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Audit: State of Europe's surface ocean CO_2 observations

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Europe's leading ocean carbon models and data products rest on an increasingly fragile and uneven observational base.

High-accuracy surface ocean CO_2 observations underpin the chain from SOCAT to the Global Carbon Budget, IPCC assessments, and climate policy. Reliability depends on the quality, continuity, and coverage of the underlying measurements. This first audit assesses Europe's ability to observe and independently assess ocean CO_2, guiding the strengthening of European ocean observation.

How to read the audit: results are assessed at global, European, regional-sea and country levels. Metric-specific datasets and comparison periods are shown beside each result group. Traffic lights indicate **improvement**, **stability** or **deterioration** against thresholds defined in the audit. SOCAT metrics used flags A-D (estimated uncertainty <= 5 µatm), flag E is excluded

Audit's main findings

Traffic-light assessment of the surface-ocean carbon value chain:



GLOBAL

SOCAT v2025: 2022–23 vs 2015–19

🟡 **Spatial coverage observations**	−24% monthly gridded cells
🔴 **Number of observations**	+4%, but shifting towards coastal waters

GCB 2025: 2020–24 vs 2015–19

🔴 **Estimated spread data products**	0.30 → 0.46 Pg C / yr
🟡 **Model–product gap**	0.57 → 0.61 Pg C / yr

EUROPEAN CONTRIBUTION

2025 vs 2015–19

🟡 **SOCAT hub**	Not operational; single point of failure

GCB 2025

🟢 **Data products**	5 of 9 in the 2025 Global Carbon Budget
🟢 **Ocean models**	7 of 10 in the 2025 Global Carbon Budget

SOCAT v2025: 2022–23 vs 2015–19

🔴 **Reporting countries**	9 → 5 European countries

REGIONAL SEAS

Annual SOCAT A–D observations: 2022–23 mean vs 2015–19 mean

🟢 **North-East Atlantic**	+15%
🟢 **Baltic Sea**	+165%
🔴 **Black Sea**	No observations since 2016
🔴 **Mediterranean Sea**	Persistently under-sampled
🔴 **Southern Ocean**	−53%

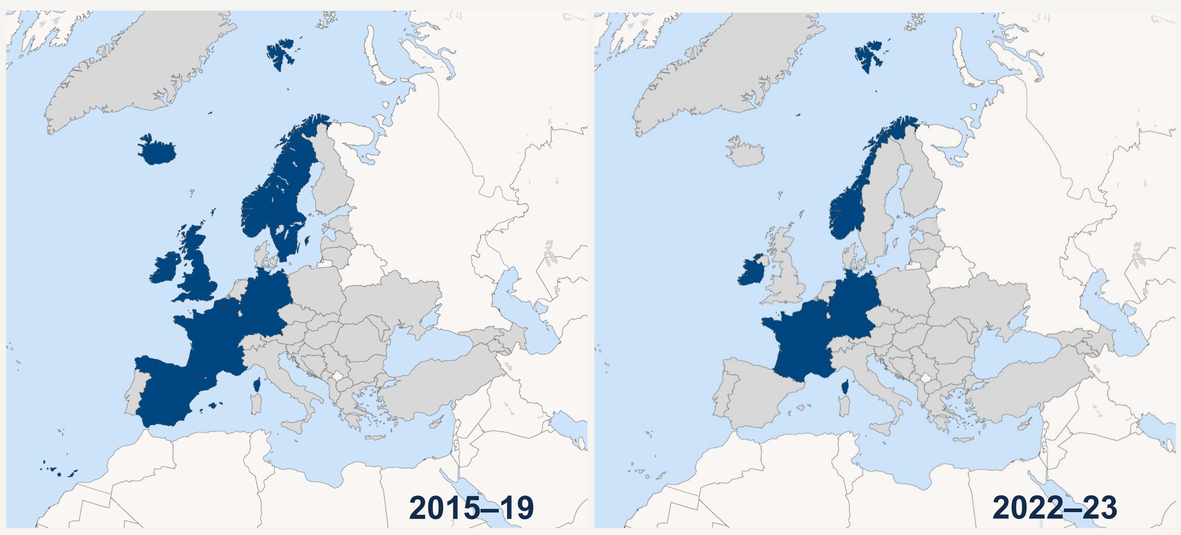
Recommendations

Strengthening every link in Europe's ocean CO_2 chain:

1. **Invest in under-observed and strategically critical regions**
   Mediterranean Sea, Black Sea, North-East Atlantic, and Southern Ocean.
2. **Expand Europe's observing capability**
   More high-accuracy surface ocean CO_2 systems deployed, from research vessels and commercial fleets to fixed installations.
3. **Secure continuous and timely data flows**
   Funding and reporting incentives for all operational platforms, treating CO_2 measurements as routine maritime operations.
4. **Re-establish a European SOCAT hub**
   Embedded in existing European ocean observing infrastructure for long-term stewardship, and connected with major initiatives
5. **Maintain leadership in data products and modelling**
   Sustained investment in European teams, modelling centres and intercomparison efforts across ocean CO_2 data products.
6. **Institutionalise the audit**
   An annual, transparent review of Europe's ocean CO_2 monitoring, expanded to cover regions such as the Arctic.
7. **Embed ocean CO_2 in European policy**
   Ocean CO_2 observations linked to European climate strategies and ocean governance, including the EU Ocean Pact and its OceanEye initiative.

Europe's observing base is narrowing

Countries contributing medium- to high-quality observations to SOCAT and the Global Carbon Budget have nearly halved:



Read the full audit:

Explore trends in Europe's surface ocean CO_2 observing system, from measurement coverage and data continuity to regional gaps and implications for data products and models.

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