Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Research Programme
- Short Call 2022 –
- Final Report -

Lead Applicant Name	Brian Kelleher
Host Organisation name	Dublin City University
Project Title	Quantification of blue carbon in core samples along an elevation gradient transect from intertidal through vegetated salt marsh sediments in Bull Island.
Contract Number	2022-sc-001

This report covers the period 1st November 2022 to project end date 31st October 2023)

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2. (a) Project information:

Final project report (*max **2500** words, excluding figures and headings*):

Executive summary:

Historically, nutrient, carbon, particulates and organic/inorganic pollutant inputs to Dublin Bay have been elevated due to riverine transport, industrial activity, sewage effluent and run-off associated with geographical proximity to a highly urbanised coastal region Invariably, algae blooms are a common occurrence in the Tolka estuary and on the mud flats of Bull Island's lagoons. This biomass is a prominent source of proteinaceous material, inevitably contributing to C, N, S and P sediment concentrations, especially during seasonal die-of when tidal surges facilitate the distribution of necromass to elevated sediments, and through outwelling. Questions remains as to the degree of influence that algae may exert in immobilising heavy metal, fluvial sediments and PAH from the water column. The accretion of sediment (elevation) and presence of vegetation in in certain areas facilitate more efficient trapping of particulate OM, silts and clays, all contributing as vehicles for C substrate and nutrients to support seasonal autotrophy. Indeed, organic root exudates from halophytes can provide additional C for substrate for biogeochemical cycling. Additionally, detoxifying metals such as Al and Pb, and importantly under certain conditions, increased stabilisation of C in soils through physical protection against microbial degradation. Furthermore, the combination of these edaphic factors facilitates accumulation of PAHs, with evidence of long-term retention of high molecular weight constituents in elevated sediment zones. The variation in organic matter and metal distribution from zone supratidal mid-Lower
marsh zone to supratidal upper marsh zones to saltmarsh zones arise due to different hydrological regimes, spatial elevation, higher deposition rates, succession of vegetation and high burial rates. However, variations between different metals in the comparisons between marsh zones is difficult to attribute to all of the factors mentioned above. Biotic factors such as vegetation composition, algae necromass, and sediment microbiology may play a larger role in metal distributions throughout the elevation gradients by catalysing sediment redox dynamics during C cycling.

- Results, scientific/engineering targets reached beyond the state of the art and conclusions

This study was performed in an anthropogenically impacted blue carbon habitat along a coastal ecotone encompassing an elevation gradient transect from intertidal sediments (un-vegetated and covered daily by tidal water), through vegetated salt marsh sediments (periodically covered by spring tides and flooding events), on Bull Island, Dublin Bay. We determined the quantity and distributions of bulk geochemical characteristics in sediments through the elevation gradient, including total organic carbon (TOC), total nitrogen (TN), total metals, silt, clay, and also, 16 individual polyaromatic hydrocarbon's (PAH's) as an indication of anthropogenic input. Elevation measurements for sample sites were determined on this gradient using a LiDAR scanner accompanied by an IGI inertial measurement unit (IMU) on board a light aircraft. Considering the gradient from the Tidal mud zone (T), through the low-mid marsh (M) to the most elevated upper marsh (H), there were significant differences between all zones for many measured environmental variables. The results of significance testing using Kruskal–Wallis analysis revealed, that %C, %N, PAH (µg/g), Mn (mg/kg), TOC:$NH4^{+}$ and pH are significantly different between all zones on the elevation gradient. The highest values for all these variables exists (excluding pH which followed a reverse trend) in zone H, decreasing in zone M and lowest in the un-vegetated zone T. TC content is 16 fold higher overall in vegetated (3.43 - 21.84%) than uninhabited (0.21–0.56%) sediments. TN was over 50 times higher (0.24–1.76%), more specifically increasing in % mass on approach to the upper salt marsh with distance from the tidal flats sediments zone T (0.002–0.05%). Clay and silt distributions were greatest in vegetated sediments, increasing in % content towards upper marsh zones. The retention of water, metals, PAHs, mud, chloride ions, $NH4^{+}$, $PO4^{3-}$ and $SO4^{2-}$ increased with elevated C concentrations, concurrently where pH significantly decreased. Sediments were categorized with respect to PAH contamination where all SM samples were placed in the high polluted category. The results highlight the ability of Blue Carbon sediments to immobilise increasing levels of C, N, and metals, and PAH over time and with both lateral and vertical expansion. This study provides a valuable data set for an anthropogenically impacted blue carbon habitat predicted to suffer from sea-level rise and exponential urban development.

- Project Implementation

WP/ Task	*Description Month*	1	2	3	4	5	6	7	8	9	10	11	*12*
1	Student training												
2	Select sample site across an elevation gradients												
3	Samples cores taken and catalogued												
4	Accurately quantify the carbon in core samples												

All timelines met.

Milestones:

- Sample sites chose: Month 4.
- Sample cores taken and catalogued: Month 6
- Quantification of carbon using universal approaches: Month 14.

All milestones met.

- **Project Deliverables**

Task No.	Deliverable description	Delivery
1	Student training	0-12 months
2	Select sample site across an elevation gradients	Month 4
3	Samples cores taken and catalogued	Month 6
4	Accurately quantify the carbon in core samples	Month 14

Management:

Brian Kelleher and Anthony Grey managed the project. The researcher (Rasmus Ritker-Svendson) was also managed by a Research Studies Panel where a panel of 3 people provided guidance for the project and support to the young researcher. Rasmus will soon be taken on as a PhD student.

- Outputs

We determined the quantity and distributions of bulk geochemical characteristics in sediments through the elevation gradient, including:

- total organic carbon (TOC),
- total nitrogen (TN),
- total metals,
- silt, clay,
- and, 16 individual polyaromatic hydrocarbon's (PAH's)

Elevation measurements for sample sites were determined on this gradient using a LiDAR scanner accompanied by an IGI inertial measurement unit (IMU) on board a light aircraft.

- Outputs to date

Outputs as above. All data is stored on hard drives, external drives and Google Drive.

- Impact

This project aligns strongly with all the Principal Goals of the Geological Survey of Ireland Research Roadmap and each of the three challenges outlined in the document. Under the National Marine Planning Framework (NMPF), future developments and activities are expected to demonstrate that they have considered available evidence and identify any significant adverse impacts on habitats, including sediments, that provide carbon sequestration ecosystem services. The NMPF identifies a number of offshore areas that includes Dublin Bay and Bull Island where the contribution of marine sediments to carbon storage is identified as being high. Therefore, a detailed understanding of the current stock of carbon in Bull Island sediments (and the habitats they support), it's evolution over time and potential for future sequestration is key to informing and developing the appropriate and effective management strategies and regulations. This includes marine spatial planning and management frameworks, such as the NMPF, and the use of Marine Protected Areas (MPA).

- Other impacts

Ireland, through the Climate Action Plan and National Marine Planning Framework, recognises Blue Carbon as having significant potential in tackling climate change. With a marine area almost 10 times that of our land mass, understanding and developing this potential as a key resource is critical. This project aims to help realise this potential through a validated inventory of carbon stock in Bull Island, a recognised Blue Carbon zone. The project achieves this aim by developing state-of-the art methodologies, databases and expertise that can be applied in an Irish context to bridge a critical knowledge gap in our understanding of Blue Carbon. Therefore, this project will contribute to knowledge in a range of areas.

Publications: In preparation

3. Supplemental information/datasets *(please clearly mark any sensitive or confidential information that should not be published and include a justification for the request)*