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*Electronic Supplementary Material*

Benthic-pelagic coupling in the Barents Sea: an integrated data-model framework

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Table S1. Reaction network implemented in the organic matter degradation model for the Barents Sea [1,2].

|  |  |
| --- | --- |
| **Reaction** | **Pathway** |
|  | *Primary redox reactions* |
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|  | *Secondary redox reactions* |
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|  | *Other reactions* |
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HR (Highly Reactive); MR (Moderately Reactive); (PR) Poorly Reactive

Table S2. Stoichiometry and reaction rates implemented in the organic matter degradation model for the Barents Sea [1,2].

|  |  |  |
| --- | --- | --- |
|  | **Stoichiometry** | **Reaction rate** |
|  | *Primary redox reactions* |  |
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|  | *Secondary redox reactions* |  |
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|  | *Other reactions* |  |
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Table S3. General model parameters implemented in the organic matter degradation model for the Barents Sea.

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| --- | --- | --- | --- |
| **Parameter** | **Unit** | **Value** | **Reference** |
| *Transport parameters* |
| Length of model domain |  | cm  | 100 | *This study* |
| Bioirrigation coefficient |  | yr–1 | 10 | [2] |
| Bioirrigation attenuation depth |  | cm | 3.5 | [2] |
| Oxygen molecular diffusion coefficient  |  | cm2 yr–1 | 380.44 | [3] |
| Nitrate molecular diffusion coefficient |  | cm2 yr–1 | 394.58 | [3] |
| Sulfate molecular diffusion coefficient |  | cm2 yr–1 | 173.92 | [3] |
| Ammonium molecular diffusion coefficient |  | cm2 yr–1 | 395.87 | [3] |
| Phosphate molecular diffusion coefficient |  | cm2 yr–1 | 112.35 | [3] |
| Manganese molecular diffusion coefficient |  | cm2 yr–1 | 123.38 | [3] |
| Iron molecular diffusion coefficient |  | cm2 yr–1 | 136.24 | [3] |
| Hydrogen sulfide molecular diffusion coefficient |  | cm2 yr–1 | 331.61 | [3] |
| Porosity |  | – | *Site-specific* | *See table S4* |
| Bioturbation coefficient  |  | cm2 yr–1 | *Site-specific* | *See table S4* |
| Bioturbation depth |  | cm | *Site-specific* | *See table S4* |
| Sedimentation rate |  | cm yr–1 | *Site-specific* | *See table S4* |
|  |  |  |  |  |
| *Reaction parameters* |
| Stoichiometry constants |  | – | 106/12/1 | [2] |
| OM Scaling parameter |  | – | *variable* | [4] |
| OM Shaping parameter  |  | yr | *variable* | [4] |
| OM reactivity – multi-G |  | yr–1 | 10–15 –  | *This study* |
| OM age |  | yr  | *variable* | [5] |
| Oxygen half-saturation constant |  | M | 8.0 ∙ 10–9 | [3] |
| Nitrate half-saturation constant |  | M | 5.0 ∙ 10–9 | [3] |
| Manganese half-saturation constant |  | M | 5.0 ∙ 10–6 | [3] |
| Iron half-saturation constant |  | M | 1.25 ∙ 10–5 | [3] |
| Sulfate half-saturation constant |  | M | 1.0 ∙ 10–7 | [3] |

Table S4. Site-specific transport parameters determined at each studied location in the Barents Sea.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **B13** | **B14** | **B15** | **B16** | **B17** |
| Porosity at sediment-water interface |  | – | 0.89 | 0.91 | 0.92 | 0.82 | 0.82 |
| Porosity at depth |  | – | 0.62 | 0.71 | 0.62 | 0.50 | 0.62 |
| Porosity attenuation |  | – | 0.15 | 0.18 | 0.10 | 0.10 | 0.10 |
| Bioturbation coefficient |  [6] | cm2 yr–1 | 6.0 | 4.0 | 2.0 | 2.5 | 2.0 |
| Bioturbation depth |  [6] | cm | 2 | 4 | 5 | 5 | 4 |
| Sedimentation rate |  [7] | cm yr–1 | 0.05 | 0.05 | 0.06 | 0.05 | 0.05 |
| Temperature |  [8] | ºC | 1.76 | 1.94 | **–**1.50 | **–**1.45 | 1.75 |
| Salinity |  [8] | – | 35 | 35 | 35 | 35 | 35 |
| Water depth |  [8] | m | 355 | 290 | 330 | 294 | 291 |

Table S5. Site-specific reaction parameters determined in this study for each studied location in the Barents Sea. Parameters correspond to reaction network outlined in Table S1 and Table S2.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **B13** | **B14** | **B15** | **B16** | **B17** |
|  | M–1 yr–1 | 1.5 ∙ 107 | 1.5 ∙ 107 | 1.5 ∙ 1011 | 1.5 ∙ 109 | 1.5 ∙ 1010 |
|  | M–1 yr–1 | 2.0 ∙ 108 | 2.0 ∙ 108 | 2.0 ∙ 108 | 2.0 ∙ 109 | 2.0 ∙ 1010 |
|  | M–1 yr–1 | 2.0 ∙ 103 | 2.0 ∙ 103 | 2.0 ∙ 103 | 2.0 ∙ 103 | 2.0 ∙ 103 |
|  | M–1 yr–1 | 2.0 ∙ 104 | 2.0 ∙ 104 | 2.0 ∙ 103 | 2.0 ∙ 103 | 2.0 ∙ 103 |
|  | M–1 yr–1 | 1.0 ∙ 109 |  1.0 ∙ 109 | 1.0 ∙ 1010 | 1.0 ∙ 109 | 1.0 ∙ 109 |
|  | M–1 yr–1 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 |
|  | M–1 yr–1 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 |
|  | M–1 yr–1 | 1.0 ∙ 104 | 1.0 ∙ 104 | 1.0 ∙ 104 | 1.0 ∙ 104 | 1.0 ∙ 104 |
|  | M–1 yr–1 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 | 1.0 ∙ 107 |
|  | M–1 yr–1 | 1.0 ∙ 106 | 1.0 ∙ 106 | 1.0 ∙ 106 | 1.0 ∙ 106 | 1.0 ∙ 106 |
|  | M–1 yr–1 | 1.0 ∙ 103 | 1.0 ∙ 103 | 1.0 ∙ 103 | 1.0 ∙ 103 | 1.0 ∙ 103 |
|  | M–1 yr–1 | 5.0 ∙ 106 | 5.0 ∙ 106 | 5.0 ∙ 106 | 5.0 ∙ 106 | 5.0 ∙ 106 |
|  | M–1 yr–1 | 1.0 ∙ 1013 | 1.0 ∙ 1013 | 1.0 ∙ 1013 | 1.0 ∙ 1013 | 1.0 ∙ 1013 |
|  | M–1 yr–1 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 | 1.0 ∙ 109 |
|  | M–1 yr–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 |
|  | M–1 yr–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 | 6.0 ∙ 10–1 |

Table S6. Model-derived relative contributions of each metabolic pathway to total rates of heterotrophic organic matter degradation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Site** | **Aerobic respiration** | **Denitrification** | **Manganese reduction** | **Iron reduction** | **Sulfate reduction** |
|  | **%** | **%** | **%** | **%** | **%** |
| B13 | 64.1 | 4.2 | 0.5 | 0.5 | 30.8 |
| B14 | 52.6 | 8.3 | 7.3 | 3.1 | 28.7 |
| B15 | 52.9 | 11.6 | 0.01 | 0.4 | 35.1 |
| B16 | 74.6 | 3.8 | 2.9 | 0.4 | 18.2 |
| B17 | 43.6 | 8.2 | 17.0 | 0.8 | 30.4 |

Table S7. Model-derived relative contributions of each transport pathway to total ammonium and phosphate benthic fluxes across the sediment-water interface.

|  |  |  |
| --- | --- | --- |
|  | **Ammonium –**  | **Phosphate –**  |
| **Site** | **Diffusion** | **Bioturbation** | **Bioirrigation** | **Advection** | **Diffusion** | **Bioturbation** | **Bioirrigation** | **Advection** |
|  | **%** | **%** | **%** | **%** | **%** | **%** | **%** | **%** |
| B13 | 59.2 | 1.1 | 39.7 | <0.01 | 90.1 | 5.9 | 4.0 | <0.01 |
| B14 | 92.9 | 1.1 | 6.0 | <0.01 | 94.3 | 3.9 | 1.8 | <0.01 |
| B15 | 31.2 | 0.2 | 68.6 | <0.01 | 90.7 | 2.2 | 7.1 | <0.01 |
| B16 | 76.8 | 0.8 | 22.4 | <0.01 | 93.4 | 3.4 | 3.2 | <0.01 |
| B17 | 82.8 | 0.6 | 16.6 | <0.01 | 94.8 | 2.4 | 2.9 | <0.01 |

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Figure S1. Oxygen concentration profiles measured in bottom waters and sediments along the 30°E S–N transect in the Barents Sea in July 2019 (*RRS* James Clark Ross – JR18006) [9]. Profiles were determined in 2–3 intact cores containing visually undisturbed bottom water and surface sediments from independent megacorer deployments (coloured dots) in each station. Depth profiles measured direct from cores using a *FireSting O2-Mini sensor (Pyro Science)* mounted on a plastic support with a mobile arm which allowed data acquisition at 0.5–1.0 cm scale.Dashed line represents the sediment-water interface. No data available at B17 since this station was inaccessible at the time of sampling.

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Figure S2. Depth evolution of heterotrophic organic matter degradation rates along the 30°E S–N transect in the Barents Sea. Rates are calculated assuming steady-state conditions and are derived from the primary redox reactions in Table S1 and S2. The top row (a–e) shows the depth profiles of total rates of degradation, and the bottom row (f–j) displays the depth evolution of relative contribution for each respiration pathway.

Table S8. Measured downcore concentration profiles used to inform the data-model fitting at site B13 (cruise JR16006 – July 2017).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Porewater** |  |  | **Sediment** |
| **Event** | **Depth** |  |  |  |  |  |  | **Event** | **Depth** |  **(R1)** |  **(R2)** |
|  | **cmbsf** | **µM** | **µM** | **µM** | **µM** | **µM** |  |  | **cmbsf** | **wt%** | **wt%** |
| E101 | 0.5 | 12.8 | 2.1 | 1.2 | 0.0 | 0.0 |  | E101 | 0.25 | 2.25 | 2.201 |
| 1.5 | 11.9 | 2.3 | 1.3 | 0.0 | 0.0 |  | 0.75 | 2.061 | 2.002 |
| 2.5 | 6.6 | 9.4 | 1.2 | 1.1 | 9.8 |  | 1.25 | 1.935 | 1.984 |
| 4.5 | 0.9 | 30.1 | 1.2 | 1.9 | 56.2 |  | 1.75 | 1.874 |  |
| 6.5 | 0.6 | 32.6 | 1.1 | 1.3 | 27.8 |  | 2.5 | 1.829 | 1.946 |
| 8.5 | 0.8 | 39.6 | 2.0 | 1.6 | 26.1 |  | 3.5 | 1.975 | 1.908 |
| 10.5 | 1.9 | 24.8 | 1.2 | 2.3 | 26.6 |  | 4.5 |  | 1.904 |
| 12.5 | 0.7 | 30.5 | 2.6 | 3.4 | 52.8 |  | 5.5 | 1.898 | 1.917 |
| 14.5 | 0.9 | 29.7 | 0.7 | 3.2 | 50.6 |  | 6.5 | 1.776 | 1.796 |
| 16.5 | 1.0 | 31.3 | 0.8 | 3.0 | 48.1 |  | 7.5 | 1.802 | 1.747 |
| 18.5 | 1.0 | 36.6 | 0.5 | 3.2 | 54.1 |  | 8.5 | 1.616 | 1.69 |
| 20.5 | 0.6 | 36.7 | 0.4 | 4.0 | 68.7 |  | 9.5 | 1.525 | 1.432 |
| 25.5 | 0.5 | 37.8 | 0.2 | 3.8 | 68.7 |  | 10.5 | 1.399 | 1.472 |
|  |  |  |  |  |  |  |  | 11.5 | 1.386 | 1.464 |
| E102 | 0.5 | 9.0 | 1.1 | 0.8 | 0.8 | 0.0 |  | 12.5 | 1.373 | 1.458 |
| 1.5 | 6.4 | 9.2 | 1.8 | 10.9 | 45.2 |  | 13.5 | 1.361 | 1.296 |
| 2.5 | 2.5 | 27.2 | 2.6 | 10.5 | 83.6 |  | 14.5 | 1.261 | 1.221 |
| 4.5 | 1.7 | 41.3 | 1.2 | 8.8 | 79.1 |  | 15.5 | 1.257 | 1.237 |
| 6.5 | 0.9 | 46.2 | 1.2 | 11.3 | 112.9 |  | 16.5 | 1.042 | 1.146 |
| 8.5 | 1.3 | 40.2 | 2.2 | 12.6 | 113.0 |  | 17.5 | 1.24 | 1.24 |
| 10.5 | 0.7 | 39.1 | 1.8 | 16.2 | 102.1 |  | 18.5 | 1.109 | 1.196 |
| 12.5 | 2.0 | 24.7 | 3.0 | 7.3 | 37.9 |  | 19.5 | 1.212 | 1.208 |
| 14.5 | 0.6 | 36.3 | 2.4 | 6.1 | 60.7 |  |  |  |  |  |
| 16.5 | 0.8 | 36.5 | 2.6 | 5.1 | 43.8 |  |  |  |  |  |
| 18.5 | 0.7 | 41.8 | 1.5 | 5.6 | 55.2 |  |  |  |  |  |
| 20.5 | 0.5 | 44.9 | 0.4 | 5.3 | 64.4 |  |  |  |  |  |
| 25.5 | 0.7 | 47.5 | 1.1 | 4.7 | 81.3 |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| E104 | 0.5 | 9.3 | 1.9 | 0.8 | 0.9 | 0.0 |  |  |  |  |  |
| 1.5 | 8.6 | 5.3 | 1.8 | 2.7 | 10.1 |  |  |  |  |  |
| 2.5 | 4.0 | 12.7 | 1.8 | 3.6 | 17.4 |  |  |  |  |  |
| 4.5 | 0.4 | 40.1 | 1.0 | 4.6 | 67.7 |  |  |  |  |  |
| 6.5 | 0.7 | 37.4 | 2.3 | 5.2 | 56.1 |  |  |  |  |  |
| 8.5 | 0.5 | 35.0 | 3.3 | 6.1 | 37.7 |  |  |  |  |  |
| 10.5 | 0.6 | 38.2 | 4.2 | 6.8 | 39.4 |  |  |  |  |  |
| 12.5 | 0.7 | 35.8 | 3.9 | 8.7 | 40.6 |  |  |  |  |  |
| 14.5 | 0.5 | 37.3 | 3.9 | 9.0 | 35.4 |  |  |  |  |  |
| 16.5 | 0.5 | 39.4 | 4.2 | 9.7 | 20.7 |  |  |  |  |  |
| 18.5 | 0.5 | 39.7 | 4.7 | 6.2 | 30.7 |  |  |  |  |  |
| 20.5 | 0.3 | 40.6 | 3.4 | 4.5 | 33.0 |  |  |  |  |  |
| 25.5 | 0.7 | 45.1 | 4.1 | 3.5 | 40.3 |  |  |  |  |  |
| 30.5 | 0.6 | 47.0 | 3.9 |  |  |  |  |  |  |  |

Table S9. Measured downcore concentration profiles used to inform the data-model fitting at site B14 (cruise JR16006 – July 2017).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Porewater** |  |  | **Sediment** |
| **Event** | **Depth** |  |  |  |  |  |  | **Event** | **Depth** |  **(R1)** |  **(R2)** |
|  | **cmbsf** | **µM** | **µM** | **µM** | **µM** | **µM** |  |  | **cmbsf** | **wt%** | **wt%** |
| E292 | 0.5 | 13.9 | 3.3 | 1.5 | 15.4 |  |  | E295 | 0.25 | 2.5 | 2.5 |
| 1.5 | 4.6 | 10.3 | 1.2 | 16.9 |  |  | 0.75 | 2.3 | 2.4 |
| 2.5 | 2.4 | 23.3 | 2.4 | 0.0 |  |  | 1.25 | 2.4 | 2.4 |
| 4.5 | 2.9 | 22.9 | 1.8 | 0.0 |  |  | 1.75 | 2.3 | 2.4 |
| 6.5 | 1.7 | 28.2 | 1.6 | 1.4 |  |  | 2.5 | 2.4 |  |
| 8.5 | 1.6 | 24.2 | 1.6 | 2.8 |  |  | 3.5 | 2.4 | 2.4 |
| 10.5 | 1.5 | 22.2 | 1.2 | 2.5 |  |  | 4.5 | 2.3 | 2.2 |
| 12.5 | 1.7 | 19.4 | 1.5 | 2.5 |  |  | 5.5 | 2.4 | 2.3 |
| 14.5 | 1.5 | 19.8 | 1.9 | 4.6 |  |  | 6.5 | 2.2 | 2.1 |
| 16.5 | 1.5 | 19.9 | 2.4 | 2.7 |  |  | 7.5 | 2.2 | 2.2 |
| 18.5 | 1.6 | 26.2 | 3.1 | 2.2 |  |  | 8.5 | 2.2 | 2.2 |
| 20.5 | 2.0 | 33.2 | 3.8 | 1.8 |  |  | 9.5 | 2.0 | 2.0 |
| 25.5 | 2.0 | 44.0 | 6.4 | 1.4 |  |  | 10.5 | 2.1 | 2.0 |
| 30.5 | 2.2 | 48.7 | 7.3 | 1.0 |  |  | 11.5 | 2.1 | 2.2 |
|  |  |  |  |  |  |  |  | 12.5 | 2.0 | 2.1 |
| E294 | 0.5 | 12.0 | 3.3 | 1.0 | 3.2 | 0.0 |  | 13.5 | 2.0 | 2.0 |
| 1.5 | 6.1 | 14.4 | 1.5 | 49.1 | 32.3 |  | 14.5 | 2.0 | 2.0 |
| 2.5 | 2.4 | 32.3 | 5.2 | 26.9 | 126.6 |  | 15.5 | 1.9 |  |
| 4.5 | 1.8 | 33.8 | 5.7 | 15.5 | 125.2 |  | 16.5 | 2.2 | 1.9 |
| 6.5 | 1.4 | 37.3 | 6.2 | 10.1 | 122.8 |  | 17.5 | 1.9 | 1.8 |
| 8.5 | 1.4 | 38.0 | 5.6 | 15.6 | 111.8 |  | 18.5 | 1.9 | 1.8 |
| 10.5 | 1.4 | 34.1 | 7.2 | 6.9 | 99.6 |  | 19.5 |  | 1.9 |
| 12.5 | 1.6 | 32.0 | 4.4 | 6.2 | 77.5 |  | 20.5 | 1.7 | 1.8 |
| 14.5 | 1.5 | 40.9 | 5.2 | 7.3 | 105.3 |  | 21.5 | 1.7 | 1.8 |
| 16.5 | 1.3 | 47.8 | 7.6 | 7.7 | 139.1 |  | 22.5 | 1.7 | 1.7 |
| 18.5 | 1.5 | 49.6 | 6.4 | 8.8 | 126.8 |  | 23.5 | 1.7 | 1.8 |
| 20.5 | 1.4 | 56.9 | 8.1 | 10.2 | 128.3 |  | 24.5 | 1.6 | 1.7 |
| 25.5 | 1.6 | 67.9 | 9.0 | 10.3 | 109.9 |  | 25.5 | 1.7 | 1.7 |
| 30.5 | 1.7 | 66.1 | 9.0 | 11.1 | 104.3 |  | 26.5 | 1.6 | 1.6 |
|  |  |  |  |  |  |  |  | 27.5 | 1.6 | 1.6 |
| E295 | 0.5 | 12.8 | 5.2 | 1.3 | 1.9 | 0.0 |  | 28.5 | 1.6 | 1.6 |
| 1.5 | 5.3 | 19.6 | 3.2 | 31.6 | 91.8 |  | 29.5 | 1.7 | 1.7 |
| 2.5 | 2.2 | 25.6 | 5.2 | 24.6 | 108.1 |  | 30.5 | 1.7 | 1.7 |
| 4.5 | 1.6 | 31.6 | 5.9 | 9.6 | 99.8 |  | 31.5 | 1.6 | 1.6 |
| 6.5 | 1.6 | 26.2 | 3.4 | 5.4 | 62.7 |  | 32.5 | 1.5 | 1.5 |
| 8.5 | 1.5 | 25.4 | 3.2 | 3.1 | 55.9 |  |  |  |  |  |
| 10.5 | 1.7 | 25.6 | 2.8 | 2.8 | 41.6 |  |  |  |  |  |
| 12.5 | 2.1 | 24.2 | 3.4 | 3.7 | 34.0 |  |  |  |  |  |
| 14.5 | 1.6 | 28.4 | 4.8 | 2.5 | 38.2 |  |  |  |  |  |
| 16.5 | 1.6 | 32.3 | 4.9 | 2.4 | 34.8 |  |  |  |  |  |
| 18.5 | 1.5 | 37.5 | 6.2 | 3.0 | 41.9 |  |  |  |  |  |
| 20.5 | 1.7 | 38.2 | 6.2 | 2.9 | 38.7 |  |  |  |  |  |
| 25.5 | 1.5 | 46.4 | 7.9 | 3.5 | 46.3 |  |  |  |  |  |
| 30.5 | 1.5 | 50.2 | 8.4 | 3.2 | 45.2 |  |  |  |  |  |

Table S10. Measured downcore concentration profiles used to inform the data-model fitting at site B15 (cruise JR16006 – July 2017).

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Porewater** |  | **Sediment** |
| **Event** | **Depth** |  |  |  |  |  |  | **Event** | **Depth** |  **(R1)** |  **(R2)** |
|  | **cmbsf** | **µM** | **µM** | **µM** | **µM** | **µM** |  |  | **cmbsf** | **wt%** | **wt%** |
| E144 | 0.5 | 12.3 | 0.6 | 1.8 | 0.0 | 0.0 |  | E144 | 0.25 | 1.7 | 1.7 |
| 1.5 | 14.0 | 0.3 | 1.9 | 0.0 | 0.0 |  | 1.25 | 1.7 | 1.8 |
| 2.5 | 13.7 | 0.6 | 2.2 | 0.0 | 0.0 |  | 1.75 | 1.8 | 1.9 |
| 4.5 | 7.5 | 0.2 | 2.1 | 5.2 | 0.0 |  | 2.5 | 1.8 | 1.8 |
| 6.5 | 1.3 | 1.0 | 2.3 | 22.4 | 0.0 |  | 3.5 | 1.7 | 1.6 |
| 8.5 | 1.9 | 3.4 | 3.1 | 33.8 | 0.0 |  | 4.5 | 1.6 | 1.6 |
| 10.5 | 1.0 | 6.9 | 1.3 | 43.5 | 26.5 |  | 5.5 | 1.5 | 1.6 |
| 12.5 | 2.1 | 7.6 | 0.8 | 38.8 | 49.1 |  | 6.5 | 1.5 | 1.6 |
| 14.5 | 0.7 | 10.5 | 0.7 | 40.4 | 84.0 |  | 7.5 | 1.4 | 1.4 |
| 16.5 | 1.8 | 13.5 | 0.5 | 45.4 | 106.1 |  | 8.5 | 1.4 | 1.5 |
| 18.5 | 1.2 | 10.2 | 0.2 | 47.1 | 113.6 |  | 9.5 | 1.4 | 1.4 |
| 20.5 | 0.8 | 22.2 | 0.8 | 107.6 | 102.5 |  | 10.5 | 1.3 | 1.3 |
| 25.5 | 0.6 | 32.4 | 2.4 | 99.4 | 157.2 |  | 11.5 | 1.4 | 1.5 |
| 30.5 | 0.5 | 35.0 | 1.4 | 106.0 | 168.3 |  | 12.5 | 1.5 | 1.5 |
|  |  |  |  |  |  |  |  | 13.5 | 1.5 | 1.5 |
| E145 | 0.5 | 11.0 | 0.2 | 1.2 | 0.0 | 0.0 |  | 14.5 | 1.5 | 1.4 |
| 1.5 | 11.8 | 0.0 | 1.3 | 0.0 | 0.0 |  | 15.5 | 1.5 | 1.5 |
| 2.5 | 11.3 | 0.1 | 1.7 | 0.0 | 0.0 |  | 16.5 | 1.5 | 1.5 |
| 4.5 | 8.5 | 0.1 | 2.0 | 10.4 | 0.0 |  | 17.5 | 1.5 | 1.4 |
| 6.5 | 3.0 | 1.3 | 1.8 | 41.4 | 0.0 |  | 18.5 | 1.5 | 1.5 |
| 8.5 | 1.7 | 3.8 | 1.3 | 55.4 | 11.9 |  | 19.5 | 1.5 | 1.5 |
| 10.5 | 0.6 | 0.5 |  | 69.2 | 22.1 |  | 20.5 | 1.4 | 1.5 |
| 12.5 | 0.5 | 13.6 |  | 59.7 | 35.9 |  | 21.5 | 1.5 | 1.5 |
| 14.5 | 0.9 | 15.9 |  | 66.3 | 48.8 |  | 22.5 | 1.5 | 1.4 |
| 16.5 | 1.0 | 16.3 |  | 78.1 | 83.0 |  | 23.5 | 1.5 | 1.4 |
| 18.5 | 0.5 | 13.6 |  | 90.4 | 105.0 |  | 24.5 | 1.4 | 1.4 |
| 20.5 |  |  |  |  |  |  | 25.5 | 1.5 | 1.5 |
| 25.5 |  |  |  |  |  |  | 26.5 | 1.4 | 1.4 |
| 30.5 |  |  |  |  |  |  | 27.5 | 1.5 | 1.4 |
|  |  |  |  |  |  |  |  | 28.5 | 1.5 | 1.5 |
| E146 | 0.5 |  | 1.7 | 0.3 | 0.0 | 0.0 |  | 29.5 | 1.4 | 1.5 |
| 1.5 | 11.7 | 1.1 | 0.9 | 0.0 | 0.0 |  | 30.5 | 1.5 | 1.4 |
| 2.5 | 13.5 | 3.2 | 1.2 | 0.0 | 0.0 |  | 31.5 | 1.4 | 1.5 |
| 4.5 | 11.5 | 3.2 | 1.4 | 22.7 | 0.0 |  | 32.5 | 1.3 | 1.3 |
| 6.5 | 4.5 | 1.5 | 1.4 | 104.7 | 14.9 |  |  |  |  |  |
| 8.5 | 1.7 | 6.3 | 1.6 | 82.2 | 0.0 |  |  |  |  |  |
| 10.5 | 1.6 | 9.8 | 1.7 | 98.3 | 0.0 |  |  |  |  |  |
| 12.5 | 1.9 | 10.0 | 1.8 | 93.1 | 0.0 |  |  |  |  |  |
| 14.5 | 0.9 | 15.0 | 1.5 | 91.3 | 0.0 |  |  |  |  |  |
| 16.5 | 0.8 | 17.8 | 1.1 | 70.1 | 192.9 |  |  |  |  |  |
| 18.5 | 0.7 | 14.8 | 0.5 | 74.4 | 134.6 |  |  |  |  |  |
| 20.5 | 1.2 | 23.4 | 0.3 | 74.3 | 105.8 |  |  |  |  |  |
| 22.5 | 1.1 | 26.6 | 0.1 |  |  |  |  |  |  |  |
| 25.5 | 1.2 | 19.7 | 0.2 | 75.1 | 78.2 |  |  |  |  |  |
| 30.5 | 1.3 | 38.9 | 0.2 | 75.1 | 78.2 |  |  |  |  |  |

Table S11. Measured downcore concentration profiles used to inform the data-model fitting at site B16 (cruise JR16006 – July 2017).

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Porewater** |  | **Sediment** |
| **Event** | **Depth** |  |  |  |  |  |  | **Event** | **Depth** |  **(R1)** |  **(R2)** |
|  | **cmbsf** | **µM** | **µM** | **µM** | **µM** | **µM** |  |  | **cmbsf** | **wt%** | **wt%** |
| E183 | 0.5 | 12.1 | 4.2 | 1.2 | 0.0 | 0.0 |  | E183 | 0.25 |  |  |
| 1.5 | 10.5 | 3.2 | 1.6 | 0.0 | 0.0 |  | 0.75 | 1.6 | 1.6 |
| 2.5 | 7.1 | 5.7 | 1.3 | 7.1 | 0.0 |  | 1.25 |  |  |
| 4.5 | 2.6 | 15.8 | 2.2 | 26.5 | 77.6 |  | 1.75 | 1.6 | 1.5 |
| 6.5 | 1.7 | 19.8 | 1.6 | 31.0 | 70.2 |  | 2.5 | 1.4 | 1.4 |
| 8.5 | 1.3 | 19.4 | 1.9 | 20.5 | 45.8 |  | 3.5 | 1.4 | 1.4 |
| 10.5 | 1.4 | 20.6 | 1.7 | 19.7 | 51.3 |  | 4.5 | 1.4 | 1.4 |
| 12.5 | 1.7 | 21.4 | 1.2 | 17.3 | 54.4 |  | 5.5 | 1.3 | 1.3 |
| 14.5 | 1.8 | 21.8 | 0.9 | 20.1 | 56.7 |  | 6.5 |  |  |
| 16.5 | 2.0 | 21.6 | 1.0 | 23.8 | 60.4 |  | 7.5 | 1.3 | 1.3 |
| 18.5 | 1.7 | 23.8 | 0.8 | 22.3 | 64.7 |  | 8.5 | 1.2 | 1.3 |
| 20.5 | 1.9 | 26.5 | 0.9 | 27.1 | 67.2 |  | 9.5 | 1.2 | 1.2 |
| 25.5 | 1.5 | 32.9 | 1.1 | 25.2 | 97.6 |  | 10.5 | 1.5 | 1.5 |
| 30.5 | 1.4 | 36.7 | 2.0 | 23.0 | 97.6 |  | 11.5 | 1.1 | 1.2 |
|  |  |  |  |  |  |  |  | 12.5 | 1.1 | 1.1 |
| E184 | 0.5 | 11.5 | 2.6 | 0.9 | 0.0 | 0.0 |  | 13.5 | 1.1 | 1.2 |
| 1.5 | 9.4 | 2.7 | 1.2 | 1.2 | 0.0 |  | 14.5 | 1.1 | 1.1 |
| 2.5 | 8.4 | 4.0 | 1.4 | 8.5 | 0.0 |  | 15.5 | 1.1 | 1.2 |
| 4.5 | 4.4 | 11.2 | 1.5 | 27.8 | 22.0 |  | 16.5 | 1.1 | 1.1 |
| 6.5 | 1.4 | 23.6 | 1.5 | 38.4 | 57.7 |  | 17.5 | 1.1 | 1.1 |
| 8.5 | 1.6 | 26.1 | 2.0 | 34.4 | 69.2 |  | 18.5 | 1.1 | 1.1 |
| 10.5 | 1.5 | 31.2 | 1.7 | 28.6 | 81.5 |  | 19.5 | 1.1 | 1.1 |
| 12.5 | 1.4 | 29.5 | 1.4 | 27.3 | 78.3 |  | 20.5 |  | 1.1 |
| 14.5 | 2.0 | 33.7 | 1.3 | 28.4 | 87.9 |  | 21.5 | 1.0 | 0.9 |
| 16.5 | 2.1 | 34.6 | 1.5 | 27.8 | 89.7 |  | 22.5 | 1.1 | 1.1 |
| 18.5 | 1.3 | 37.6 | 1.4 | 32.9 | 115.4 |  | 23.5 | 1.0 | 1.0 |
| 20.5 | 1.4 | 33.9 | 0.6 | 23.7 | 87.9 |  | 24.5 | 1.0 | 1.0 |
| 25.5 | 1.4 | 34.6 | 0.7 | 24.2 | 81.6 |  | 25.5 | 1.0 | 1.0 |
|  |  |  |  |  |  |  |  | 26.5 | 1.1 | 1.1 |
| E185 | 0.5 | 12.2 | 5.2 | 1.1 | 0.0 | 0.0 |  |  |  |  |  |
| 1.5 | 8.4 | 3.9 | 1.0 | 0.0 | 0.0 |  |  |  |  |  |
| 2.5 | 6.4 | 4.7 | 1.3 | 6.2 | 0.0 |  |  |  |  |  |
| 4.5 | 1.8 | 25.9 | 1.2 | 17.4 | 54.1 |  |  |  |  |  |
| 6.5 | 2.3 | 14.9 | 1.1 | 14.9 | 28.7 |  |  |  |  |  |
| 8.5 | 1.4 | 19.5 | 0.9 | 18.8 | 43.6 |  |  |  |  |  |
| 10.5 | 5.7 | 24.2 | 1.2 | 16.0 | 61.7 |  |  |  |  |  |
| 12.5 | 1.7 | 29.8 | 1.2 | 18.5 | 70.0 |  |  |  |  |  |
| 14.5 | 1.6 | 29.5 | 0.9 | 20.0 | 70.8 |  |  |  |  |  |
| 16.5 | 2.2 | 30.7 | 1.2 | 22.4 | 71.0 |  |  |  |  |  |
| 18.5 | 2.0 | 33.0 | 1.1 | 23.2 | 76.7 |  |  |  |  |  |
| 20.5 | 1.3 | 39.0 | 0.8 | 26.0 | 108.1 |  |  |  |  |  |
| 25.5 | 1.3 | 37.9 | 1.3 | 27.8 | 111.6 |  |  |  |  |  |

Table S12. Measured downcore concentration profiles used to inform the data-model fitting at site B17 (cruise JR16006 – July 2017).

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Porewater** |  | **Sediment** |
| **Event** | **Depth** |  |  |  |  |  |  | **Event** | **Depth** |  **(R1)** |  **(R2)** |
|  | **cmbsf** | **µM** | **µM** | **µM** | **µM** | **µM** |  |  | **cmbsf** | **wt%** | **wt%** |
| E223 | 0.5 | 12.1 | 0.4 | 0.8 | 0.0 | 0.0 |  | E226 | 0.3 | 1.6 | 1.7 |
| 1.5 | 12.5 | 0.4 | 2.0 | 0.0 | 0.0 |  | 0.5 | 1.7 | 1.8 |
| 2.5 | 3.3 | 3.9 | 1.9 | 65.4 | 0.0 |  | 1.3 | 1.6 | 1.7 |
| 4.5 | 1.4 | 16.4 | 3.5 | 108.1 | 110.4 |  | 1.8 | 1.7 | 1.7 |
| 6.5 | 0.8 | 23.7 | 1.3 | 118.2 | 182.0 |  | 2.5 | 1.5 | 1.6 |
| 8.5 | 1.2 | 25.3 | 4.3 | 122.1 | 117.0 |  | 3.5 | 1.4 | 1.5 |
| 10.5 | 1.2 | 34.9 | 3.8 | 110.7 | 133.5 |  | 4.5 | 1.4 | 1.4 |
| 12.5 | 1.3 | 33.4 | 3.3 | 97.9 | 196.1 |  | 5.5 | 1.2 | 1.3 |
| 14.5 | 0.8 | 32.5 | 1.7 | 77.3 | 152.8 |  | 6.5 | 1.1 | 1.2 |
| 16.5 | 0.9 | 35.0 | 7.8 | 80.5 | 169.4 |  | 7.5 | 1.1 | 1.2 |
| 18.5 | 0.8 | 34.8 | 2.1 | 75.6 | 150.8 |  | 8.5 | 1.1 | 1.1 |
| 20.5 | 1.1 | 33.3 | 2.4 | 72.0 | 126.0 |  | 9.5 | 1.0 | 1.1 |
| 25.5 | 1.8 | 35.6 | 1.5 | 68.9 | 99.6 |  | 10.5 | 1.1 | 1.0 |
| 30.5 | 0.3 | 14.0 | 0.3 | 53.4 | 125.3 |  | 11.5 | 1.0 | 1.0 |
|  |  |  |  |  |  |  |  | 12.5 | 1.0 | 0.9 |
| E225 | 0.5 | 11.6 | 1.4 | 1.0 | 0.0 | 0.0 |  | 13.5 | 1.0 | 1.0 |
| 1.5 | 9.8 | 0.5 | 1.7 | 0.0 | 0.0 |  | 14.5 | 1.1 | 1.0 |
| 2.5 | 6.3 | 2.8 | 1.6 | 35.9 | 0.0 |  | 15.5 | 1.1 | 1.2 |
| 4.5 | 0.8 | 21.5 | 2.8 | 102.2 | 184.1 |  | 16.5 | 1.1 |  |
| 6.5 | 0.7 | 29.4 | 6.2 | 107.0 | 189.4 |  | 17.5 | 1.0 | 1.1 |
| 8.5 | 1.0 | 30.1 | 3.1 | 99.8 | 191.6 |  | 18.5 | 1.0 | 1.1 |
| 10.5 | 0.7 | 35.1 | 5.6 | 87.2 | 211.9 |  | 19.5 | 1.0 | 1.0 |
| 12.5 | 1.2 | 40.4 | 2.2 | 79.8 | 212.6 |  | 20.5 | 0.9 | 0.9 |
| 14.5 | 0.9 | 41.5 | 3.7 | 80.4 | 200.5 |  | 21.5 | 0.8 | 0.9 |
| 16.5 | 1.5 | 42.7 | 2.7 | 75.1 | 192.8 |  | 22.5 | 0.9 | 0.9 |
| 18.5 | 0.9 | 47.0 | 3.6 | 69.7 | 185.8 |  | 23.5 | 0.9 | 0.9 |
| 20.5 | 0.9 | 59.8 | 4.1 | 66.1 | 183.6 |  | 24.5 | 0.9 | 0.9 |
| 25.5 | 0.8 | 51.2 | 4.5 | 63.4 | 172.2 |  | 25.5 | 0.9 | 0.9 |
| 30.5 | 1.0 | 50.9 | 3.8 | 62.4 | 158.8 |  | 26.5 | 0.9 | 0.9 |
|  |  |  |  |  |  |  |  | 27.5 | 0.9 | 0.9 |
| E226 | 0.5 | 11.3 | 0.0 | 0.6 | 0.0 | 0.0 |  | 28.5 | 0.8 | 0.8 |
| 1.5 | 14.0 | 2.3 | 1.2 | 3.0 | 0.0 |  | 29.5 | 0.8 | 0.8 |
| 2.5 | 4.7 | 11.8 | 1.3 | 54.8 | 0.0 |  | 30.5 | 0.8 | 0.8 |
| 4.5 | 1.1 | 18.4 | 2.5 | 180.0 | 57.5 |  | 31.5 | 0.7 | 0.7 |
| 6.5 | 0.9 | 32.1 | 5.6 | 151.4 | 187.5 |  | 32.5 | 0.7 | 0.8 |
| 8.5 | 1.0 | 34.5 | 5.0 | 137.3 | 198.6 |  | 33.5 | 0.8 | 0.8 |
| 10.5 | 1.2 | 35.4 | 5.9 | 120.9 | 164.3 |  |  |  |  |  |
| 12.5 | 1.3 | 43.0 | 2.3 | 98.8 | 224.1 |  |  |  |  |  |
| 14.5 | 1.0 | 45.3 | 3.6 | 96.2 | 208.5 |  |  |  |  |  |
| 16.5 | 0.8 | 39.7 | 1.9 | 96.4 | 211.7 |  |  |  |  |  |
| 18.5 | 1.0 | 49.0 | 4.3 | 91.4 | 198.8 |  |  |  |  |  |
| 20.5 | 0.8 | 48.6 | 2.7 | 83.5 | 207.1 |  |  |  |  |  |
| 25.5 | 1.0 | 46.6 | 2.7 | 75.6 | 175.0 |  |  |  |  |  |
| 30.5 | 1.0 | 59.6 | 2.7 | 68.6 | 152.3 |  |  |  |  |  |

**References**

1. Aguilera DR, Jourabchi P, Spiteri C, Regnier P. 2005 A knowledge-based reactive transport approach for the simulation of biogeochemical dynamics in Earth systems. *Geochem. Geophys. Geosystems* **6**, n/a-n/a. (doi:10.1029/2004GC000899)

2. Thullner M, Dale AW, Regnier P. 2009 Global-scale quantification of mineralization pathways in marine sediments: A reaction-transport modeling approach. *Geochem. Geophys. Geosystems* **10**, n/a-n/a. (doi:10.1029/2009GC002484)

3. Van Cappellen P, Wang Y. 1996 Cycling of iron and manganese in surface sediments; a general theory for the coupled transport and reaction of carbon, oxygen, nitrogen, sulfur, iron, and manganese. *Am. J. Sci.* **296**, 197–243. (doi:10.2475/ajs.296.3.197)

4. Boudreau BP, Ruddick BR. 1991 On a reactive continuum representation of organic matter diagenesis. *Am. J. Sci.* **291**, 507–538. (doi:10.2475/ajs.291.5.507)

5. Mogollón JM, Dale AW, Fossing H, Regnier P. 2012 Timescales for the development of methanogenesis and free gas layers in recently-deposited sediments of Arkona Basin (Baltic Sea). *Biogeosciences* **9**, 1915–1933. (doi:10.5194/bg-9-1915-2012)

6. Solan M, Ward ER, Wood CL, Reed AJ, Grange LJ, Godbold JA. In press. Benthic biodiversity-function relations transition across the Barents Sea Polar Front. *Phil. Trans. R. Soc. A.*

7. Zaborska A, Carroll J, Papucci C, Torricelli L, Carroll ML, Walkusz-Miotk J, Pempkowiak J. 2008 Recent sediment accumulation rates for the Western margin of the Barents Sea. *Deep Sea Res. Part II Top. Stud. Oceanogr.* **55**, 2352–2360. (doi:10.1016/j.dsr2.2008.05.026)

8. Dumont E, Brand T, Hopkins J. 2019 CTD data from NERC Changing Arctic Ocean Cruise JR16006 on the RRS James Clark Ross, Jun-August 2017. (doi:doi:10.5285/89a3a6b8-7223-0b9c-e053-6c86abc0f15d)

9. Barnes DKA. 2019 Changing Arctic Ocean Seafloor JR18006 Cruise Report. , 106.