SOCONET Network Attribute Report

1. Overview of SOCONET

Over the past two and a half decades automated surface water CO_2 observations have provided data for climatologies and monthly estimates of global air-sea CO_2 fluxes. They have been used to create maps of changing surface ocean pCO_2 levels and its effect on ocean acidification. Moreover, the measurements have yielded numerous insights on the environmental controls on surface ocean carbon chemistry. The observations have resulted in key publications ranging in topics from aquatic chemistry, and process level understanding, to global constraints on the carbon cycle. A tremendous advance took place when data from dozens of research groups were collated and distributed as part of the Surface Ocean Carbon Atlas (SOCAT), a volunteer effort initiated by the International Ocean Carbon Coordination Project (IOCCP). SOCAT updates occur annually since 2011.

The next step is to improve coordination at the measurement level. Formalized surface ocean CO_2 observing network will facilitate interactions between participating groups, assure high quality data in uniform format, and provide an efficient means of tracking platforms. The Surface Ocean CO_2 Observing Network (SOCONET) will be global network formed by consolidating efforts of around 20 groups engaged in performing quality surface water CO_2 measurements for more than two decades in most cases. It is recognized that formalizing SOCONET has its challenges and opportunities, however the latter significantly outweigh the former. The challenges are for the groups to agree to act as a single entity following agreed upon best practices, tracking of data, data submission, and future goals. The advantages are many: the provision of timely data to determine air-sea CO_2 fluxes and surface water trends for assessments is critical for our society; proper exposure to the groups involved in the effort, including anticipated product development and advocacy should increase the ability to sustain funding; serving metadata and performing platform tracking through OceanOPS will provide important exposure and linkages to other operational efforts; and more.

The initial objectives of formalized SOCONET can be summarized as:

- To create a network of partners with proven track record of operations who will follow agreed upon procedures to obtain quality measurements.
- The CO_2 measurements should meet agreed accuracy targets and partners will document how these targets are met and verified.
- Near-real-time platform tracking will be performed.
- Metrics on data quality and quantity will be provided on an annual basis.
- Quality assessment intercomparison exercises will be performed to assure that standards are met.

- An agreement will be reached concerning how often and what parts of the systems need to be checked, and when to perform calibrations for different types of platforms (before installation, during operation, after recovery of system)
- Mutual aid, exchange and assistance will be provided within the group dealing with technical issues in operations.
- Scientific outreach will be encouraged focusing on elevating quality and providing assistance to other groups in sustaining quality observations with a goal to entrain additional platforms into the network.
- SOCONET members will provide guidance to the community on new platforms, measurements, and protocols with a vision towards implementing a biogeochemical network and support marine boundary layer atmospheric measurements.
- The network participants will provide resources towards implementing tracking platforms through OceanOPS and other agreed upon mutual services.

The SOCONET goals and activities are well aligned with the GOOS OCG Network Criteria (see Table 1 below), and SOCONET is committed to working towards OCG data, metadata and best practices requirements. This includes implementation of the OCG data strategy, as well as ensuring that required metadata is available at OceanOPS in near-real time.

2. **Alignment with OCG Attributes**

OCG Network Attributes	SOCONET alignment
Global in Scale	Global coverage with ships, moorings, uncrewed surface vehicles (USVs).
Observes one or more EOVs/ECVs	Inorganic Carbon EOV/ECV
Observations are sustained	Observations date back to 1957 and more than 43 million observations were collected to date.
Community of Practice	Based on community input received before, during and after the series of Workshops on Surface Ocean pCO2 Observations, Synthesis and Data Products held in late 2023, a clear pathway to creating of the SOCONET Steering Committee (SC) was established as well as governance and technical support functions were defined and relevant implementation steps were identified and are being initiated.
Maintains network missions/targets	SOCONET Implementation Plan will include specific targets relevant for the mission which is well developed and briefly described in this document. Annual reporting against those targets is envisaged.

Delivers data that are free, open and available in timely manner	Data collected on SOCONET will continue to be submitted through the established SOCAT data system. Data are freely and openly available through SOCAT as well as country-specific National Data Centers wherever they exist. ERDDAP services are available for annual SOCAT releases.
Ensures metadata quality and delivery	Metadata is collected and included with SOCAT data product and will be augmented, if needed, to be compliant with with OceanOPS metadata requirements.
Develops Standards and Best Practices	Several standards and best practices have been developed and implemented over the two and a half decades and many are used across the network participants. As part of SOCONET Implementation Plan, they will be collated, updated and disseminated through the the IOC Ocean Best Practices System (OBPS) wherever feasible.
Undertakes capacity development	Scientific outreach is encouraged focusing on elevating quality and providing assistance to disadvantaged groups to entrain additional platforms into the network. Where possible SOCONET members provide guidance to the community on new platforms, measurements, and protocols.
Environmental stewardship	SOCONET observations are taken in large proportion from commercial vessels. The SOCONET SC will work to assess the current environmental stewardship strategies of commercial partners and if/where feasible co-develop an environmental stewardship capacity development activities aimed at reductions of carbon footprint of SOCONET.

Table 1. SOCONET alignment with OCG Network Criteria.

3. Value Proposition: Unique value proposition that SOCONET brings to GOOS and how it complements existing networks.

A formalized and coordinated Surface Ocean CO2 Observing Network (SOCONET) is designed to be the backbone of constraining the understanding of the global surface ocean CO2 fields and air-sea CO2 flux. SOCONET-borne measurements allow proper incorporation of ocean sinks in global carbon assessments and stocktakes, the evaluation of the effectiveness of planned mitigation actions, and monitoring, reporting and verification (MRV) of marine carbon dioxide removal (m-CDR) interventions. A uniquely designed and distributed SOCONET will aim to create monthly surface ocean CO2 fields and air-sea CO2 flux maps that help in assessing surface ocean health as

it pertains to ocean acidification; and to quantify ocean mitigation potential to reduce atmospheric CO2 increases.

Figure 1 below provides a visual description of how SOCONET fits into the value chain of the surface ocean carbon information delivery. The collection of surface ocean pCO2 data is currently performed on ocean platforms that are already part of the GOOS OCG global in situ networks. SOCONET is a thematic, cross-platform EOV-based network, that will work seamlessly with existing OCG networks such as GO-SHIP, SOOP, and OceanSITES and enhance their ability to provide key surface pCO_2 information into global assessments. The SOCONET Steering Committee and the IOCCP will also be responsible for liaising with other initiatives that SOCONET plays a role in, such as the WMO Global Greenhouse Gas Watch, GOA-ON and other.
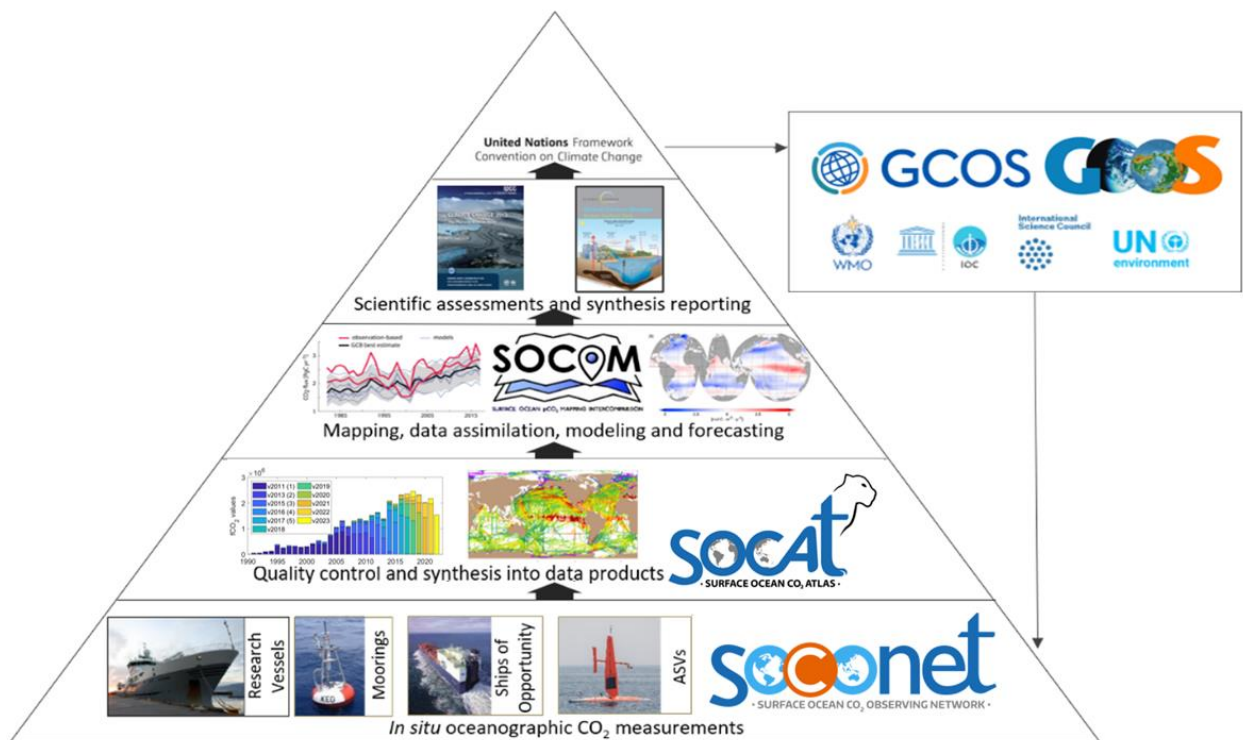

Figure 1. The Value Chain of Surface Ocean CO_2 Measurements. Modified from Guidi et al. (2020) Big Data in Marine Science, EMB Future Science Brief 6, 10.5281/zenodo.3755793.

4. **Network opportunity and sustainability: SOCONET's plans for sustainability and growth as an emerging network?**

During workshops on Surface Ocean pCO_2 Observations, Synthesis and Data Products held in November 2023 at the Flanders Marine Institute, Oostend, Belgium, attendees identified several

next steps required to ensure the sustainability and growth of SOCONET. Creating a SOCONET Steering Committee (SC) is the first priority. The SOCONET SC and the IOCCP (GOOS Biogeochemistry Panel) will then develop an Implementation Plan for SOCONET. Priority areas of work identified during the November 2023 workshops that will likely require establishment of subcommittees or working groups include: standards and best practices, training and capacity building, and satellite community collaboration and partnerships.

Successful development and implementation of the steps listed above will provide the following anticipated benefits to individual operators and SOCONET as a whole:

- Increased visibility and identity of participants and their efforts, reinforcement of the importance of sustained observations,
- Serving metadata and performing platform tracking through OceanOPS will provide important exposure and linkages to other operational efforts,
- Development and/or refinement of a common set of standards and best practices,
- Provision of training, education and capacity building efforts, encouraging countries and regions to start measuring surface ocean CO_2,
- A coherent vision for sustained surface ocean CO_2 measurements as part of a global integrated observing syste,
- Stronger contribution to data management, quality control and data products (streamlined output of data releases, etc.).
- Connectivity to other networks (e.g. help in recruitment of platforms),
- Targeting critical data gaps and determination of global priorities in gaps filling,
- Improved network utility, such as increased effort towards atmospheric CO_2 measurements from ships.

Securing financial assistance to the OceanOPS office for technical coordination and monitoring tasks, and to the IOCCP for coordination of governance, strategy development and secretariat support is another important area of focus for the network's SC. In fact, short term funds were secured in late 2023 by US NOAA Global Ocean Monitoring and Observing Program and were provided to both OceanOPS and IOCCP to implement initial tasks in preparation for formal recognition of SOCONET as GOOS OCG Network. Further, an application to the EU Horizon Europe call has been submitted, including mid-term (48 months) funding support for 1 FTE for SOCONET (0.75 FTE Technical Support at OceanOPS and 0.25 FTE Coordination at IOCCP) for years 2025-2028. If successful, this funding source would account for 50% of personnel needs for SOCONET for technical and governance coordination.