Towards a robust and sustained production and global supply of reference materials for the seawater carbonate system

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Abstract

A robust and sustained production and global supply of certified reference materials (CRMs) for the seawater carbonate system is critical for ocean carbon research and climate science. The availability and consistent use of CRMs over the past decades have enabled comparable measurements of seawater total alkalinity, dissolved inorganic carbon, and pH with known quality, which underpin our ability to assess changes in the ocean carbon cycle and trends of ocean acidification. The COVID-19 pandemic highlighted the fragility of the current global production and supply system of primary CRMs, which is dependent on one unique lab at the Scripps Institution of Oceanography, USA. The dramatic reduction in CRM supply from the USA forced many research laboratories to produce secondary (in-house) standards, a challenging task since there are no standard protocols for their production, thus resulting in non-uniform production and compliance measures. Given the current inability to produce the CRMs elsewhere, a more robust distribution and production scheme has been proposed by the international community of ocean carbon researchers, supported by the International Ocean Carbon Coordination Project (IOCCP), the U.S. Interagency Working Group on Ocean Acidification, and the Integrated Carbon Observation System - Ocean Thematic Centre (ICOS-OTC) among others. A proposed solution to create a more resilient production of CRMs is the production of primary CRMs in an accredited lab and of secondary reference materials (ultimately dependent on the values of the primary reference materials - CRMs) among regional hubs distributed across multiple continents. Reduced costs (e.g. of shipping) and greater production capacity enabled by regional hubs would ensure consistent use of RMs by the rapidly growing ocean acidification and ocean carbon dioxide removal communities. The ultimate goal for a resilient CRM production would be to reduce the reliance on just one lab producing CRMs. The successful use of RMs by the ocean observing community depends on the robustness of the production system. To this end, there is a need to develop Standard Operating Procedures (SOPs) for producing secondary reference materials for the seawater carbonate system which include guidance on establishing traceability using primary CRMs and constructing the total uncertainty budget with consideration of batch homogeneity and stability. Close collaborations with national metrology labs across the globe are indispensable in this process.

Seawater carbonate system RMs are critical for ocean carbon science & policy

The availability and consistent use of seawater reference materials with assigned values for total dissolved inorganic carbon and total alkalinity over the past three decades have enabled comparable measurements of seawater total alkalinity, total dissolved inorganic carbon, and pH with known quality for millions of measures taken by hundreds of scientists underpinning our ability to assess changes in the ocean carbon cycle and quantify trends in ocean acidification.

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Global access to seawater carbon RMs is vulnerable

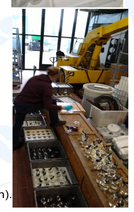
A single production and supply centre at Scripps Institution of Oceanography (USA) provides RM's and other reagents needed for ocean carbon measurements:

- Total alkalinity (TA)
- Total dissolved inorganic carbon (DIC)
- Tris buffer for pH
- Standardized HCl (for TA titrations)

https://www.science.org/content/article/world-s-only-source-critical-seawater-samples-could-dry

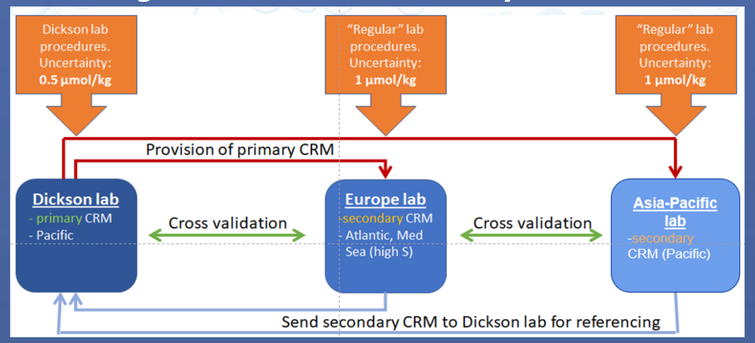
Production crisis caused by the COVID pandemic

- The dramatic reduction in CRMs supply during the COVID-19 pandemic forced laboratories to produce secondary sub-standards, resulting in non-uniform production and compliance measures/uncertainty.
- Secondary sub-standards are currently produced in Japan, China, Australia, and South America for in-house use, and in Europe, ICOS produced them for the ICOS network (Figures on the right).
- ICOS produced stable secondary sub-standards but their certification still needs work to not compromise the quality of CO_2 measurements.



Pictures from Tobias Steinhoff (ICOS RMs production).

Possible global ocean carbon RM system structure



Local hubs could significantly decrease costs for **logistics** and **distribution**.

Role of national metrology labs and expert labs

Measurement Services	Consultation/ Guidance	New CRM Development
• Develop capability within NMI's to produce the quality seawater TA and DIC measurements. • For example, NIST (USA) is working to establish the capabilities to certify seawater for total alkalinity and total dissolved inorganic carbon.	• Providing guidance to develop standard operating procedures for secondary RM's which also include methods for estimating uncertainty of secondary batches.	• Develop new types of CRMs for other carbon system parameters, e.g. for pH. • Development methods to standardize isotopic values in the marine CO2 system. • Development of cheaper and more time efficient methods

Next steps:

- Drafting a position paper to promote the vision for a global distributed system for production and supply of seawater CRMs.
- Establishing common procedures and best practices for quantifying uncertainty in secondary RMs.

Achieving a robust and sustained production and global supply of Certified Reference Materials (CRMs) for the seawater carbonate system is critical for the sustainability and reliability of both the ocean carbon research and climate science.