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From Greenland to the deep sea via ocean express: North Atlantic Seaweed has potential as major carbon trap

Greenland's coastal macroalgal forests may be a far more significant contributor to global carbon storage than previously thought. That is the outcome of a new study co-led by the Leibniz Institute for Baltic Sea Research (IOW) and the Helmholtz-Zentrum Hereon. By combining satellite imagery, ocean drifter trajectories, and high-resolution ocean turbulence models, the international research team demonstrated, how ocean currents and intense mixing events act to push seaweeds – and thus the carbon in their tissues – into the deep ocean. The study was recently published in the Journal Science of the Total Environment.

While scientists have long recognized that macroalgae – seaweeds – are highly productive, quantifying their contribution to carbon sequestration has been a major challenge. Unlike seagrass, mangroves, and salt marshes, where carbon is stored in the plants and soil where the plants grow, seaweeds grow on rocky shorelines, where burial cannot happen. Instead, seaweed carbon storage probably occurs far away from the rocky shores where they grow. For carbon sequestration to have a chance of occurring, detached seaweed must survive a complicated journey before it decomposes or is eaten by little critters. It leads from the rocky shoreline, across the continental shelf, and into the deep ocean.

"Quantifying these carbon fluxes is incredibly complex because the storage doesn't happen where the seaweed grows," says Daniel F. Carlson. He is the lead author of the study and recently transferred from the Hereon to the IOW to head the institute's new department of Marine Observations. "Our research confirms that for carbon to be effectively withdrawn from fast recycling, it requires a sequence of various events: offshore transport by surface currents followed by a transition from floating to sinking, which is often triggered by intense physical processes far from the source habitat," Carlson explains.

Fast traveling via the oceanic express highway
The multinational research team, which, besides further Hereon scientists, also included researchers from the Norwegian Institute of Marine Research, the University of Alberta, Canada, the Plymouth Marine Laboratory, UK, the Portuguese University of the Algarve, the Saudi Arabian King Abdullah University of Science and Technology, and the Danish Aarhus University, utilized Southwest Greenland as a testbed. This region, according to a 2024 Nature Geoscience study, annually exports nearly one million tons of carbon, thus ranking it 20th globally in macroalgal carbon export potential.

Using 305 GPS-tracked surface drifters to investigate the oceanic currents in the relevant sea regions, the team overturned previous assumptions about how long it takes for seaweed materials to leave the Greenland coast. While earlier models suggested a residence time of 91 to 180 days, the new data revealed a high-speed "express highway" that moves floating seaweed offshore in an average of just 12.1 days – well within the time frame that the plants remain intact.

High-speed sinking through an effective turbulence pump
The most striking discovery of the study, however, involves the Labrador Sea. There, powerful winter storms create deep convective mixing. Through advanced Large Eddy Simulations – numerical model simulations of turbulent currents – the researchers identified what they call an "alternating-turbulence pump".

This "pump" generates vertical velocities of up to 9 metres per minute, which overcome the buoyancy of some of the floating seaweed mats. As the seaweed is dragged down to depths of 120 to 130 metres, the intense water pressure causes its gas-filled air sacs to collapse. This loss of buoyancy is irreversible, causing the carbon-rich tissues to sink to the deep-sea floor – potentially reaching depths of more than 2,000 meters.

“As climate change causes Arctic Sea ice to recede, habitat suitability models predict that macroalgae distributions in Greenland and the Arctic will expand. Our study provides a vital ‘blueprint’ that can now be applied to other coastal regions to accurately quantify the role of seaweeds in the ocean carbon cycle”, concludes the study’s principal investigator Daniel Carlson.

An interdisciplinary achievement of open science
The findings of the study were made possible by an immense interdisciplinary effort that synthesized data from several fields:

- Satellite remote sensing: Over 1,380 Sentinel-two images were analysed to detect nearly 8,000 floating mats of macroalgae on the shelf.
- Advanced modelling: The team used high-resolution Lagrange particle tracking and turbulence simulations to resolve the “invisible” vertical currents.
- International collaboration: The study involved experts from eight countries and utilized open-access data from Europe’s Copernicus programme and the U.S. National Oceanic and Atmospheric Administration (NOAA).

“Our publication leveraged the interdisciplinary expertise of the co-authors to synthesize data from satellites, ocean drifters, and advanced ocean models to test key underlying assumptions in the macroalgae export paradigm,” says Carlson. “Because the ocean’s currents and carbon cycles do not recognize national boundaries, our transition to an open-access scientific framework is essential for fostering the international transparency and collective action required to manage the global blue carbon commons”, the ocean observation expert emphasises.

Original publication:
Daniel F. Carlson, Nobuhiro Suzuki, Ruben Carrasco, Karen Filbee-Dexter, Laura C. Gillard, Paul G. Myers, Ana M. Queir´os, Jorge Assis, Carlos M. Duarte, Mikael Sejr, Dorte Krause-Jensen (2026): *Ocean transport and vertical mixing connect Greenland’s macroalgae to deep ocean carbon sinks.* Science of the Total Environment 1012, 181247 doi.org/10.1016/j.scitotenv.2025.181247

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The Leibniz Institute for Baltic Sea Research Warnemünde (IOW) investigates natural and anthropogenic changes in coastal and marginal seas using a system-wide and interdisciplinary approach, ranging from fundamental to applied research. The Baltic Sea serves as an ideal case study on the institute’s doorstep. An important mission of the IOW is to engage in knowledge-based dialogue with policy-makers, stakeholders, and society, thereby contributing to the sustainable development of coastal seas.
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