from the pool of people who attended the University of Hawaii workshop. The expertise in ocean research and advanced analytical instrumentation tends to be largely confined to a few wealthy countries, although we are proposing two Full Members from developing countries. In addition, since capacity building would be one of the goals of this working group, with SCOR's assistance we would endeavour to identify individuals from these places, and would seek SCOR's assistance in funding their participation in the meetings through SCOR's fund for travel of developing country scientists. The proposed members would create good connections between this working group and other relevant SCOR working groups, as well as with the SCOR-sponsored GEOTRACES project. The work of this group will benefit the field of chemical oceanography mostly after GEOTRACES is completed and GEOTRACES does not fund this kind of activity.

Expertise
O = Oceanography
AC = Analytical Chemistry
OE = Ocean Engineering

Full members

O Chris Measures (USA), *Chair* – Co-chair of GEOTRACES Data Management Committee and expert on measurement of iron and aluminum in the ocean.

AC Sandy Dasgupta (USA) Editor Analytica Chimica Acta and expert in development of miniature detectors and automated instrumentation, expert in membrane systems and ion chromatography.

AC Paul Worsfold (UK) Past President, Analytical Division of the Royal Society of Chemistry, current Chair, Division of Analytical Chemistry, The European

Association of Chemical and Molecular Sciences (EuCheMS) and expert in research at the interface of analytical chemistry and oceanography.

OE Matt Mowlem (UK) Expert in development of low cost high performance electrochemical, lab on a chip and optical sensors for nutrients, metals, gasses and carbonate system parameters.

O Kristin Buck (Bermuda) – Co-Chair of SCOR WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean and expert in ligand chemistry.

O Sunil Singh (India) – Leader of GEOTRACES India, expert in the development of measurement techniques of various stable, radiogenic and radioactive isotopes and trace elements in the ocean.

AC Spas Kolev (Australia) Expert in aquatic analysis and monitoring of analytes at trace levels based on the application of advanced sampling and preconcentration techniques.

AC Raquel Mesquita (Portugal) Expert in developing robust, versatile and miniaturized automatic flow systems for studying water quality in dynamic systems

AC Jian Ma (China-Beijing) Background in both analytical chemistry and the oceanography with expertise in the application of solid phase extraction to ocean waters

O/AC Suenghee Han (Korea) Expert in mercury determination in coastal waters and sediments

Associate members

O Ed Boyle (USA) – Co-chair of GEOTRACES project and expert on measurement of iron and iron isotopes and lead and lead isotopes in the ocean.

O Maeve Lohan (UK) - Co-Chair of SCOR WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean, member of GEOTRACES Scientific Steering Committee, and expert in ligand chemistry.

OE Ken Johnson (USA) – Co-Chair of SCOR WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders, chemical oceanographer who has become an expert in instrument development, and member of the committee that produced the 1993 NRC report cited herein.

OE Carsten Frank (Germany) Expert in developing chemical analyzers and sensors for oceanographic applications.

OE Carole Barus (France) Expert in development of low energy electrochemical sensors for ocean use that generate reagents in situ.

AC Steven Soper (USA) Expert in developing minituarised chemical analysis systems, micro and nanofabrication, and LOC systems for field monitoring of both organic and inorganic ions.

AC Gary Heiftje (USA) Expert in the development of novel instrumentation for mass and optical spectrometry and elemental analysis.

O Tung Yuan Ho (China-Taipei) – Member of the GEOTRACES Scientific Steering Committee. Expert in marine trace metal biogeochemistry, trace metal analysis in seawater

- George Luther (USA) – Member of SCOR WG 135 on Hydrothermal Energy Transfer and its Impact on Ocean Carbon Cycles, and expert on development and measurements of sedimentary geochemistry using microelectrodes. Also a physical chemist.

References

Cowles, T., J. Delaney, J. Orcutt, and R.Weller, The Ocean Observatories Initiative: Sustained Ocean Observing Across a Range of Spatial Scales, Marine Technology Society Journal, Volume 44, Number 6, November/December 2010 , pp. 54-64(11)

Clark, H.L., New seafloor observatory networks in support of ocean science research, *OCEANS, 2001. MTS/IEEE Conference and Exhibition* , vol.1, no., pp.245,250 vol.1, 2001 doi: 10.1109/OCEANS.2001.968733

Goldberg, E.D., (editor), ChemRawn: Modern chemistry and chemical technology applied to the ocean and its resources. Appl. Geochem., 3, 1, 1988.

NRC. Applications of Analytical Chemistry to Oceanic Carbon Cycle Studies Washington, DC: The National Academies Press, 1993

Rudnick, D. L., R.E. Davis, C.C. Eriksen, D.M. Fratantoni, M.J. Perry, Underwater Gliders for Ocean Research, Marine Technology Society Journal, Volume 38, Number 2, 2004 , pp. 73-84(12)

Walt, D.R., and Urban, E., New sensor technology for in situ measurements of ocean chemistry. Oceanography, 8, 24, 1995.