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Consequences of large-scale carbon sequestration with floating macro-algae on the marine oxygen distribution

Presented By: Benjamin Owusu
Reviewers: Dr. Christoph Voelker, PD Dr. Thorsten Warneke,

Abstract

To meet the 1.5 °C global atmospheric temperature target from the Paris Agreement, the IPCC's fifth assessment report addressed the urgency to invoke negative emission technologies that would counteract the global CO_2 emissions as well as to draw down the present-day CO_2 concentrations. One of these negative emission technologies is enhanced ocean afforestation through artificial ocean upwelling which makes use of ocean pipes.

In this study, the regulated ecosystem model version 2 (REcoM-2) has been adopted to analyse the consequences that ocean afforestation via artificial upwelling technique would potentially have on the dissolved oxygen concentrations.

The growth of Sargassum across the tropical Atlantic Ocean, as well as the net effect of ocean pipes that seek to translocate nutrient rich waters from deep ocean to the surface of the ocean to support the growth of Sargassum have been implemented in the model. The study analyses carbon fixation by the modelled Sargassum growth with and without the net effect of the ocean pipes from a 1000-year simulation and recorded that naturally, Sargassum can fix about 0.90 PgC/year but could potentially fix about 1.23 PgC/year with the effect of the ocean pipes. However, this would come as a detriment to phytoplankton as the presence of Sargassum reduced the phytoplankton net primary production by about 4 PgC/year. The net effect of the modelled ocean pipes could not supplement the phytoplankton primary production as it reduced this phytoplankton net primary production by a further 0.13 PgC/year.

The study also analysed how the modelled Sargassum growth with and without the artificial upwelling effect affected tracer concentrations like dissolved inorganic nitrogen which is a fundamental requirement for primary production by marine autotrophs. The dissolved inorganic nitrogen was reduced in the Atlantic Ocean at mid-depth by about 5 $\mu mol\ kg^{-1}$ with the presence of Sargassum and increased it in the deep oceans by the same magnitude. In the global oceans the presence of Sargassum growth with and without the effect of the modelled ocean pipes had less effect on the dissolved inorganic nitrogen concentrations.

The modelled Sargassum growth increased the dissolved oxygen concentrations to about 40 $\mu mol\ kg^{-1}$ at mid-depths in the tropical Atlantic but the reduction in the global oceans at mid-depths was less than 5 $\mu mol\ kg^{-1}$. The impact of the modelled ocean pipes had a less impact on dissolved oxygen

concentrations in the global oceans than in the tropical Atlantic. The dissolved oxygen concentrations were about 270 and 220 μmol kg^{-1} in the deep oceans of the Atlantic and global oceans respectively for all three simulations.