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Perspective

Ocean Temperature Controls Kelp Decomposition

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ABOUT THE STUDY

The organic carbon cycle in the ocean is an important but unresolved part of the global carbon cycle. As a result, the focus has been on global intake of inorganic carbon (CO_2) and resolution of primary productivity. However, ecosystem-level organic carbon removal rates, which are known to change with environmental conditions such as temperature, can be equally important in determining the balance between organic and inorganic carbon pools. At the land-sea interface, the carbon cycle through macroalgae and other macrophytes has recently become an important process, with the potential for CO_2 capture, storage and sequestration in the ocean. Therefore, quantifying the rate of degradation of macroalgae debris in the marine environment is essential to more generally estimate the potential contribution to blue carbon and its fate in the global carbon cycle.

Organic carbon removal rates are geographically different, which poses challenges to current climate models. Current climate models typically use spatially consistent relationships to represent important processes or routes. On land, models that explain the spatiotemporal dependence of temperature, surface microbial and mineral interactions are predicted to have weaker and more variable feedback between soil carbon and climate than models using average velocities. In the open ocean, global biopumps show significant regional variability, with Particulate Organic Carbon (POC) removal rates exceeding double digits. As a result of these spatial differences, commonly applied POC degradation rates, based on measurements from several regions, overestimate the global flux of POC to the seafloor. Similarly, changes in deep-sea submarine biotic communities appear to promote strong heterogeneity of post-deposition carbon turnover, and differences in microbial activity at latitudes increase the rate of dissolved organic carbon degradation at high latitudes.

The rate of kelp decomposition revealed here suggests that the future turnover of kelp detritus will accelerate as the coastal areas warm. Fast turnover means that detritus dwell time is short and is unlikely to be exported and transported to deep-sea sediments or water bodies or buried in shallow soft sediments. This means the potential loss of carbon sequestration within the current distribution of kelp forests with future warming. This change will also change the nature of kelp as a resource subsidy, which will affect the harmful food webs of kelp forests and adjacent habitats that depend on this source.

Importantly, although degradation varies from region to region, kelp debris decomposes more slowly than many other major sources of marine organic carbon (such as seagrass and other seaweed). This may be related to the physicochemical properties of the seaweed material, such as the presence of structural compounds and phenols. It may also be because the substance, even debris, can survive for a long time and maintain photosynthetic activity in shallow tidal regions with sufficient light to maintain net photosynthesis. Important information about this detritus export is still missing in many areas, but our result is that kelp detritus has a long coastal residence time and is therefore likely to be transported to deeper areas. This is consistent with evidence that significant amounts of seaweed reach deep-sea sinks where they can be quarantined in the long run.

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