Assessing the Influences of Demersal Trawling on Sedimentary Marine Carbon Stores

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1. Introduction

Carbon dioxide (CO_2) is removed from the atmosphere into the marine environment via gas-exchange where it is fixed via photosynthesis in primary producers to form particulate organic carbon (POC). This POC plays a substantial role in both pelagic and benthic ecosystems. In the latter, POC which has not been consumed in the water column sinks to the seabed where it may be consumed by the benthic food-web or it may be buried and stored within marine sediments [1]. This process plays a fundamental role in the transfer of CO_2 from the atmosphere to long-term sedimentary carbon stores. It is estimated that approximately 476 Mt of POC is stored within the top 10 cm of sediments on the North-West European continental shelf area (1,111,812 km^2) [2].

The rate at which POC accumulates and is stored in marine sediments is thought to be highly variable due to several processes occurring on the seabed. For example, natural processes such as storm events and tidal movement can influence the particle movement of the seabed, leading to sediment resuspension events [3]. Anthropogenic processes such as benthic trawling may also influence POC supply, accumulation rate, and long-term storage [4–6]; however the impact of benthic trawling on these carbon stores remains poorly understood.

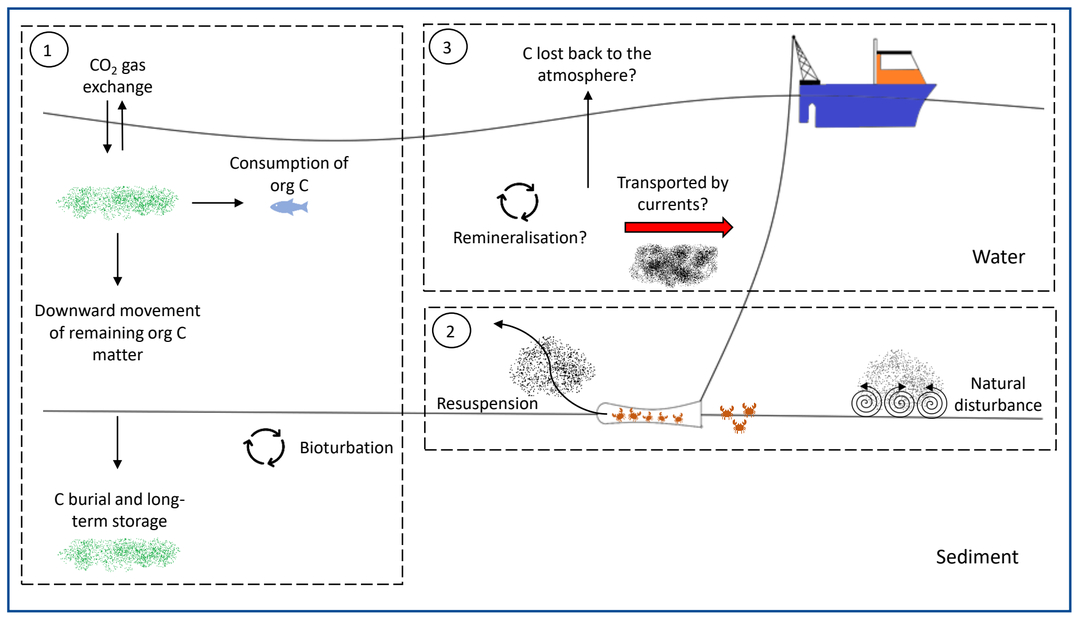


Fig. 1: Schematic of C storage and the disturbances occurring on the seabed. (1) C fixation occurs in phytoplankton via photosynthesis. Phytoplankton is then consumed. Remaining org C continues sinking and is buried, where it enters the long-term C store. Bioturbation occurs in the upper sediment layer from benthic biota, leading to degradation of C. (2) Natural disturbance to marine sediments occurs in the form of currents and storm events. Anthropogenic disturbance (e.g. trawling), leads to massive sediment resuspension events and wide scale impacts on infaunal benthic communities. (3) What happens to anthropogenically resuspended sediments? C may be remineralised, transported by predominant local currents, or lost back to the atmosphere via gas exchange. This remains poorly quantified

2. Experimental Objectives and Design

In order to try gain a better understanding of the post-disturbance effects of carbon cycling in marine sediments, an experimental trial was conducted at the Tvärminne Zoological Station, Finland. The purpose of this experiment was to investigate the following:

"If sediments undergo daily disturbance and resuspension over the period of 21 days what happens to carbon in these sediments?"

1. **Is there a change in POC/DOC from daily disturbance?**
2. **Does the depth of the disturbance (and thus the amount of sediment resuspended) influence POC/DOC?**
3. **Are nutrients effected by disturbance?**

To test these objectives, sediment was collected from the Finnish Archipelago area beside the research station. Here, two key sample sites were used. The first, was in a sheltered outflow region of Skogbyfjarden, which is dominated by terrestrial influences. The second, was in a more open marine influenced area of the Baltic Sea. Due to the differing carbon types (e.g. marine and terrestrial) from the two sample sites, an additional objective was added:

4. **How does carbon content, DOC, and nutrients vary with depth in cores collected from the two sites?**

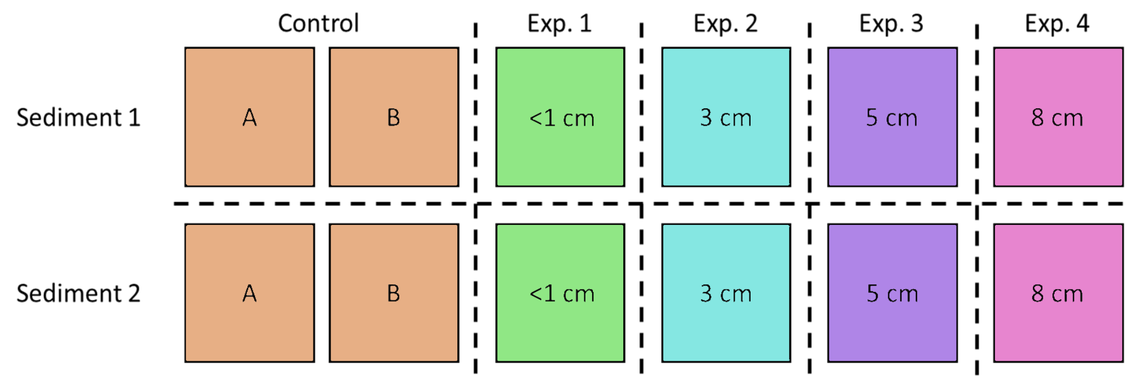
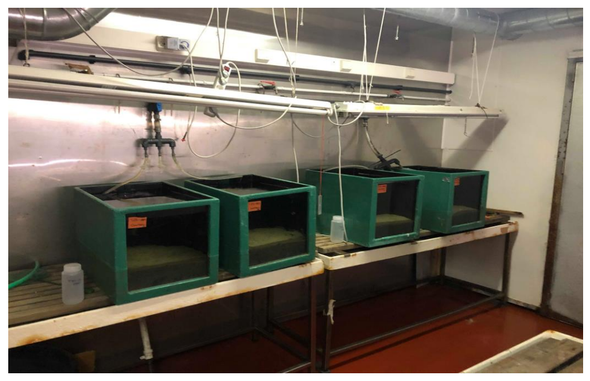


Fig. 2: Set-up of the aquaria facilities used for the experiment. For sediment 1 and 2 there were two control tanks A and B. For each of the disturbance regimes there was one tank per sediment type.

- Over the 21-day period, sediments underwent an artificial disturbance event every 24 hours. The disturbance was conducted via the use of a wooden paddle of a set length. This ensured that the daily disturbance depth of the sediments was uniform.
- During the resuspension process the flow waters to the tanks was turned off to minimise the loss of the resuspended sediments from the tanks. The flow was resumed once the sediments had settled. The experimental aquaria room was kept at a constant 7°C for the duration of the experiment, this was the approximate temperature of the seawater in the local area at this time.
- Upon sediment resuspension, a 500ml water sample was immediately collected. This sample was then refrigerated before filtering (<3 hours between sampling and filtering). Samples were filtered on Whatman GF/F filters. The filters were dried for LOI analysis, while the filtrate was separated: 20ml samples were acidified for DOC, 50ml samples were frozen for nutrient analysis.
- On day 1 and day 21 a time series of sample collection was conducted, where a pre-resuspension sample was collected, and a post-resuspension sample was collected immediately after the disturbance and then every hour for 4 hours. Sediment push cores were also collected from the tanks on these days.



Figs. 2-5: Various stages of the experiment. Fig 2 (top right): Pore water extractions via Rhizons. Two cores were collected from each station. Pore waters were then used for DOC and nutrient analysis. Fig 3 & 4 (above): The top figure shows the four control tanks, whilst the bottom figure shows the 8 experimental tanks. The aquaria room was kept at a constant temperature, and all tanks were supplied with a low flow of water at a constant temperature. Fig 5: Filtration set up for the sample waters. A 70ml subsample was filtered on Whatman GF/F filters. Filtrate was kept for DOC and nutrient analysis while the filter papers were dried for LOI.

3. What's Next?

Currently waiting on data **(ON HOLD DUE TO COVID-19).** All water samples collected throughout the experiment are **undergoing analysis at Tvärminne Zoological Station in Finland**. These samples are as following:

1. Porewater profiles: DOC and nutrients (PO_4, SiO_2, NH_4, NO_2, NO_3)
2. DOC from the daily filtrate
3. Nutrients (PO_4, SiO_2, NH_4, NO_2, NO_3) from the daily filtrate

All sediment and filter samples collected will **undergo analysis at The University of St Andrews**. These samples are as following:

1. Dried GF/F filters for LOI
2. Elemental analysis (C & N) on the sediment samples collected from the tanks
3. Elemental analysis (C & N) on the sediment sample slices from the cores collected at the two stations
4. Particle size analysis on all sediment samples
5. Thermogravimetric analysis on all sediment samples

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