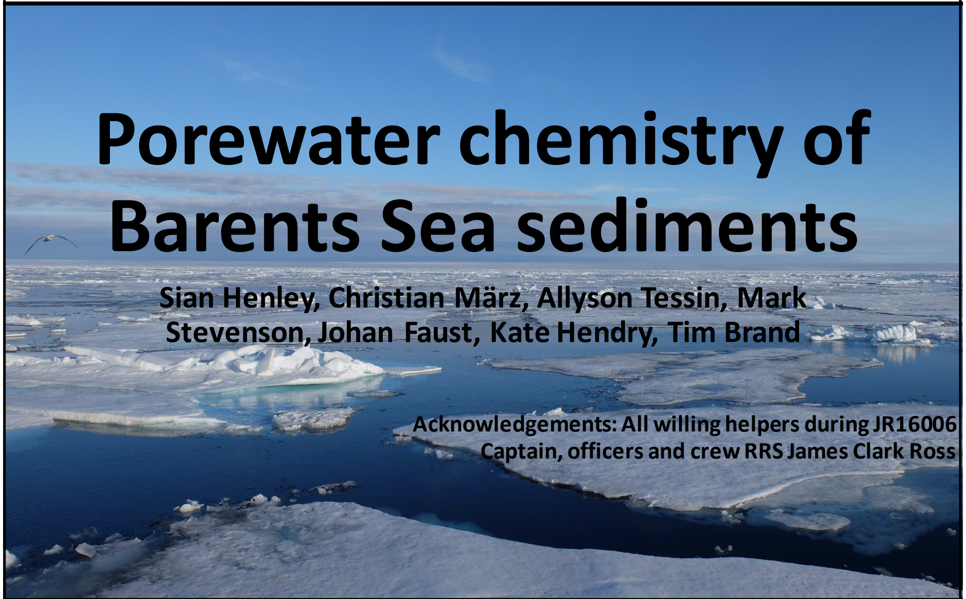
The Changing Arctic Ocean Seafloor (ChAOS)



Porewater chemistry of Barents Sea sediments

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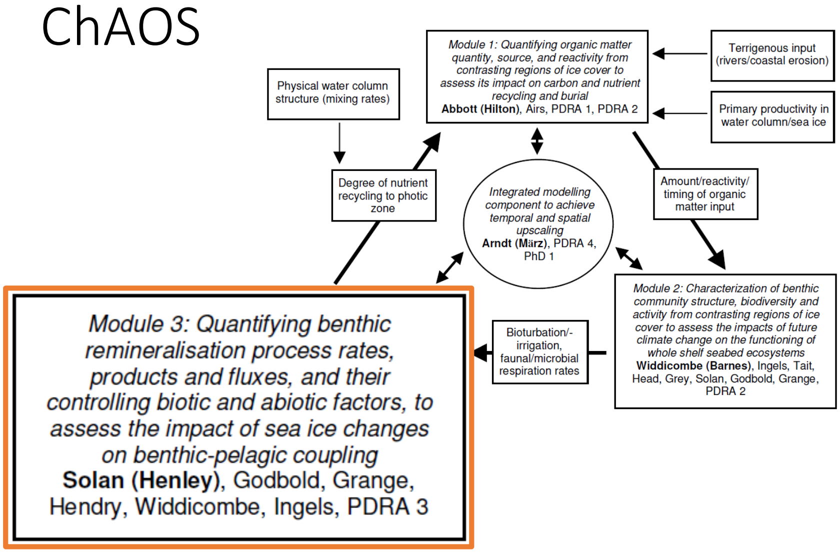
Acknowledgements: All willing helpers during JR16006
Captain, officers and crew RRS James Clark Ross

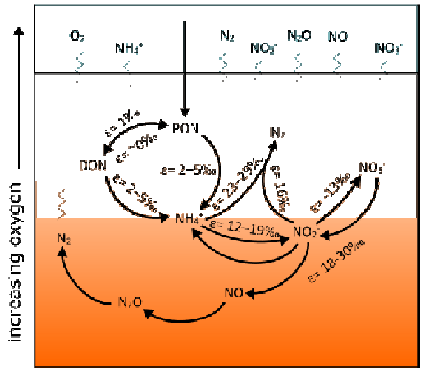
ChAOS



Objectives

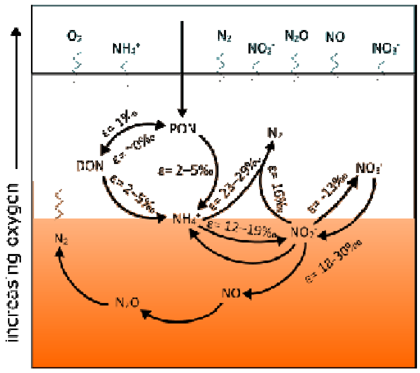
- To assess the amount and quality of OM and associated nutrients exported to the seafloor
- To describe redox conditions and zonation in upper sediment horizons
- To characterise nutrient and carbon cycling and loss processes in sediments
- To quantify macronutrient (N, P, Si) fluxes from sediments to the overlying water column, thus estimate burial fluxes
- To assess the most important biotic and abiotic factors driving variability with latitude and sea ice conditions
  - ➢ Future changes in response to environmental changes associated with ongoing sea ice declines…

Benthic nitrogen cycling



- Nitrogen is the limiting nutrient in most parts of the Arctic
- Arctic sediments can be a significant source of N species to the overlying water column *(Link et al., 2011)*
- N recycling processes control the degree to which OM is buried or remineralised and returned as nutrients to the water column
- Benthic denitrification can be a significant sink for N with implications for Arctic N budgets *(Granger et al., 2011; McTigue et al., 2016)*
- Assess N inputs, cycling and losses in benthic environments and consequences for benthic-pelagic coupling, Arctic N budgets and larger-scale biogeochemical cycling

Benthic nitrogen cycling



- N isotope systematics in sediments and overlying water column
- Denitrification
- Anammox
- Dissimilatory nitrate reduction to ammonium (DNRA)

- PON inputs to sediments
- Nutrient profiles in porewaters and overlying seawater
- $\delta^{15}N$ and $\delta^{18}O$ of nitrate in porewaters and overlying seawater

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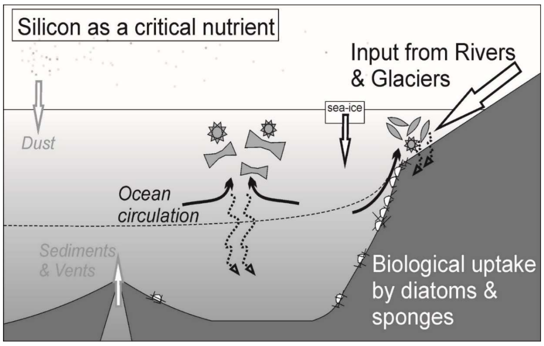
Role of benthic processes on silicon cycle

Kate Hendry, Stephanie Bates, James Ward + PDRA

- Why the silicon cycle?
  - Weathering of silicate rocks consumes CO_2
    - *Reverse weathering?... Complicates the story...*
  - Diatoms (and other siliceous organisms) lock up organic carbon
  - Specific seafloor processes may impact global budget



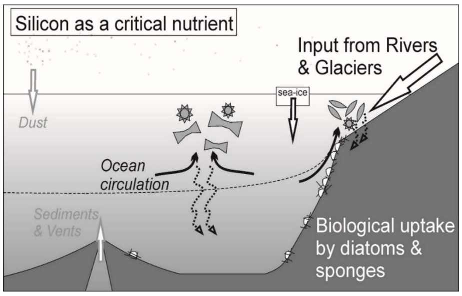
Cartoon of the marine silicon cycle

Role of benthic processes on silicon cycle

Why the Arctic?

Specific seafloor processes may impact global budget and can be traced using stable silicon isotopes

- Light silicon isotopes from glacial weathering *(Hatton et al., submit.)*
- Benthic biological processing by sponges *(Hendry et al., 2010 etc.)*
- Dissolution of biogenic material and clays in sediments *(Cassarino et al., in prep)*
- Benthic recycling of silicic acid from Arctic sediments into the water column ≈ total annual silicic acid input from Arctic rivers *(März et al., 2015)*



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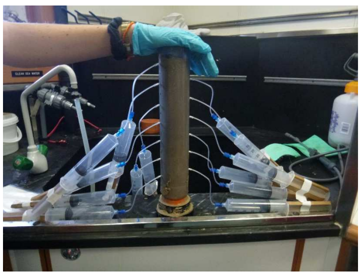
Role of benthic processes on silicon cycle

- What will we (mostly James + PDRA!) do?
  - Sample sediments, porefluids, benthic sponges, and overlying waters
  - Analyse…
    - Silicic acid concentrations (with Sian Henley)
    - Silicon isotope compositions of waters, biogenic opal, and sediments
  - Reaction transport modelling



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Fieldwork: JR16006 + 2 years

- Six stations, ~300-400 m, muddy seafloor in glacial troughs
- Across polar front and winter sea ice boundary
- Three multicorer deployments per station within 20-30 m
- Macronutrient (shipboard) and DIC concentrations
- Fe and Mn speciation and concentration
- $\delta^{15}N$ and $\delta^{18}O$ of nitrate
- $\delta^{30}Si$ of silicic acid
- $\delta^{13}C$ of DIC

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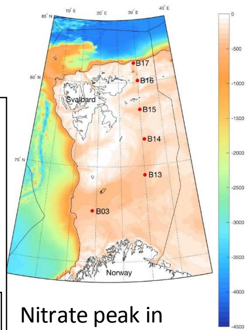
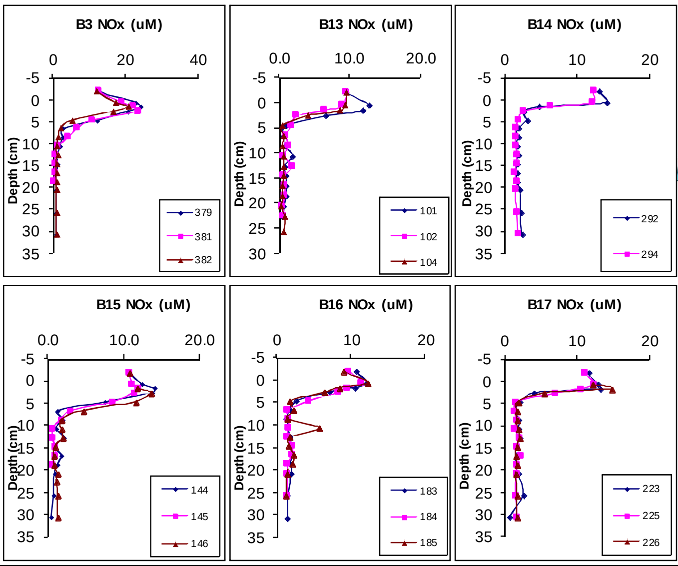
Initial results: nitrate





Nitrate peak in uppermost sediments

Highest $[NO_3^-]$ at southernmost station

Porewater $[NO_3^-] \geq$ bottom water $[NO_3^-]$

Sedimentary nitrate source to water column

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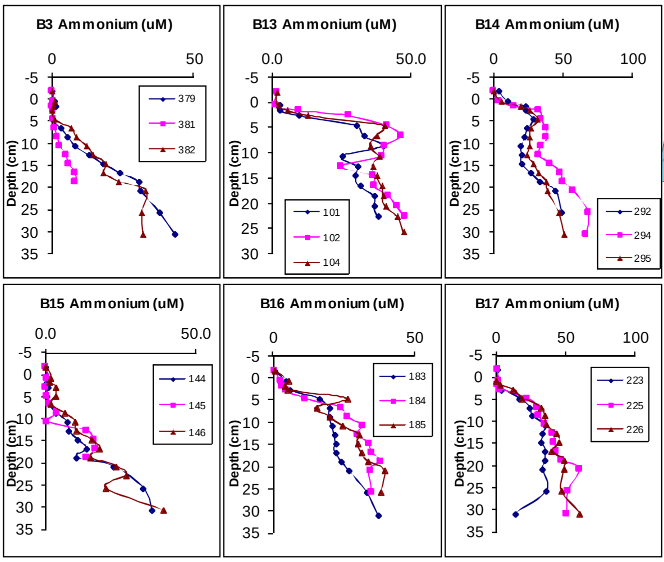
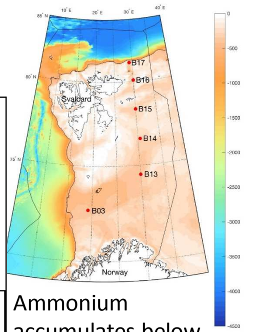
Initial results: ammonium





Ammonium accumulates below nitrate-rich (oxic) horizon

OM breakdown
Nitrate reduction

Progressive increase with depth, peak >20cm

Low $[NH_4^+]$ in surface sediments – no source to water column

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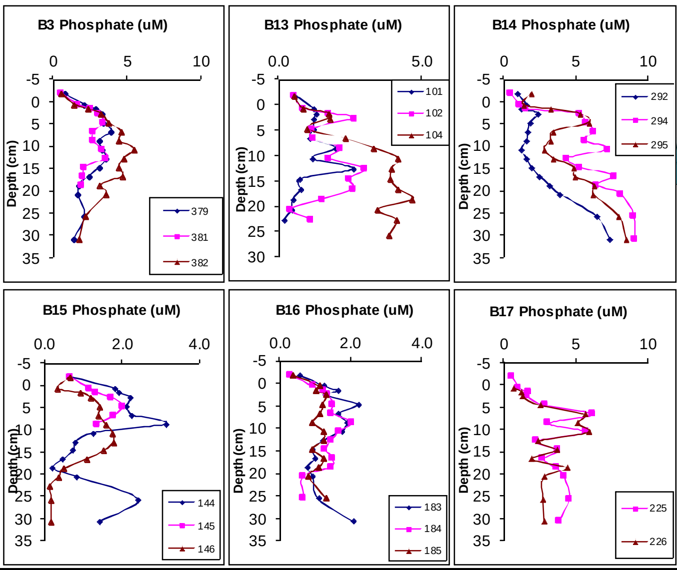
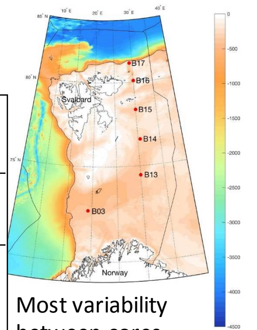
Initial results: phosphate





Most variability between cores

Phosphate increases below surface sediments

Peak at intermediate depths or increase with depth

Porewater $[PO_4^{3-}] \geq$ bottom water $[PO_4^{3-}]$ – source to water column

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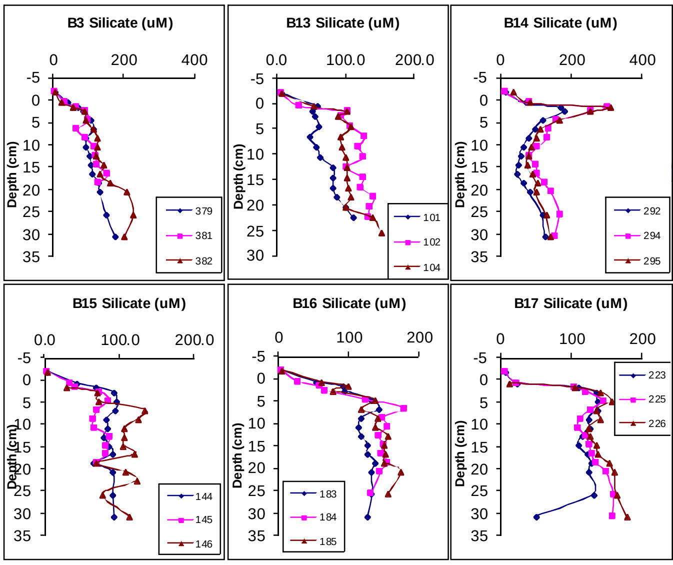
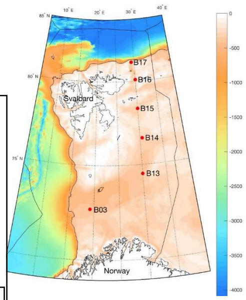
Initial results: silicate





Silicate increases with depth, most rapidly in uppermost sediments

Peaks in upper sediments (B14) or at depth

Porewater $[Si(OH)_4^-]$ >> bottom water $[Si(OH)_4^-]$ – large sedimentary source to water column

Reverse weathering?

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Summary and next steps

- Sedimentary source of nitrate, phosphate and silicic acid to bottom waters
- No significant difference in porewater nutrient concentrations (and fluxes) along N-S transect, nor between N and S of the polar front

- Spatial variability vs. biotic and abiotic forcings
- Temporal variability during austral summers 2017-2019
- Isotopic and geochemical studies of processes controlling porewater chemistry, benthic fluxes and benthic-pelagic coupling

Thank you

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