Seasonal biogeochemical cycling of permeable sediments in a shelf sea environment

Sarah Reynolds[a]*, Jessy Klar[b], Vassilis Kitidis[c], Will B. Homoky[d], Lesley Chapman-Greig[a], Anouska Panton[a], Charlie Thompson[b], Peter J. Statham[b] & Gary R. Fones[a]

[a] School of Earth and Environmental Sciences, University of Portsmouth, UK, [b] Ocean and Earth Science, University of Southampton, UK, [c]Plymouth Marine Laboratory, UK, [d]University of Oxford, UK

*Contact email: sarah.reynolds@port.ac.uk

Rationale

Shelf seas are globally important in contributing to the biogeochemical cycling of carbon and nutrients. Much of the benthic environment found in shelf seas comprise of relic permeable sands whereby advective pore-water flow processes govern the biogeochemical cycling within these sediments. To further our understanding of these processes we embarked on a field campaign as part of the UK led Shelf Sea Biogeochemistry Programme; three cruises took place in the southern Celtic Sea in 2015 and were timed to sample pre-bloom (March [DY021), post-bloom (May [DY030] and late summer (August [DY034]) conditions.

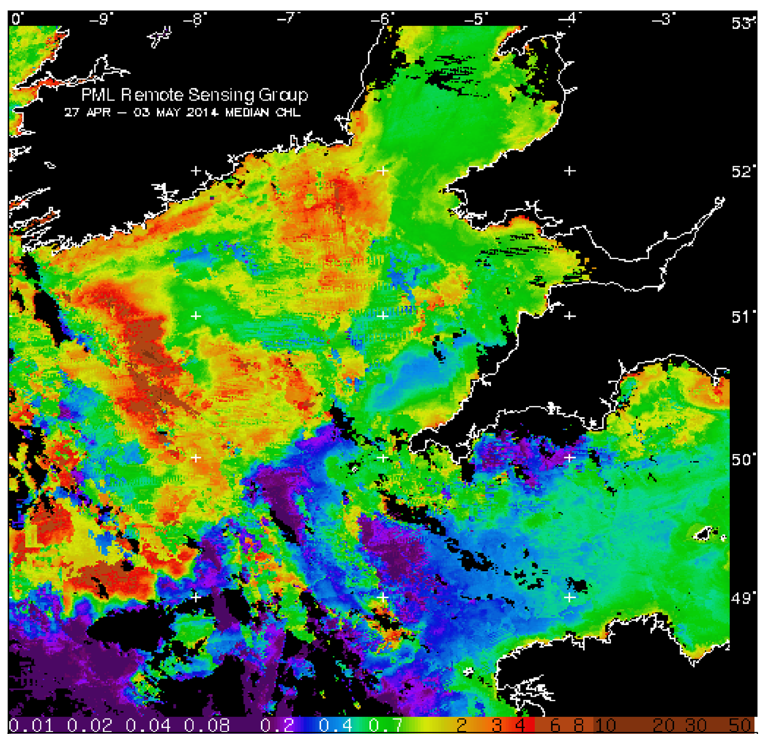

Figure 1 MODIS Chlorophyll OC5 weekly composite (27th April - 3rd May 2014). NERC Earth Observation Data Acquisition and Analysis Service

Approach

Flow-through reactors (Rao et al, 2007) were employed to investigate the biogeochemical cycling of permeable sediments.

- Surface sediment (<5 cm) was collected from a permeable site.
- Experimental conditions were set with flow rates of 1 ml min^{-1} and at bottom temperature (8°C – 11°C).

Figure 2 Flow through reactor set up

Inflow and outflow samples were collected (12-24 hours) for O_2 (Unisense sensors), iron (II), inorganic nutrients (M. Woodward, PML), and DOC/DON.

Results

Pre-bloom

Post-bloom

Late summer

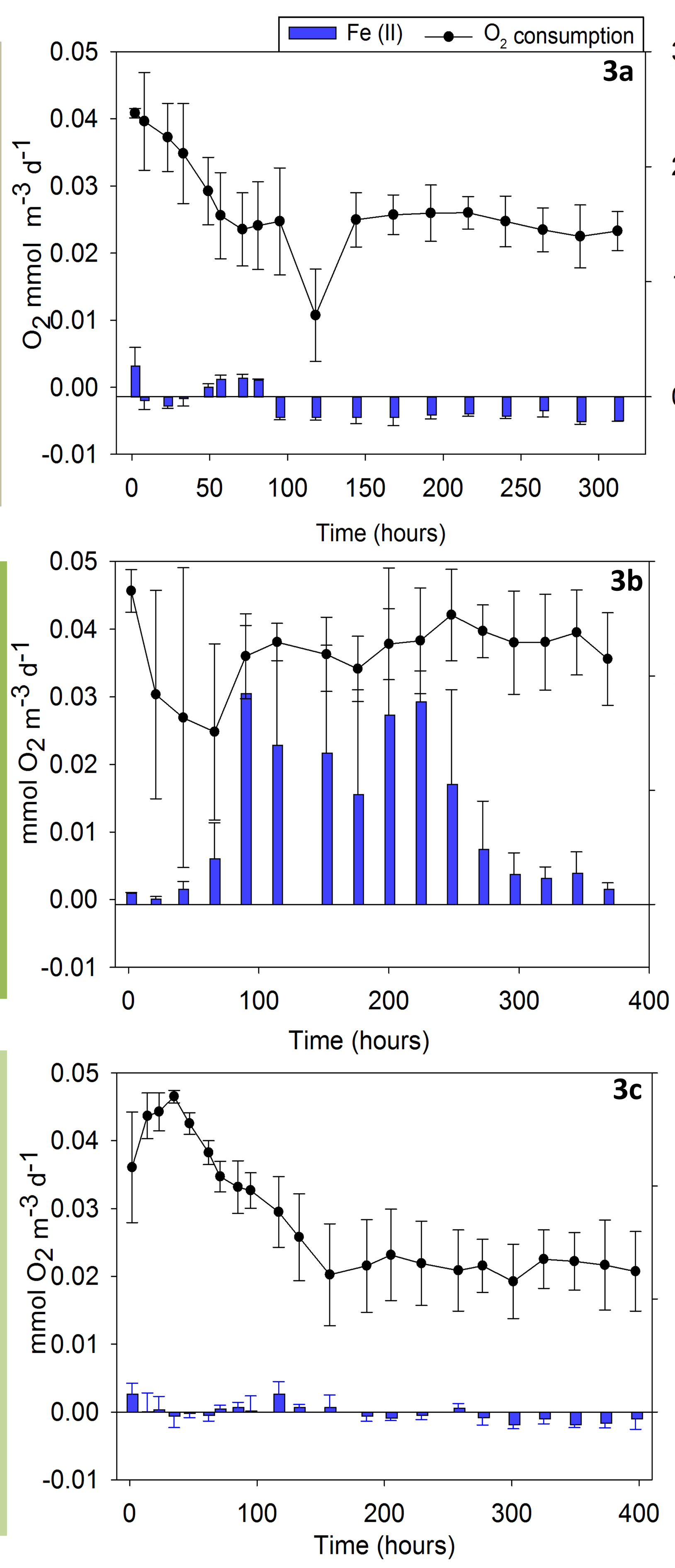

Figure 3 FTR fluxes of oxygen consumption and Fe (II) release (a) pre-bloom (b) post bloom (c) late summer

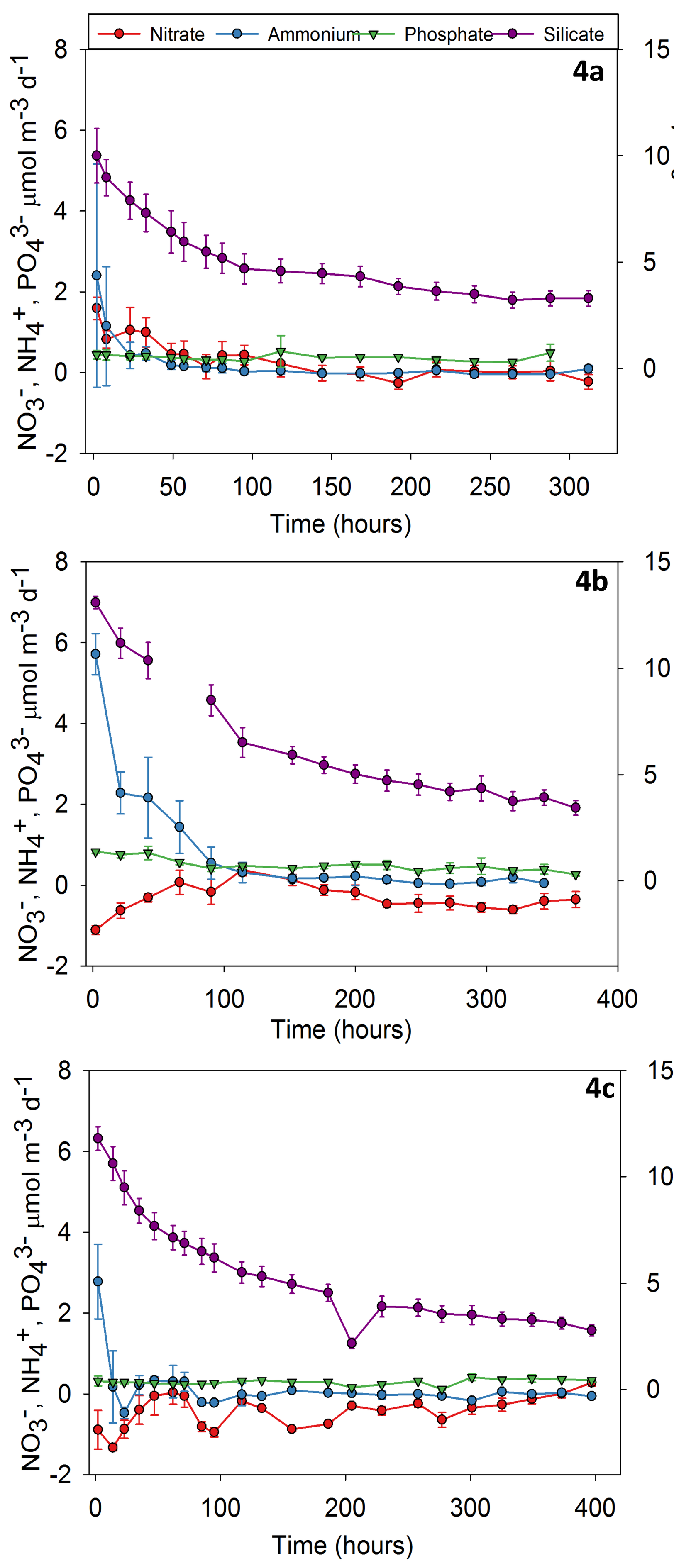

Figure 4 FTR fluxes of inorganic nutrients (a) pre-bloom (b) post-bloom (c) late summer

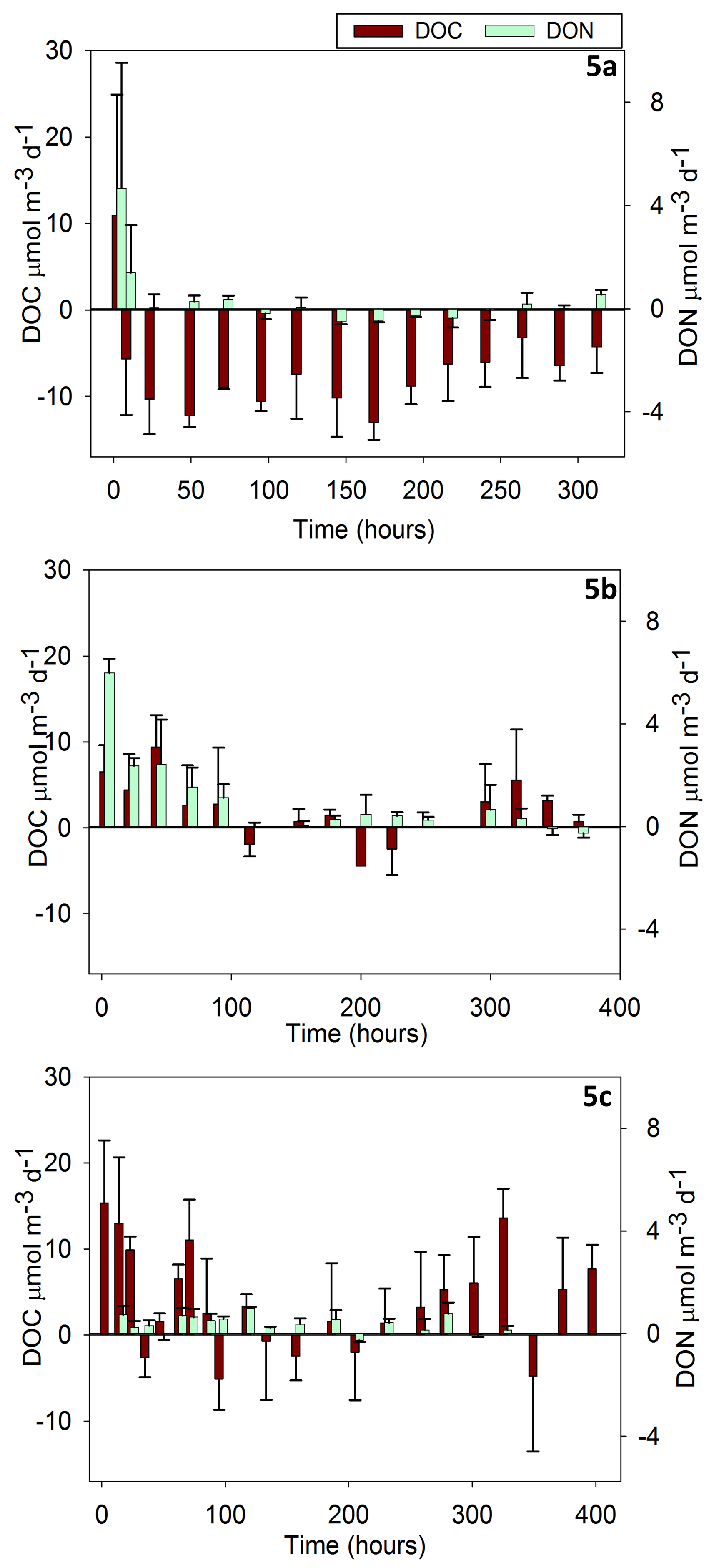

Figure 5 FTR fluxes of DOC and DON (a) pre-bloom (b) post-bloom (c) late summer

Similar ***O_2 consumption*** for pre-bloom and late summer; initially ~ 0.04 mmol O_2 m^{-3} d^{-1} decreasing to 0.023 and 0.022 mmol O_2 m^{-3} d^{-1} respectively. Post-bloom were almost double at 0.038 mmol O_2 m^{-3} d^{-1}

Drawdown of ***Fe (II)*** pre-bloom, with significant releases of up to 18 nmol Fe (II) m^{-3} d^{-1} post-bloom. Late summer Fe (II) appears balanced.

Significant and comparable rates of ***DSi*** release over all seasons. Consistent flux of ***PO_4^{3-}*** (~0.4 μmol m^{-3} d^{-1}) over all seasons.

Pre-bloom initial release of ***NO_3^-*** decreasing to a more balanced system. Post-bloom and late summer net drawdown of ***NO_3^-*** observed.

Initial fluxes of ***NH_4^+*** of ~3 μmol m^{-3} d^{-1} pre-bloom and late summer with upto ~6 μmol m^{-3} d^{-1} post bloom. System becomes balanced across all seasons.

Significant drawdown of ***DOC*** (up to 13 μmol m^{-3} d^{-1}) pre-bloom. Release of ~10 μmol m^{-3} d^{-1} in post-bloom. Highly variable net fluxes during late summer (-4.77 – 5.11 μmol m^{-3} d^{-1}). Substantial initial releases of ***DON*** across all seasons, highest post-bloom (18 μmol m^{-3} d^{-1}), decreasing with some net removal during pre-bloom.

Initial conclusions…

- Appears DOC fuelling respiration pre-bloom
- Seasonality observed in O_2 consumption can be attributed to an assumed increase in organic C loading to sediment
- Fe (II) release during post-bloom as a result of oxic breakdown of organic matter.
- Permeable sediments can act as a substantial and consistent source of DSi and PO_4 to the pelagic system.

Permeable sediments are dynamic systems which play a substantial role in carbon and nutrient biogeochemistry

Reference: Rao, A. M. F., M. J. McCarthy, W. S. Gardner and R. A. Jahnke (2007). *Continental Shelf Research*, 27, 1801 – 1819.

Acknowledgements: This work is funded by NERC NE/K001809/1. The authors wish to thank the Master, officers and crew of the RRS Discovery. Further thanks goes to the personnel of NMF-SS.