

# Linking Oxygen and Carbon Uptake with the Meridional Overturning Circulation Using a Transport Mooring Array

By Dariia Atamanchuk, Jaime Palter, Hilary Palevsky, Isabela Le Bras, Jannes Koelling, and David Nicholson

The Atlantic Meridional Overturning Circulation (AMOC) is a system of ocean currents that transports warm, salty water poleward from the tropics to the North Atlantic. Its structure and strength are monitored at several latitudes by mooring arrays installed by the international ocean sciences community. While the main motivation for deploying these mooring arrays is to understand the AMOC's influence on Northern Hemisphere climate, the circulation system also plays a crucial role in distributing oxygen ( $O_2$ ) and carbon dioxide ( $CO_2$ ) throughout the global ocean. By adding  $O_2$  sensors to several of the moorings at 53°N–60°N (Figure 1) in the western Labrador Sea, Koelling et al. (2021) demonstrated that the formation of deep water, in which the AMOC brings surface water to the deep ocean, is important for supplying the oxygen consumed by deep-ocean ecosystems throughout the North Atlantic. Additionally, variability in the deep-water formation has been linked to changes in the amount of anthropogenic  $CO_2$  stored in the subpolar ocean (Raimondi et al., 2021). These studies, using data collected during research cruises and a small number of moored sensors, showed that deep-water formation and the AMOC are key to oxygen and carbon cycles in the North Atlantic. However, the common assumption that the magnitude and variability of  $O_2$  and  $CO_2$  uptake by the ocean are tied to the dynamics of the AMOC has never been evaluated on the basis of direct observations.

The Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP) takes on this challenge. GOHSNAP is a US National Science Foundation funded and international collaborative effort to collect the observations necessary to relate the ocean uptake of carbon and oxygen to the ocean circulation in the Atlantic. Linking oxygen and carbon cycling to the knowledge of AMOC will have three important outcomes. First, it will aid in reconstructing the past variability in oxygen and carbon by leveraging decades-long multinational observations of AMOC. Second, it provides an opportunity to “take

the ocean's pulse,” record and understand the uptake and transport of  $O_2$  and  $CO_2$  right now, and more robustly predict future changes. Third, supplemented by the observations from the SeaCycler mooring in the central Labrador Sea (Atamanchuk et al., 2020) and the Biogeochemical Argo program in the region, GOHSNAP will provide unique information on the contemporary carbon cycle, including linkages between the Labrador Sea and the adjacent basins.

GOHSNAP has benefited from close collaboration with international partners to add over 30 dissolved gas sensors to the OSNAP (Overturning in the Subpolar North Atlantic Program) mooring array, joining about 20 sensors previously deployed by a Canadian/German collaboration in the western Labrador Sea (Figure 1). In 2020, the Woods Hole Oceanographic Institution added another 25 sensors to monitor the Irminger Current. Collectively, these 70 sensors will enable quantification of the full-depth transport of oxygen into and out of the Labrador Sea and provide insights into the  $CO_2$  uptake and transport in the region.

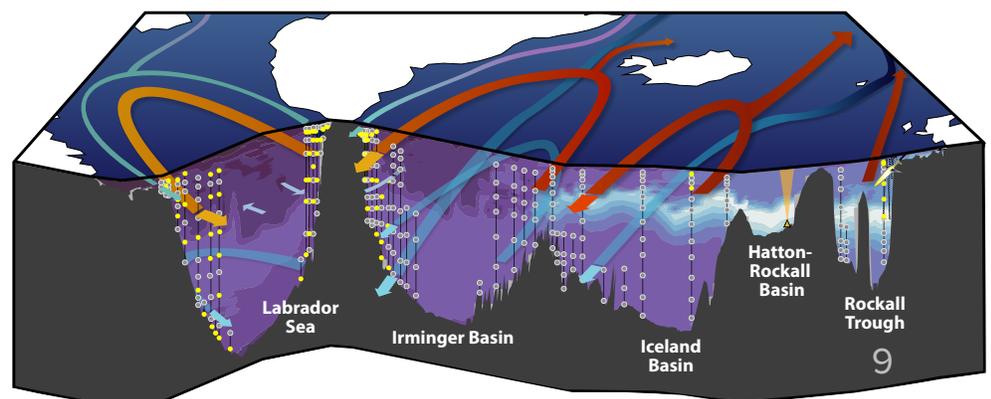
The ongoing effort to expand direct observations of oxygen and carbon by adding to the existing mooring array is a prime example of how oceanographers can investigate interrelated oceanic processes through international collaborations to efficiently advance research priorities that cross geographic and disciplinary boundaries.

## REFERENCES

- Atamanchuk, D., J. Koelling, U. Send, and D.W.R. Wallace. 2020. Rapid transfer of oxygen to the deep ocean mediated by bubbles. *Nature Geoscience* 13:232–237, <https://doi.org/10.1038/s41561-020-0532-2>.
- Koelling, J., D. Atamanchuk, J. Karstensen, P. Handmann, and D.W.R. Wallace. 2021. Oxygen export to the deep ocean following Labrador Sea Water formation. *Biogeosciences*, <https://doi.org/10.5194/bg-2021-185>, in review.
- Raimondi, L., T. Tanhua, K. Azetsu-Scott, I. Yashayaev, and D.W.R. Wallace. 2021. A 30-year time series of transient tracer-based estimates of anthropogenic carbon in the Central Labrador Sea. *Journal of Geophysical Research: Oceans* 126:e2020JC017092, <https://doi.org/10.1029/2020JC017092>.

ARTICLE DOI: <https://doi.org/10.5670/oceanog.2021.supplement.02-03>

FIGURE 1. Schematic of the circulation in the subpolar North Atlantic (colored arrows) and the original locations of OSNAP moorings (black lines) at 53°N–60°N containing sensors that simultaneously measure salinity, temperature, and depth at various depths (gray circles). The locations of added GOHSNAP and partner oxygen sensors are in yellow. The shading on the front face of the section represents oxygen concentration—white colors below 250  $\mu M$  and dark purple above 300  $\mu M$ —and demonstrates how ventilation enriches the water column in oxygen along the pathway of the cyclonic circulation. Credit: Penny Holliday, NOC



## AUTHORS

**Dariia Atamanchuk** ([dariia.atamanchuk@dal.ca](mailto:dariia.atamanchuk@dal.ca)), Department of Oceanography, Dalhousie University, Canada. **Jaime Palter**, Graduate School of Oceanography, University of Rhode Island, USA. **Hilary Palevsky**, Department of Earth and Environmental Sciences, Boston College, USA. **Isabela Le Bras**, Woods Hole Oceanographic Institution, USA. **Jannes Koelling**, Department of Oceanography, Dalhousie University, Canada. **David Nicholson**, Woods Hole Oceanographic Institution, USA.

## ARTICLE CITATION

Atamanchuk, D., J. Palter, H. Palevsky, I. Le Bras, J. Koelling, and D. Nicholson. 2021. Linking oxygen and carbon uptake with the meridional overturning circulation using a transport mooring array. P. 9 in *Frontiers in Ocean Observing: Documenting Ecosystems, Understanding Environmental Changes, Forecasting Hazards*. E.S. Kappel, S.K. Juniper, S. Seeyave, E. Smith, and M. Visbeck, eds, A Supplement to *Oceanography* 34(4), <https://doi.org/10.5670/oceanog.2021.supplement.02-03>.

## COPYRIGHT & USAGE

This is an open access article made available under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution, and reproduction in any medium or format as long as users cite the materials appropriately, provide a link to the Creative Commons license, and indicate the changes that were made to the original content.