Case for SOCAT as an integral part of the value chain advising UNFCCC on ocean CO_2 uptake

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Executive Summary: The ocean absorbs approximately 25 % of the CO_2 (carbon dioxide) we emit to the atmosphere. This slows the rate of climate change substantially and gives us more time to put in place mitigation and adaptation measures. However, data-based estimates exceed model-based estimates of net ocean CO_2 uptake, meaning that the evolution of the ocean CO_2 sink and hence the cost of mitigation and adaptation measures are uncertain. For this reason, scientists have established a near real-time system to measure the ocean sink strength alongside similar systems to assess CO_2 emissions and the land sink. This system exists, consisting of a series of actions referred to as a value chain, linking (1) in water observations, (2) data synthesis (Fig. 1a), (3) data analysis, (4) integration of sink strength estimates into the Global Carbon Budget and (5) annual reporting of these to the Conference of the Parties (COP) (Fig 1b, numbers indicate levels in the value chain).

The crucial second stage of this value chain is the community-led Surface Ocean CO_2 Atlas (SOCAT, www.socat.info), an open access synthesis of *in situ* surface ocean CO_2 observations from across the world ocean (Fig. 1a). In recent years operations ceased in SOCAT's second regional hub, which has historically been based in Europe. This threatens the inclusion of estimates of ocean CO_2 uptake in future Global Carbon Budgets and our ability to develop climate policy in full knowledge of the ocean's role in controlling climate.

We request that funding agencies work with SOCAT to *a) provide emergency support over 2024-25 to ensure that the next two Global Carbon Budgets can contain an ocean element and b) from 2026 transition SOCAT into a sustainable funding space based on nations underwriting its core elements, national hubs, a subscription-based model, or a mix of these.*

Background: Observations made by multiple research groups are assembled in SOCAT (Fig. 1a). They have shown that the ocean takes up a quarter of the CO_2 emissions from human activity, thus helping to mitigate climate change. The observations demonstrate that the strength of this uptake varies from year-to-year and decade-to-decade. The evolution of ocean CO_2 uptake upon society's move towards net-zero CO_2 emissions is highly uncertain. Increasingly the ocean is being looked upon for carbon offsetting schemes, creating an urgent need for monitoring, reporting and verification that does not exist. The importance of measuring ocean CO_2 uptake is well recognized by efforts such as the COP of the United Nations Framework Convention on Climate Change (UNFCCC), the UN Global Stocktake and the World Meteorological Organization's (WMO) Global Greenhouse Gas Watch (GGGW).

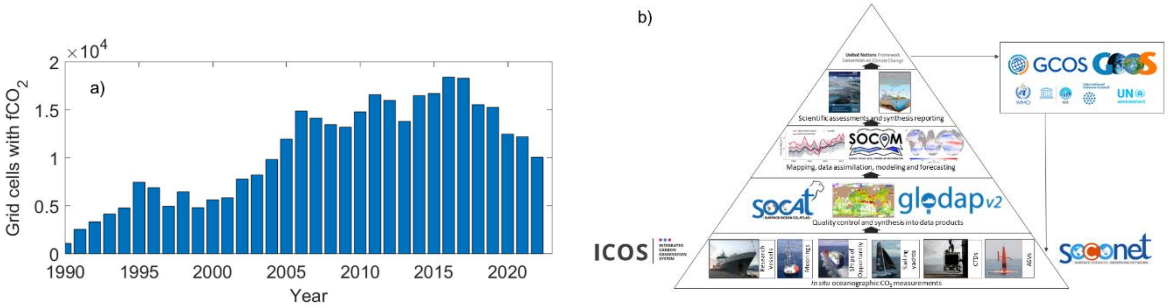

Fig. 1. a) Number of monthly grid cells with surface ocean fCO_2 values for each year in SOCATv2023. b) The value chain of in situ inorganic carbon measurements of the ocean (after Guidi et al., 2020).

Current structure, governance and funding: The SOCAT synthesis is a community effort with more than one hundred scientific contributors around the world that operates to a fixed annual schedule. Data providers submit data sets by mid-January (Fig. 2a). Scientists carry out expert (secondary) quality control by March. The updated SOCAT product is made public in June, allowing analysis to occur and ocean CO_2 uptake to be reported to the COP in November by the Global Carbon Budget. SOCAT is coordinated by a global group, chaired in the UK, by Dorothee Bakker at the University of East Anglia. This group sets strategy and oversees the regional hubs which provide support for data upload, expert quality control and product release, while maintaining and innovating the SOCAT software platform and website (Fig. 2a). Many of the above actions do not have dedicated financial support. The SOCAT computing infrastructure is in urgent need of modernization as well as adapting to the evolving needs of scientists and users.

Until recently SOCAT had two regional hubs, funded by the European Union, Norway and the US. However, its European regional hub was closed in 2022 and as a result the annual releases now rely on a single person at the NOAA's (National Oceanic and Atmospheric Administration) Pacific Marine Environmental Laboratory for support. This situation represents a critical single point of failure, is not sustainable and there is a real risk that SOCAT is terminated entirely.

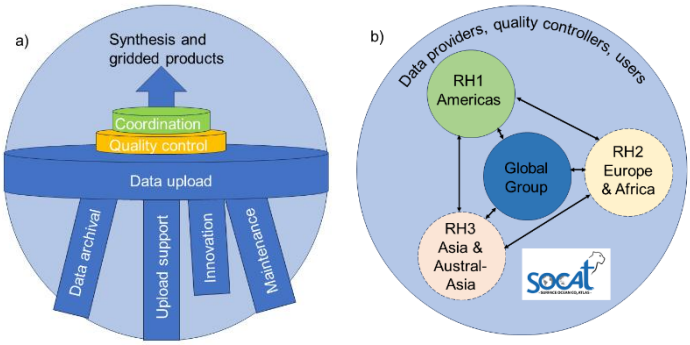

Fig. 2. a) Annual SOCAT activities with data upload (by mid-January), expert quality control (by March), coordination and product publication (in June). Regional hubs support these activities, while maintaining and innovating the infrastructure. b) Possible future SOCAT structure with scientists and users, a global group and regional hubs (RH).

Future evolution of SOCAT: The majority of the effort required to run SOCAT is in a) the submission of data by scientists collecting data and b) the expert quality control they deliver. However, there are significant central costs, estimated as 3 FTE per year, involved in developing and maintaining of software systems (1.5 FTE), supporting and troubleshooting the submission process (1 FTE) and coordinating the annual process including liaising with the Global Carbon Project (0.5 FTE). Of these only 1 FTE are currently directly supported. This is below the level required and leads to an erosion of the basic data infrastructure. *Our first request is that money be made available to support coordination (ca 0.5 FTE per year) and staff already skilled in supporting SOCAT over the next 2 years (ca 1 FTE per year).*

Whilst these actions would solve the immediate crisis, they would not give the system sufficient resilience to guarantee the long-term inclusion of the ocean CO_2 sink in future Global Carbon Budgets. Ultimately, we consider that a mechanism is required to share these central costs across interested nations. This could be via all interested nations providing central support in national hubs or allocating funding to an international effort based on three regional hubs, including potentially one for the Arctic (Fig. 2b). Working out the details of this future model will take time and our second request is therefore that *interested funding agencies work over 2024-25 to support the design of this system and its implementation in 2026, including allocating secure funding to scientists involved in data collection and quality control.*

Reference: Guidi et al. (2020) EMB Future Science Brief 6, doi:10.5281/zenodo.3755793