A brief overview of Biogeochemistry, macronutrient and carbon cycling in the benthic layer (BMCC)


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Natural transition with depth, sediment type or human impact. Decreasing temporal coupling and C cycling rates.
Site selection
4 regions (mud, sandy mud, muddy sand, sand), cohesive and non-cohesive
Accounting for temperature, water column structure/physics, MCZs, human usage
VMS chronic impacts (trawls 2009-2012)

Regional work across habitats/strata – transect through sites, within and between strata and boundaries

Seasonal work at these sites – landers and buoy (Celtic deep only)
Processes
Temporal variability of C & N storage in biomass

- Several methods will be used to collect sediment and fauna.

- At each site and on each cruise, 5 x 0.1m² box core samples will be taken and analysed for macrofaunal (>0.1mm) community structure and biomass.

- In addition, 5 x 0.5m² cores will be taken at each site and sieved over a 1cm mesh to assess the abundance and biomass of large mega-infauna.

- Trawls will collect voucher specimens for AUV survey data.
Biogeochemical cycling of sediment N, P, Si and C [M1]

SSB stocks and flows

- microbial and faunal structure
- temporal and spatial variability
- quality and quantity of organic material
- impact of trawling, tidal currents or storms

C & N within detrital and biological pools
 burial of organic and inorganic C
 model long-term C storage under different scenarios

Role of sediments in C storage [M2]

N, P, Si and C cycling
 Short to long term C storage

Effects of environmental, seasonal and stochastic events on rates, processes, controls

Role of natural and anthropogenic disturbance
 Microbial-macrofaunal coupling

Climate change

infaunal contributions to C and nutrient dynamics
 cohesive and non-cohesive / natural and anthropogenically disturbed (trawling)

Role of macrofauna and impacts of natural and anthropogenic disturbance [M3]

exchange of nutrients and C across the sediment-water interface
 near-bed processes and temporal variability in sediment-water column exchange
 Effects of alternative hydrodynamic and environmental futures

Impacts of sediment resuspension and near-bed current flow [T4]

Observations – Experiments - Modelling
Module 1

(Diaggeochemical cycling of sediment N, P, Si and C)

**Mini-flumes**

1. Temporal variability
2. Physical disturbance / alternative hydrodynamics

Diffusive fluxes
Flow through reactor (FTR)
C & N cycling, sulphate reduction
Microbial dynamics
Porewater profiles / microprofiling
Fe/Mn DET/DGT
t-SPI, g-SPI

Continuous monitoring
Pulse-chase experiments

1D ERSEM pelagic/benthic model

5. Scaling up using ERSEM
MODULE 2
(Role of sediments in C storage)

1. Variability of C & N storage in detrital pool, biogenic carbonates
   - vertical profiles org and inorgan C & N calcification rates

2. Variability of C & N storage in organismal biomass

3. Long-term C storage - recycling & burial efficiency
   - Sediment accumulation rate & organic C content
   - POC input = POC burial + DOC efflux + DIC efflux
   - \[ \frac{POC_{\text{burial}}}{POC_{\text{input}}} \times 100 = \text{burial efficiency} \]

4. Explore long-term scenarios using ERSEM

Core incubations / sediment enclosures

POC -> DOC -> DIC
AIM 3.1: Role of the microbial-macrofaunal coupling in affecting sediment biogeochemical processes.

1. Quantify macrofaunal activity
2. Determine the significance of functional traits
3. Process based models to explore faunal and biogeochemical coupling
4. Explore long-term scenarios using ERSEM
AIM 3.2: Determine how anthropogenic drivers affect the microbial-macrofaunal couple and quantify the implications for C- and nutrient cycling

1. **Quantify chronic effects of trawling**
   
   Observations and experiments, Irish Sea, 2015

2. **Determine importance of functionally important fauna**
   
   Separate direct effects of bottom trawling on sediment from the effects of less macrofauna using transplant experiments

3. **Determine vulnerability under anticipated future environmental conditions**

4. **Model impact of faunal assemblage alteration by trawling and climate change**

Experiments – site incubations under OA, temperature and O2 futures
AIM 4.1: Quantify exchange over a range of sediment types

OUTPUTS
- Intertidal variations in N-cycling, nutrient fluxes, pCO2, alkalinity
- Long-term mean current velocities and turbidity
- Intra tidal variation in in situ benthic O2 fluxes
- Suspended sediment size
- Bed-form morphology and transport
- Diffusive fluxes
- Sediment permeability
- Base rates of O2, C and N cycling in permeable sediments
AIM 4.2: Asses the effect of resuspension (including trawling) and near bed flows on macronutrient and Carbon exchanges.

1. Hydrodynamics and the effects of physical disturbance: ship-board and in situ expts.
2. Effects of alternative hydrodynamic environments and vulnerability to anticipated future environmental change

OUTPUTS
- Critical erosion thresholds
- Depth of erosion
- Erosion rates
- C and N cycling in high permeability sediments under high bottom flow
- Likelihood of resuspension based on current and future hydrodynamic conditions
- Fluxes of N, P, Si under a range of temperatures, organic matter, O2 and nutrient inputs, over and after extreme resuspension events

Voyager II: in situ flume
Flow Through Reactors
Core mini flume: ship-board resuspension experiments.
Mini Flume: lab based resuspension experiments.
AIM 4.3: estimate changes in regional carbon and nutrient fluxes across the SWI for different substrates, regions and storm/trawl gear distributions

1. Modelling of benthic-pelagic fluxes
2. Modelling the resuspension effects of trawling

OUTPUTS
- One-dimensional modelling of benthic-pelagic fluxes (ERSEM) (4.3.1)
- Regional assessment of C and N fluxes including estimates of trawling and storm contributions (4.3.2)
  - Significance of trawling in comparison to ambient and storm fluxes
  - Effort redistribution scenarios
QUESTIONS?

**Biogeochemical cycling of sediment**

\[ N, P, Si \text{ and } C \] [M1]

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- temporal and spatial variability
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- Effects of alternative hydrodynamic and environmental futures

**Impacts of sediment resuspension and near-bed current flow** [T4]

- Observations – Experiments - Modelling

- Shelf Sea Biogeochemistry

- N, P, Si and C cycling
- Short to long term C storage
- Effects of environmental, seasonal and stochastic events on rates, processes, controls
- Role of natural and anthropogenic disturbance
- Microbial-macrofaunal coupling
- Climate change