Comment on “Seaweed ecosystems may not mitigate CO2 emissions” by Gallagher et al. (2022)

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Abstract

The role of animal (and plant) respiration in assessing the true carbon sequestration potential of a system is vital to acknowledge, and addressed in Gallagher et al. (2022). However, within this article there is confusion around the respiration of kelp once exported to open waters from kelp ecosystems but respired before sequestration. From their consideration of a closed kelp ecosystem (but with import of phytoplankton and export of kelp), respiration of phytoplankton transported into the system is correctly considered in their net respiration figures (but not the fixation of carbon dioxide by the phytoplankton outside the system, again correct for a closed system). However, the respiration of kelp exported from the closed system is also considered as part of the kelp community respiration. A closed system must remove this respiration of exported kelp from calculations. Alternatively, an open system must consider also the carbon fixation by phytoplankton. The outcome of redefining open and closed systems is that the systems examined in Gallagher et al. (2022) will be net sinks of carbon, although, as yet, the magnitude of this sink is poorly quantified.

The implementation of net-zero policies around the world has resulted in a rapid increase in the perceived importance of nature-based solutions which mitigate climate change effects by drawing carbon from the atmosphere (Howard et al., 2017; Stafford et al. 2021a; House of Lords, 2022). Arguably this is a case of trying to quantify what natural processes are already in place, to limit the emissions cuts we need to make to meet net-zero, hence the interest in quantifying carbon sequestration in a wide range of ecosystems, with only limited acknowledgement of restoration and regeneration of these systems (Seddon et al., 2021).

Seaweeds, especially kelps, which are fast growing and fix large amounts of carbon are a natural consideration for blue carbon, despite evidence of their role of carbon sequesterers being uncertain (e.g. Krause-Jensen and Duarte, 2016; Filbee-Dexter and Wernberg, 2020). As such, the recent article by Gallagher et al. (2022) has much to be commended, questioning this assumption, and recognising the importance of the respiration of fixed carbon in reducing sequestration. However, while the calculations on sparse datasets are impressive, I believe there are some fundamental logical flaws in the analysis.

The first example (Case i in Gallagher et al. 2022), of a closed system, other than the export of organic kelp material is sound. Primary productivity of kelp, minus any respiration from feeding on this kelp (grazers and detritivores) and minus the respiration of kelp itself equates to the export of organic matter from a closed system. It arguably is a slight overestimate of the export amount, not accounting for higher trophic level or microbial respiration. Much of this export is subsequently respired outside of the closed system, and only a small amount is sequestered.

The second example (Case ii in Gallagher et al. 2022) is confused. If we consider the kelp ecosystem as closed, other than import of organic carbon (phytoplankton in this case), and the export of organic carbon (from kelp, as in case i, above), then it is incorrect to use the amount of sequestered kelp as a term in determining the overall carbon budget of the (closed) kelp ecosystem, since much of the respiration of kelp occurs once it has been exported from this system. Equation 3 in Gallagher et al. should therefore not include the Er term (the respiration of kelp occurring outside the kelp ecosystem).

Alternatively, we could consider a wider ecosystem approach, beyond the confines of the kelp ecosystem. In this case, it would be correct to use the smaller, ultimately sequestered amount of kelp as part of the calculation for overall carbon sequestration. However, additional respiration from consuming phytoplankton can only be considered if, in addition, the photosynthesis and carbon fixation of the phytoplankton were also considered. From basic laws of energy conservation, the carbon produced from respiration from feeding on primary producers cannot exceed that fixed from the environment, and is likely slightly less. Ultimately, although biomass storage of carbon, and deep sea respiration can move carbon dioxide out of the atmosphere, primary production is equal to respiration plus sequestration (see discussion in Stafford et al. 2021b).

Given either of these scenarios, kelp ecosystems become a net sink of carbon, and never a net source. Of course, kelp ecosystems provide a huge number of other benefits, and considering them solely as a blue carbon source is not appropriate. Holistic consideration of net zero policies, as discussed in Gallagher et al. (2022), should consider the implications of phase shifts in currently kelp dominated ecosystems and provide appropriate action to prevent these changes.

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