A Next Generation Risk Assessment of Fishing Associated Seabed Carbon Disturbance.

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**Motivation** - Seabed sediments accumulate and store organic carbon (OC) over millennia, resulting in vast stores of OC eclipsing those found in terrestrial environments (Atwood et al., 2020). Through the storage of OC marine sediments provide a long-term climate regulation service and are a crucial component of the global carbon cycle. However, when disturbed sediments that have accumulated over hundreds or thousands of years can be mobilised allowing the OC to be remineralized and potentially lost to the atmosphere as carbon dioxide (CO₂) further intensifying the global climate crisis.

Bottom contact fishing, such as bottom trawling has been identified as the most significant threat to OC held within marine sediments (Sala et al., 2021). Bottom trawling is ubiquitous across global continental shelves, annually in European waters 28% – 85% of the continental shelf is impacted by bottom trawling (Fig.1; Eigaard et al., 2017). Estimates have calculated that annually bottom trawling releases 1,470 million tonnes of CO₂ into the water overlying the sediment which is equivalent to emission associated with global air travel (Sala et al., 2021). Recently, these estimates have been disputed with many arguing that they represent a significant overestimation (Hilborn and Kaiser, 2022; Hiddink et al., 2023). The disparity in these estimates arise from an incomplete understanding of:

**Spatial extent and intensity of bottom trawling activities** – Sala et al., (2021) estimate trawling activities using data from Automated Identification Systems (AIS). However, there is little coverage by AIS in some areas, and more importantly, these devices can be switched off by skippers. These could result in a misrepresentation of the true spatial extent and intensity of trawling.

**OC composition across sediments** - Current sediment maps are constructed from bulk OC measurements (Diesing et al., 2017; Smeaton et al., 2021) and provide a broad overview of OC on the seafloor and can be used to identify “Hotspots” for OC storage. Yet, these bulk measurements provide no information on the reactivity (i.e., the likelihood the OC will be degraded and convert to CO₂) of the OC and it-turn no understanding of the vulnerability of sedimentary OC stores to disturbance (Smeaton and Austin, 2022).

The magnitude of the sedimentary OC stores twinned with the threat of bottom trawling has led to calls to protect and manage sedimentary OC with proponents championing a range of measures from developing new fishing gear to full bans. Yet, the current lack of unified understanding of the risks posed by bottom trawling to seabed OC significantly hinders the development of evidence-based policy and management options which need to both protect the globally significant OC stores while ensuring no unnecessary economic or societal burden is placed on coastal communities.

**Aim** - This project will bring together state-of-the-art geochemical and geo-spatial techniques to assess the risk which bottom trawling poses to the OC held within the sediments of the United Kingdom’s Exclusive Economic Zone (UK EEZ).
Methods - The project will improve the current understanding of the spatial extent and intensity of bottom trawling activities by developing a method to join AIS data with Vessel Monitoring System (VMS) data. VMS are legally required for all vessels > 12 metres in length, transmit location every 2 hours and have gear-related information which improves estimation of the impact of fishing activities.

The project will use pre-existing surficial sediment samples (>3,000) collected by the United Kingdom Hydrographic Office (UKHO) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) that are distributed across the UK EEZ. During the project opportunities may arise to collect samples at sea depending on berth availability on scheduled research cruises.

This project will utilise a new state-of-the-art analytical approach to directly quantify the different OC pools (labile, recalcitrant, and refractory) within a single sample facilitating the quantification of OC reactivity. This new two-step analytical approach will first identify the thermal characteristics of the sedimentary OC using a ramped oxidation combustion technique (Garnett et al., 2023) where samples are ramp heated at 5°C min⁻¹ from room temperature through to 1000°C with the CO₂ evolved from the ramped combustion being measured. This technique will be applied to a sub-set of the samples with differing characteristics (sediment type, OC content, distance to land, etc.). The peaks in the CO₂ thermograms (Fig.2) will allow the different OC pools to be identified and thermally characterised. Using the thermal characteristics of the OC pools in tandem with a bespoke ramped oxidation total organic carbon analyser housed in the school all available samples will be analysed allowing the OC in the different pools quantified.

The new OC data will be combined with a range of spatial modelling techniques (boosting, multiple regression, Bayesian incorporating spatial Gaussian processes) to develop a next generation suite of OC maps allowing the total OC stock of the UK EEZ to be reevaluated, alongside producing a new understanding of the distribution of the different OC pools across the UK sediments. Together these data will allow the vulnerability/likelihood that the OC could be converted to CO₂ if disturbed to be mapped for the first time globally.

The project will build upon the methodology of Black et al. (2022) by bringing together the new OC and fisheries data to undertaking a UK EEZ wide risk assessment of bottom trawling disturbance on the sediment OC stores. The assessment will estimate the quantity of OC at risk from bottom trawling in the UK EEZ and highlight the area’s most at risk. The outputs from this analysis will facilitate the evaluation of current and future policy and management approaches to preserve and protect sedimentary OC stores in UK waters including the role of the nation’s marine protected areas.

RTSG Request - This project requests a RTSG of £2,000 per year. Alongside the training requirements of the candidate, the funds will cover: (i) travel and subsistence to collect UKHO and Cefas samples from repositories in the UK (£500); (ii) high powered laptop to facilitate spatial modelling (£1,000); (iii) costs associated with the laboratory analysis (£3,500); (iv) attendance of academic conferences (£1,000).