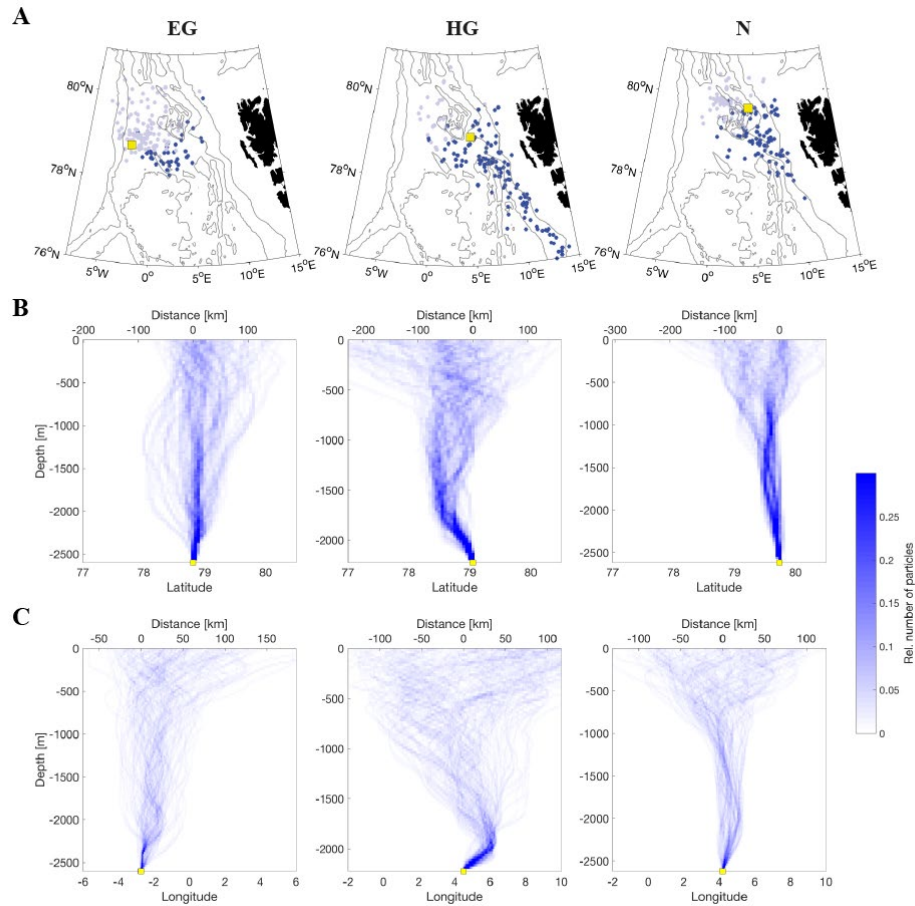


## **Supplementary Information**

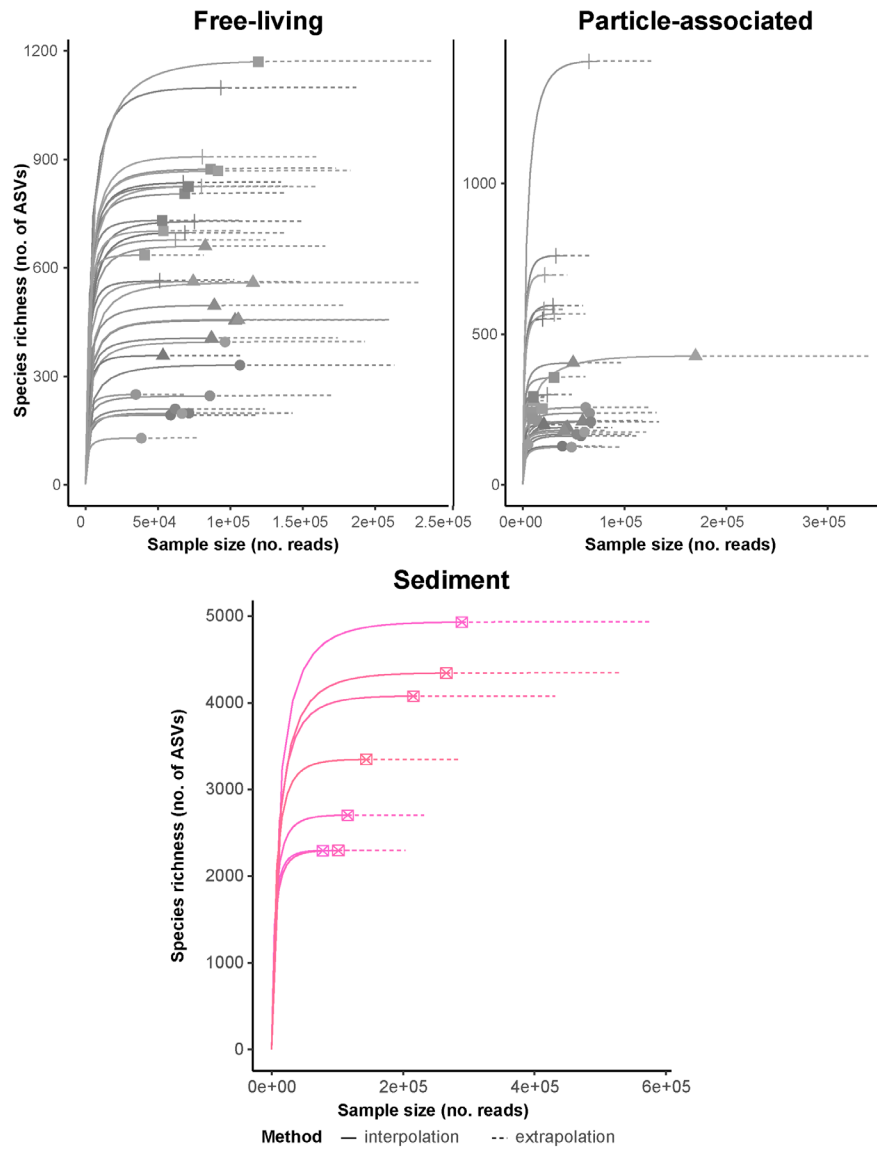
### **Sea-ice retreat may decrease carbon export and vertical microbial connectivity in the Eurasian Arctic basins**

Eduard Fadeev, Andreas Rogge, Simon Ramondenc, Eva-Maria Nöthig, Claudia Wekerle, Christina Bienhold, Ian Salter, Anya M. Waite, Laura Hehemann, Antje Boetius, Morten H. Iversen

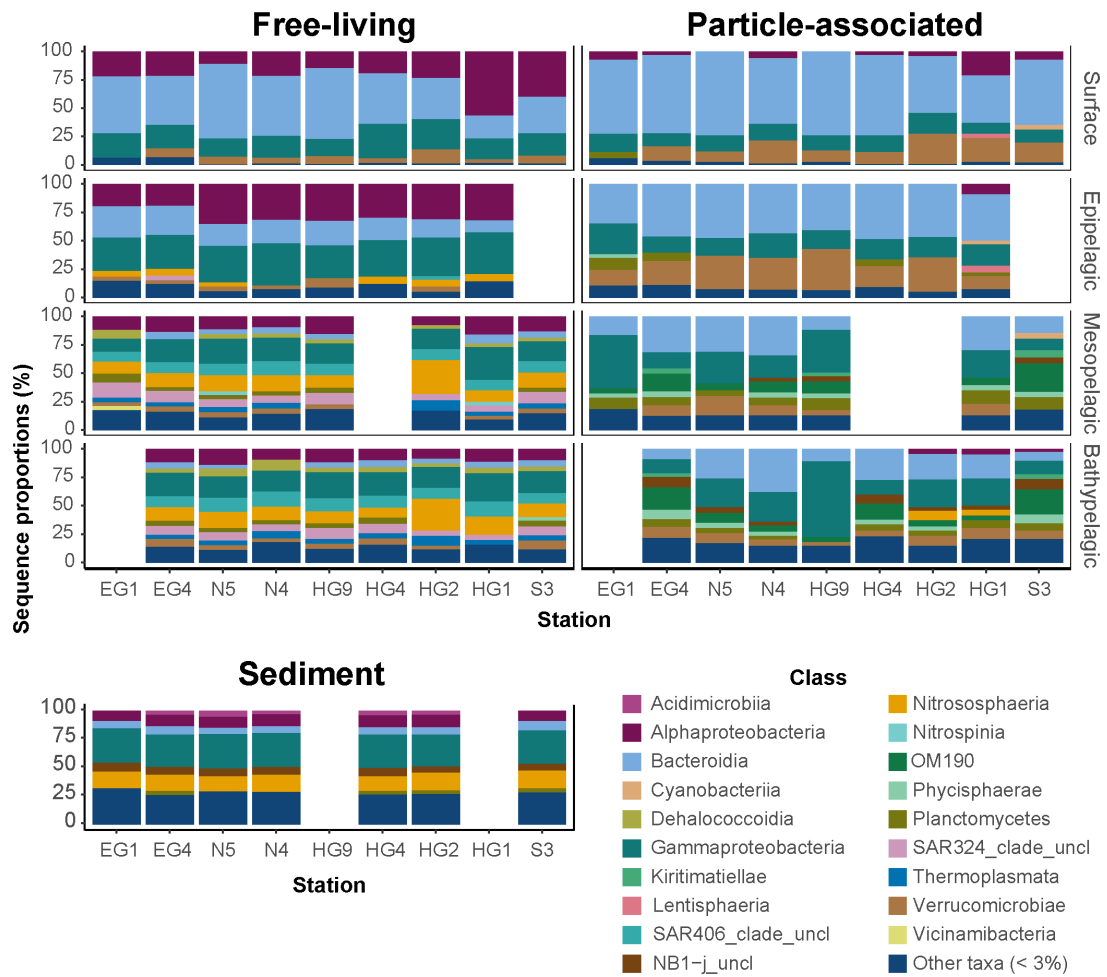
## Figures



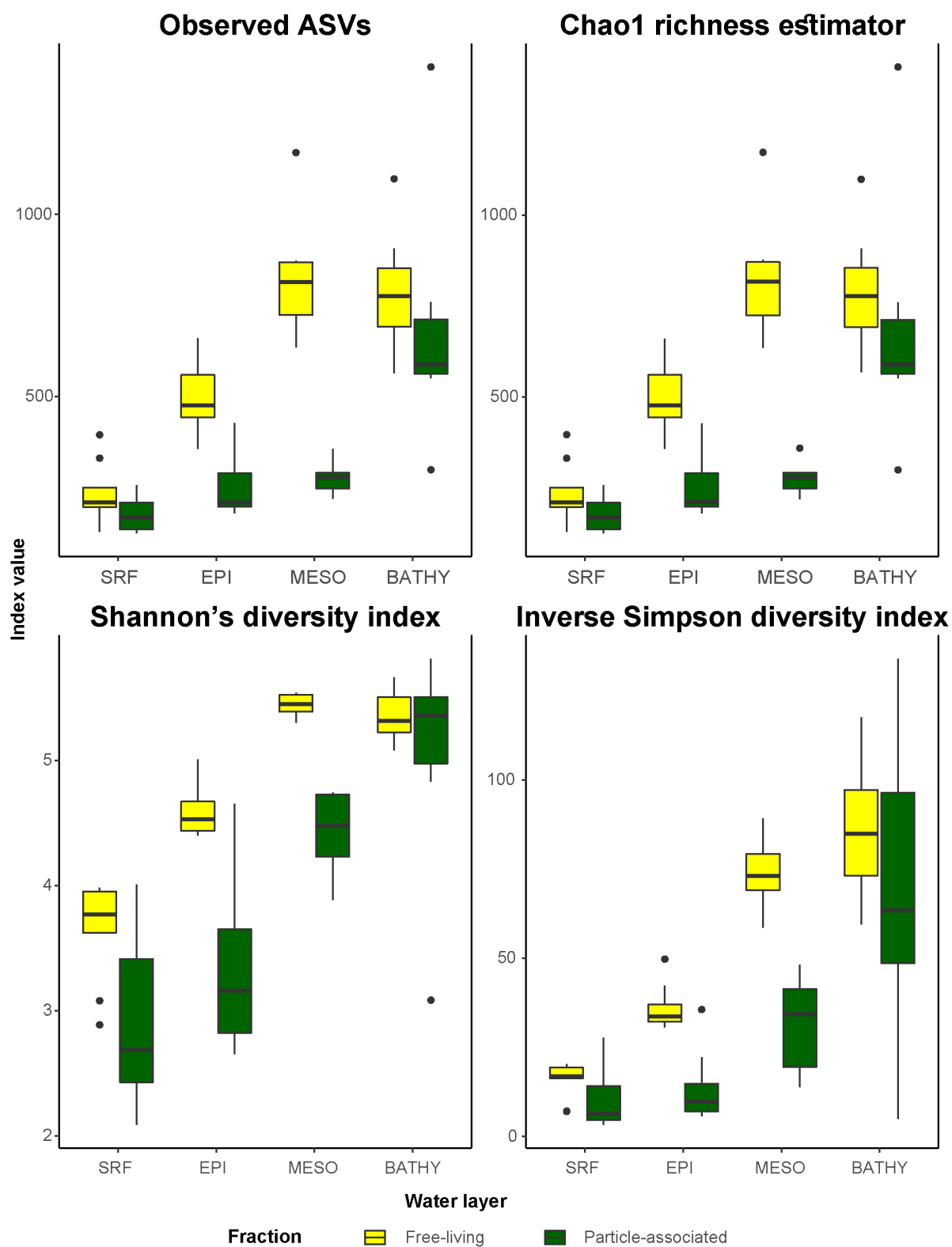
**Supplementary Figure 1:** Sinking trajectories of aggregates across the Fram Strait. Distribution of particle origin in surface (A), and sinking trajectories as a function of latitude (B) and longitude (C). The backward particle trajectories were computed for the time period March-July 2016, based on measured mean sinking velocities (Table 1). In panel A light blue dots represent aggregates originated in ice-covered waters, and dark blue dots represent aggregates originated in ice-free waters. The yellow square indicates the starting point of the backward particle trajectory calculation.



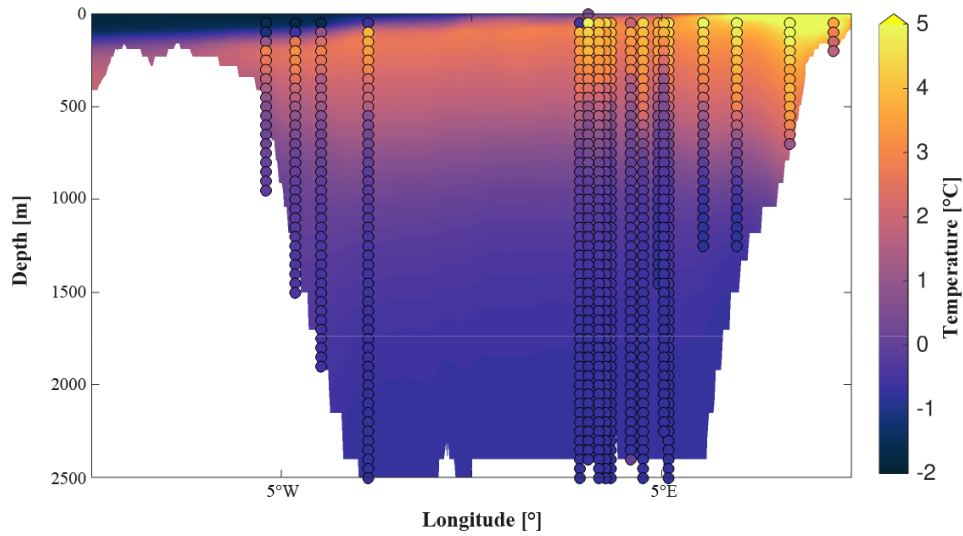
**Supplementary Figure 2:** Rarefactions of 16S rRNA gene analysis of bacterial and archaeal communities. The solid lines represent the observed accumulation with the number of reads sampled, and the dashed lines represent the extrapolated accumulation up to the double amount of reads. The observed values for each community are denoted by solid shapes. Sample-size-based rarefaction curves generated with the R-package “iNEXT”, based on the Hill number of order  $q = 0$ . The rarefaction curves for each sample were generated based on 40 equally spaced rarefied sample sizes with 100 iterations.



**Supplementary Figure 3:** Sequence proportion overview of bacterial and archaeal classes in free-living and particle-associated communities, and uppermost centimeter of deep-sea sediment. The classes represented by colors according to the legend, all classes with sequence proportion below 3% were classified as “Other classes”.



**Supplementary Figure 4:** Calculated alpha diversity indices of free-living and particle-associated bacterial and archaeal communities along the water column. The x-axis values represent the four distinct water layers: SRF - surface (10 - 30 m), EPI - epipelagic (100 m), MESO - mesopelagic (1000 m) and BATHY - bathypelagic (~50 m above the seafloor).



**Supplementary Figure 5:** Comparison of modeled and *in situ* measured water temperature across the Fram Strait. The background represents the mean model results for July 2016, which have been overlaid with the *in situ* measurements from the PS99.2 expedition. The division between warm Atlantic Water (AW) in the eastern Fram Strait and cold Arctic water in the western Fram Strait, the intermediate mixed Atlantic Water, and the cold Eurasian Basin Deep Water at bathypelagic depths, are clear in both the modeled results and the *in situ* measurements.

## Tables

**Supplementary Table 1: Microscopy counts of protists communities in chlorophyll a max. depth across the Fram Strait.** All cell concentrations are provided in cells ml<sup>-1</sup>.

| Region                                                           | ice-covered |            |            |            | ice-free   |            |
|------------------------------------------------------------------|-------------|------------|------------|------------|------------|------------|
| Station Name                                                     | EG1         | EG4        | N5         | N4         | HG4        | S3         |
| PANGAEA StationID                                                | PS99/51-02  | PS99/48-11 | PS99/52-02 | PS99/55-01 | PS99/42-11 | PS99/41-06 |
| Depth [m]                                                        | 13          | 10         | 19         | 22         | 28         | 28         |
| <b>Autotrophic Protists</b>                                      |             |            |            |            |            |            |
| Diatoms (pennate and centric)                                    | 148         | 65         | 14         | 119        | 29         | 57         |
| <i>Phaeocystis spp.</i>                                          | 163         | 13178      | 9401       | 5047       | 4007       | 165        |
| Coccolithophores                                                 | 2           | 7          | 2          | 3          | 2          | 44         |
| Nanoflagellates (others)                                         | 109         | 67         | 128        | 92         | 88         | 103        |
| <i>Prorocentrum spp.</i> (autotrophic dinoflagellate)            | 109         | 67         | 128        | 92         | 88         | 103        |
| <i>Myrionecta rubra</i> (ciliate with autotrophic endosymbionts) | 2           | 14         | 2          | 7          | 0          | 0          |
| <b>Heterotrophic Protists</b>                                    |             |            |            |            |            |            |
| Dinoflagellates                                                  | 65          | 54         | 162        | 131        | 46         | 138        |
| Ciliates                                                         | 2           | 18         | 8          | 25         | 2          | 9          |
| Tintinnids                                                       | 0           | 2          | 2          | 1          | 1          | 1          |

**Supplementary Table 2: Overview of microbial samples collected during RV Polarstern expedition PS99.2.** The table consists of sampling information for each station, number of sequences and calculated alpha diversity indices.

| PANGAEA StationID | Station Name | Lat (°N) | Long (°E) | Ice covered? | Layer    | Depth (m) | Fraction | No of sequences | No of ASVs | Chao1 richness | Shannon diversity index ( <i>H</i> ) | Inverse Simpsons diversity index |
|-------------------|--------------|----------|-----------|--------------|----------|-----------|----------|-----------------|------------|----------------|--------------------------------------|----------------------------------|
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | SRF      | 13        | FL       | 100072          | 395        | 396            | 3.95                                 | 16.56                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | SRF      | 13        | PA       | 47419           | 135        | 135.17         | 4.01                                 | 27.65                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | EPI      | 100       | FL       | 75445           | 562        | 562.12         | 4.91                                 | 42.38                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | EPI      | 100       | PA       | 48461           | 251        | 251.43         | 4.04                                 | 22.19                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | MESO     | 971       | FL       | 40802           | 635        | 635            | 5.54                                 | 83.08                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | MESO     | 971       | PA       | 45912           | 242        | 242            | 4.08                                 | 13.79                            |
| PS99/051-2        | EG1          | 78.99    | -5.42     | yes          | Sediment | 1002      | Sediment | 102302          | 2296       | 2296.47        | 6.81                                 | 333.29                           |
| PS99/048-11       | EG4          | 78.82    | -2.73     | yes          | SRF      | 24        | FL       | 42408           | 250        | 250.12         | 3.96                                 | 16.36                            |
| PS99/048-11       | EG4          | 78.82    | -2.73     | yes          | SRF      | 24        | PA       | 92652           | 257        | 257            | 2.69                                 | 4.6                              |
| PS99/048-11       | EG4          | 78.82    | -2.73     | yes          | EPI      | 100       | FL       | 84058           | 660        | 660.3          | 5.01                                 | 49.74                            |
| PS99/048-11       | EG4          | 78.82    | -2.73     | yes          | EPI      | 100       | PA       | 48650           | 209        | 209            | 3.52                                 | 12.09                            |
| PS99/048-1        | EG4          | 78.82    | -2.73     | yes          | MESO     | 1000      | FL       | 87599           | 873        | 876.5          | 5.4                                  | 67.09                            |
| PS99/048-1        | EG4          | 78.82    | -2.73     | yes          | MESO     | 1000      | PA       | 22240           | 219        | 219            | 4.38                                 | 34.26                            |
| PS99/048-1        | EG4          | 78.82    | -2.73     | yes          | BATHY    | 2527      | FL       | 62259           | 677        | 677            | 5.24                                 | 77.17                            |
| PS99/048-1        | EG4          | 78.82    | -2.73     | yes          | BATHY    | 2527      | PA       | 23950           | 582        | 582.21         | 5.3                                  | 67.94                            |
| PS99/048-1        | EG4          | 78.82    | -2.73     | yes          | Sediment | 2604      | Sediment | 116030          | 2705       | 2705.69        | 7.02                                 | 469.45                           |
| PS99/055-1        | N4           | 79.74    | 4.51      | yes          | SRF      | 22        | FL       | 88632           | 210        | 210            | 3.68                                 | 17.96                            |
| PS99/055-1        | N4           | 79.74    | 4.51      | yes          | SRF      | 22        | PA       | 69065           | 168        | 168            | 2.81                                 | 7.01                             |
| PS99/055-1        | N4           | 79.74    | 4.51      | yes          | EPI      | 100       | FL       | 103789          | 455        | 455.6          | 4.4                                  | 30.63                            |
| PS99/055-1        | N4           | 79.74    | 4.51      | yes          | EPI      | 100       | PA       | 67340           | 190        | 190            | 2.83                                 | 7.44                             |
| PS99/055-7        | N4           | 79.74    | 4.51      | yes          | MESO     | 1000      | FL       | 73605           | 825        | 825.86         | 5.47                                 | 73.33                            |
| PS99/055-7        | N4           | 79.74    | 4.51      | yes          | MESO     | 1000      | PA       | 16773           | 290        | 290.11         | 4.74                                 | 48.1                             |
| PS99/055-7        | N4           | 79.74    | 4.51      | yes          | BATHY    | 2500      | FL       | 93569           | 1098       | 1098.4         | 5.66                                 | 117.51                           |
| PS99/055-7        | N4           | 79.74    | 4.51      | yes          | BATHY    | 2500      | PA       | 36841           | 595        | 595.05         | 4.83                                 | 38.08                            |
| PS99/055-7        | N4           | 79.74    | 4.51      | yes          | Sediment | 2625      | Sediment | 215774          | 4077       | 4077.63        | 7.21                                 | 446.95                           |

|             |     |       |      |     |          |      |          |        |      |         |      |        |
|-------------|-----|-------|------|-----|----------|------|----------|--------|------|---------|------|--------|
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | SRF      | 19   | FL       | 82376  | 129  | 129     | 2.89 | 7.14   |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | SRF      | 19   | PA       | 72459  | 125  | 125     | 2.09 | 3.3    |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | EPI      | 100  | FL       | 105894 | 457  | 457     | 4.44 | 30.89  |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | EPI      | 100  | PA       | 69530  | 180  | 180     | 2.81 | 7.06   |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | MESO     | 1000 | FL       | 56871  | 702  | 702.33  | 5.35 | 72.93  |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | MESO     | 1000 | PA       | 42994  | 253  | 253     | 3.89 | 17.71  |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | BATHY    | 2427 | FL       | 81053  | 907  | 907.4   | 5.52 | 108.05 |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | BATHY    | 2427 | PA       | 47617  | 567  | 567.43  | 5.02 | 52.07  |
| PS99/053-2  | N5  | 79.92 | 3.06 | yes | Sediment | 2604 | Sediment | 266731 | 4343 | 4346.42 | 7.13 | 418.86 |
| PS99/066-5  | HG1 | 79.14 | 6.09 | no  | SRF      | 17   | FL       | 89522  | 246  | 249     | 3.98 | 19.37  |
| PS99/066-5  | HG1 | 79.14 | 6.09 | no  | SRF      | 17   | PA       | 79111  | 238  | 238.33  | 3.95 | 24.39  |
| PS99/066-5  | HG1 | 79.14 | 6.09 | no  | EPI      | 100  | FL       | 90603  | 496  | 496.3   | 4.59 | 32.89  |
| PS99/066-5  | HG1 | 79.14 | 6.09 | no  | EPI      | 100  | PA       | 54571  | 405  | 405.33  | 4.65 | 35.61  |
| PS99/066-2  | HG1 | 79.14 | 6.09 | no  | MESO     | 500  | FL       | 69054  | 805  | 807.33  | 5.52 | 78     |
| PS99/066-2  | HG1 | 79.14 | 6.09 | no  | MESO     | 500  | PA       | 44706  | 356  | 359     | 4.74 | 47.21  |
| PS99/066-2  | HG1 | 79.14 | 6.09 | no  | BATHY    | 1253 | FL       | 76181  | 728  | 728.91  | 5.21 | 59.43  |
| PS99/066-2  | HG1 | 79.14 | 6.09 | no  | BATHY    | 1253 | PA       | 54021  | 760  | 760.16  | 5.72 | 134    |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | SRF      | 22   | FL       | 127252 | 331  | 331.11  | 3.8  | 19.34  |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | SRF      | 22   | PA       | 77470  | 209  | 209     | 2.64 | 6.33   |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | EPI      | 100  | FL       | 116371 | 559  | 559.83  | 4.55 | 35.23  |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | EPI      | 100  | PA       | 200555 | 427  | 427     | 2.83 | 7.03   |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | MESO     | 1000 | FL       | 119432 | 1170 | 1172.44 | 5.3  | 58.57  |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | BATHY    | 1500 | FL       | 68834  | 697  | 697.09  | 5.08 | 61.21  |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | BATHY    | 1500 | PA       | 87070  | 1405 | 1407.23 | 5.81 | 96.31  |
| PS99/057-1  | HG2 | 79.13 | 4.91 | no  | Sediment | 1540 | Sediment | 144608 | 3346 | 3346.4  | 7.15 | 434.99 |
| PS99/042-11 | HG4 | 79.06 | 4.18 | no  | SRF      | 28   | FL       | 73032  | 193  | 193     | 3.62 | 16.85  |
| PS99/042-11 | HG4 | 79.06 | 4.18 | no  | SRF      | 28   | PA       | 55574  | 128  | 128     | 2.43 | 5.29   |
| PS99/042-11 | HG4 | 79.06 | 4.18 | no  | EPI      | 100  | FL       | 54083  | 357  | 357     | 4.5  | 34.39  |
| PS99/042-11 | HG4 | 79.06 | 4.18 | no  | EPI      | 100  | PA       | 58695  | 200  | 200     | 3.49 | 12.37  |
| PS99/042-1  | HG4 | 79.06 | 4.18 | no  | BATHY    | 2462 | FL       | 67887  | 835  | 836.91  | 5.5  | 93.54  |
| PS99/042-13 | HG4 | 79.06 | 4.18 | no  | BATHY    | 2462 | PA       | 28981  | 550  | 550.75  | 5.43 | 96.73  |

|             |     |       |      |    |          |      |          |        |         |         |        |        |
|-------------|-----|-------|------|----|----------|------|----------|--------|---------|---------|--------|--------|
| PS99/042-13 | HG4 | 79.06 | 4.18 | no | Sediment | 2460 | Sediment | 289702 | 4931    | 4933.85 | 7.33   | 507.23 |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | SRF      | 24   | FL       | 84265  | 198     | 198     | 3.08   | 7.03   |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | SRF      | 24   | PA       | 73332  | 162     | 162     | 2.21   | 3.61   |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | EPI      | 100  | FL       | 87844  | 406     | 406.43  | 4.44   | 32.58  |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | EPI      | 100  | PA       | 76560  | 211     | 212.5   | 2.65   | 5.73   |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | MESO     | 1000 | FL       | 52959  | 731     | 731.09  | 5.54   | 89.24  |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | MESO     | 1000 | PA       | 16983  | 293     | 293     | 4.48   | 21.19  |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | BATHY    | 2499 | FL       | 51577  | 564     | 567.33  | 5.23   | 85.24  |
| PS99/059-2  | HG9 | 79.13 | 2.84 | no | BATHY    | 2499 | PA       | 44906  | 299     | 299.17  | 3.08   | 4.9    |
| PS99/041-6  | S3  | 78.61 | 5.05 | no | SRF      | 28   | FL       | 67254  | 197     | 197     | 3.77   | 20.31  |
| PS99/041-6  | S3  | 78.61 | 5.05 | no | SRF      | 28   | PA       | 69873  | 175     | 175     | 3.41   | 14.19  |
| PS99/041-1  | S3  | 78.61 | 5.05 | no | MESO     | 1000 | FL       | 91629  | 868     | 868.6   | 5.43   | 69.71  |
| PS99/041-1  | S3  | 78.61 | 5.05 | no | MESO     | 1000 | PA       | 18517  | 279     | 279.11  | 4.71   | 35.49  |
| PS99/041-1  | S3  | 78.61 | 5.05 | no | BATHY    | 2338 | FL       | 80160  | 825     | 825.06  | 5.39   | 84.49  |
| PS99/041-1  | S3  | 78.61 | 5.05 | no | BATHY    | 2338 | PA       | 34827  | 696     | 696.08  | 5.42   | 58.95  |
| PS99/041-1  | S3  | 78.61 | 5.05 | no | Sediment | 2344 | Sediment | 2295   | 2296.15 | 7.04    | 545.83 | 2295   |

**Supplementary Table 3: List of taxonomic groups with significantly enriched ASVs with depth along the water column.**

| Phylum            | Class               | Order                              | Family                | Genus                              | ice-covered | ice-free |
|-------------------|---------------------|------------------------------------|-----------------------|------------------------------------|-------------|----------|
| Planctomycetota   | OM190               | OM190_uncl                         | OM190_uncl            | OM190_uncl                         | 19          | 35       |
| NB1-j             | NB1-j_uncl          | NB1-j_uncl                         | NB1-j_uncl            | NB1-j_uncl                         | 13          | 21       |
| Bdellovibrionota  | Bdellovibrionia     | Bdellovibrionales                  | Bdellovibrionaceae    | OM27_clade                         | 6           | 15       |
| Planctomycetota   | Planctomycetes      | Pirellulales                       | Pirellulaceae         | Pirellulaceae_uncl                 | 6           | 8        |
| Crenarchaeota     | Nitrososphaeria     | Nitrosopumilales                   | Nitrosopumilaceae     | Candidatus_Nitrosopumilus          | 4           | 12       |
| Planctomycetota   | Planctomycetes      | Pirellulales                       | Pirellulaceae         | Rhodopirellula                     | 4           | 9        |
| Planctomycetota   | Planctomycetes      | Planctomycetales                   | Planctomycetales_uncl | Planctomycetales_uncl              | 4           | 4        |
| Planctomycetota   | Planctomycetes      | Planctomycetales                   | Rubinisphaeraceae     | Rubinisphaeraceae_uncl             | 4           | 3        |
| Planctomycetota   | Phycisphaerae       | Phycisphaerales                    | Phycisphaeraceae      | JL-ETNP-F27                        | 3           | 8        |
| Proteobacteria    | Gammaproteobacteria | Steroidobacterales                 | Woeseiaceae           | Woeseia                            | 3           | 7        |
| Desulfobacterota  | Desulfuromonadia    | Bradymonadales                     | Bradymonadales_uncl   | Bradymonadales_uncl                | 3           | 5        |
| Planctomycetota   | BD7-11              | BD7-11_uncl                        | BD7-11_uncl           | BD7-11_uncl                        | 3           | 5        |
| Planctomycetota   | Planctomycetes      | Pirellulales                       | Pirellulaceae         | Blastopirellula                    | 3           | 4        |
| Proteobacteria    | Gammaproteobacteria | Gammaproteobacteria_Incertae Sedis | Unknown_Family        | Unknown_Family_uncl                | 3           | 2        |
| Planctomycetota   | Planctomycetes      | Pirellulales                       | Pirellulaceae         | Bythopirellula                     | 3           | 1        |
| Planctomycetota   | Phycisphaerae       | Phycisphaerales                    | Phycisphaeraceae      | CL500-3                            | 2           | 6        |
| Planctomycetota   | Pla3_lineage        | Pla3_lineage_uncl                  | Pla3_lineage_uncl     | Pla3_lineage_uncl                  | 2           | 6        |
| Bacteria_uncl     | Bacteria_uncl       | Bacteria_uncl                      | Bacteria_uncl         | Bacteria_uncl                      | 2           | 5        |
| Planctomycetota   | Planctomycetes      | Pirellulales                       | Pirellulaceae         | Pir4_lineage                       | 2           | 5        |
| Verrucomicrobiota | Kiritimatiellae     | WCHB1-41                           | WCHB1-41_uncl         | WCHB1-41_uncl                      | 2           | 5        |
| Desulfobacterota  | Desulfuromonadia    | PB19                               | PB19_uncl             | PB19_uncl                          | 2           | 4        |
| Verrucomicrobiota | Lentisphaeria       | Lentisphaerales                    | Lentisphaeraceae      | Lentisphaera                       | 2           | 3        |
| Planctomycetota   | Phycisphaerae       | Phycisphaerales                    | Phycisphaeraceae      | Urania-1B-19 marine sediment group | 2           | 2        |
| Actinobacteriota  | Acidimicrobiia      | Actinomarinales                    | Actinomarinales_uncl  | Actinomarinales_uncl               | 2           | 2        |
| Myxococcota       | Polyangia           | Haliangiales                       | Haliangiaceae         | Haliangium                         | 2           | 2        |

|                               |                                    |                                    |                                    |                                    |   |    |
|-------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|---|----|
| Bacteroidota                  | Bacteroidia                        | Flavobacteriales                   | Crocinitomicaceae                  | Crocinitomicaceae_uncl             | 2 | 1  |
| Proteobacteria                | Gammaproteobacteria                | AT-s2-59                           | AT-s2-59_uncl                      | AT-s2-59_uncl                      | 2 | 1  |
| Gemmatimonadota               | BD2-11_terrestrial_group           | BD2-11_terrestrial_group_uncl      | BD2-11_terrestrial_group_uncl      | BD2-11_terrestrial_group_uncl      | 2 | 1  |
| Verrucomicrobiota             | Verrucomicrobiae                   | Verrucomicrobiales                 | Rubritaleaceae                     | Luteolibacter                      | 2 |    |
| Bacteroidota                  | Bacteroidia                        | Flavobacteriales                   | NS9_marine_group                   | NS9_marine_group_uncl              | 1 | 10 |
| Verrucomicrobiota             | Verrucomicrobiae                   | Verrucomicrobiales                 | Rubritaleaceae                     | Roseibacillus                      | 1 | 5  |
| Marinimicrobia_(SAR406_clade) | Marinimicrobia_(SAR406_clade)_uncl | Marinimicrobia_(SAR406_clade)_uncl | Marinimicrobia_(SAR406_clade)_uncl | Marinimicrobia_(SAR406_clade)_uncl | 1 | 4  |
| Planctomycetota               | Planctomycetes                     | Planctomycetales                   | Gimesiaceae                        | Gimesiaceae_uncl                   | 1 | 3  |
| Nitrospinota                  | Nitrospina                         | Nitrospinales                      | Nitrospinaceae                     | LS-NOB                             | 1 | 3  |
| Crenarchaeota                 | Nitrososphaeria                    | Nitrosopumilales                   | Nitrosopumilaceae                  | Nitrosopumilaceae_uncl             | 1 | 3  |
| Planctomycetota               | 028H05-P-BN-P5                     | 028H05-P-BN-P5_uncl                | 028H05-P-BN-P5_uncl                | 028H05-P-BN-P5_uncl                | 1 | 3  |
| Bacteroidota                  | Bacteroidia                        | Chitinophagales                    | Saprospiraceae                     | Aureispira                         | 1 | 3  |
| Myxococcota                   | Polyangia                          | Blfdi19                            | Blfdi19_uncl                       | Blfdi19_uncl                       | 1 | 3  |
| Proteobacteria                | Alphaproteobacteria                | SAR11_clade                        | Clade_II                           | Clade_II_uncl                      | 1 | 3  |
| Hydrogenedentes               | Hydrogenedentia                    | Hydrogenedentiales                 | Hydrogenedensaceae                 | Hydrogenedensaceae_uncl            | 1 | 3  |
| Thermoplasmatota              | Thermoplasmata                     | Marine_Group_II                    | Marine_Group_II_uncl               | Marine_Group_II_uncl               | 1 | 3  |
| Bacteroidota                  | Bacteroidia                        | Flavobacteriales                   | Crocinitomicaceae                  | Salinirepens                       | 1 | 3  |
| Proteobacteria                | Gammaproteobacteria                | Arenicellales                      | Arenicellaceae                     | Arenicellaceae_uncl                | 1 | 2  |
| Proteobacteria                | Gammaproteobacteria                | Cellvibrionales                    | Haliaceae                          | Marimicrobium                      | 1 | 2  |
| Desulfobacterota              | Desulfobacterota_uncl              | Desulfobacterota_uncl              | Desulfobacterota_uncl              | Desulfobacterota_uncl              | 1 | 2  |
| Planctomycetota               | Phycisphaerae                      | Phycisphaerales                    | Phycisphaeraceae                   | FS140-16B-02_marine_group          | 1 | 2  |
| Planctomycetota               | Phycisphaerae                      | Phycisphaerales                    | Phycisphaeraceae                   | Phycisphaeraceae_uncl              | 1 | 2  |
| Proteobacteria                | Gammaproteobacteria                | Oceanospirillales                  | Pseudohongiellaceae                | Pseudohongiella                    | 1 | 2  |
| Proteobacteria                | Alphaproteobacteria                | Rhodospirillales                   | Magnetospiraceae                   | Magnetospira                       | 1 | 1  |
| Actinobacteriota              | Actinobacteria                     | Corynebacteriales                  | Mycobacteriaceae                   | Mycobacterium                      | 1 | 1  |
| Verrucomicrobiota             | Lentisphaeria                      | P.palmC41                          | P.palmC41_uncl                     | P.palmC41_uncl                     | 1 | 1  |
| Verrucomicrobiota             | Verrucomicrobiae                   | Verrucomicrobiales                 | Rubritaleaceae                     | Rubritalea                         | 1 | 1  |
| Dependentiae                  | Babeliae                           | Babeliales                         | Babeliales_uncl                    | Babeliales_uncl                    | 1 | 1  |
| Proteobacteria                | Gammaproteobacteria                | Alteromonadales                    | Moritellaceae                      | Moritella                          | 1 | 1  |
| Myxococcota                   | Polyangia                          | Nannocystales                      | Nannocystaceae                     | Nannocystaceae_uncl                | 1 | 1  |

|                   |                     |                          |                               |                               |   |   |
|-------------------|---------------------|--------------------------|-------------------------------|-------------------------------|---|---|
| Proteobacteria    | Gammaproteobacteria | OM182_clade              | OM182_clade_uncl              | OM182_clade_uncl              | 1 | 1 |
| Bdellovibrionota  | Oligoflexia         | 053A03-B-DI-P58          | 053A03-B-DI-P58_uncl          | 053A03-B-DI-P58_uncl          | 1 | 1 |
| Proteobacteria    | Alphaproteobacteria | Rickettsiales            | AB1                           | AB1_uncl                      | 1 | 1 |
| Bdellovibrionota  | Bdellovibrionia     | Bacteriovorales          | Bacteriovoraceae              | Bacteriovoraceae_uncl         | 1 | 1 |
| Proteobacteria    | Gammaproteobacteria | Alteromonadales          | Colwelliaceae                 | Colwellia                     | 1 | 1 |
| Proteobacteria    | Gammaproteobacteria | EPR3968-O8a-Bc78         | EPR3968-O8a-Bc78_uncl         | EPR3968-O8a-Bc78_uncl         | 1 | 1 |
| Proteobacteria    | Alphaproteobacteria | Rhizobiales              | Hyphomicrobiaceae             | Hyphomicrobiaceae_uncl        | 1 | 1 |
| Proteobacteria    | Gammaproteobacteria | Burkholderiales          | Nitrosomonadaceae             | IS-44                         | 1 | 1 |
| Proteobacteria    | Gammaproteobacteria | Oceanospirillales        | Kangiellaceae                 | Kangiellaceae_uncl            | 1 | 1 |
| Chloroflexi       | KD4-96              | KD4-96_uncl              | KD4-96_uncl                   | KD4-96_uncl                   | 1 | 1 |
| Bacteroidota      | Bacteroidia         | Sphingobacteriales       | Lentimicrobiaceae             | Lentimicrobiaceae_uncl        | 1 | 1 |
| Verrucomicrobiota | Lentisphaeria       | Lentisphaeria_uncl       | Lentisphaeria_uncl            | Lentisphaeria_uncl            | 1 | 1 |
| Myxococcota       | Myxococcia          | Myxococcales             | Myxococcaceae                 | P3OB-42                       | 1 | 1 |
| RCP2-54           | RCP2-54_uncl        | RCP2-54_uncl             | RCP2-54_uncl                  | RCP2-54_uncl                  | 1 | 1 |
| Myxococcota       | Polyangia           | Polyangiales             | Sandaracinaceae               | Sandaracinaceae_uncl          | 1 | 1 |
| Myxococcota       | Polyangia           | Polyangiales             | Sandaracinaceae               | Sandaracinus                  | 1 | 1 |
| Actinobacteriota  | Acidimicrobiia      | Microtrichales           | Microtrichaceae               | Sva0996_marine_group          | 1 | 1 |
| Bacteroidota      | Bacteroidia         | Flavobacteriales         | Flavobacteriaceae             | Formosa                       | 1 |   |
| Bacteroidota      | Bacteroidia         | Flavobacteriales         | Flavobacteriaceae             | Winogradskyella               | 1 |   |
| Firmicutes        | Clostridia          | Clostridiales            | Clostridiaceae                | Clostridium_sensu_stricto_1   | 1 |   |
| Proteobacteria    | Gammaproteobacteria | Oceanospirillales        | Halomonadaceae                | Halomonas                     | 1 |   |
| Planctomycetota   | Pla4_lineage        | Pla4_lineage_uncl        | Pla4_lineage_uncl             | Pla4_lineage_uncl             | 1 |   |
| Acidobacteriota   | Vicinamibacteria    | Vicinamibacterales       | Vicinamibacterales_uncl       | Vicinamibacterales_uncl       | 1 |   |
| Bacteroidota      | Bacteroidia         | Flavobacteriales         | Flavobacteriaceae             | Flavobacteriaceae_uncl        |   | 4 |
| Verrucomicrobiota | Verrucomicrobiae    | Arctic97B-4_marine_group | Arctic97B-4_marine_group_uncl | Arctic97B-4_marine_group_uncl |   | 4 |
| Bacteroidota      | Bacteroidia         | Flavobacteriales         | NS7_marine_group              | NS7_marine_group_uncl         |   | 4 |
| Bacteroidota      | Bacteroidia         | Flavobacteriales         | Cryomorphaceae                | Cryomorphaceae_uncl           |   | 3 |
| Proteobacteria    | Gammaproteobacteria | Thiomicrospirales        | Thioglobaceae                 | SUP05_cluster                 |   | 3 |
| Proteobacteria    | Gammaproteobacteria | Cellvibrionales          | Spongiibacteraceae            | BD1-7_clade                   |   | 3 |
| Bacteroidota      | Bacteroidia         | Cytophagales             | Cyclobacteriaceae             | Cyclobacteriaceae_uncl        |   | 3 |
| Planctomycetota   | Phycisphaerae       | MSBL9                    | SM23-30                       | SM23-30_uncl                  |   | 3 |

|                   |                      |                      |                        |                             |  |   |
|-------------------|----------------------|----------------------|------------------------|-----------------------------|--|---|
| Proteobacteria    | Alphaproteobacteria  | Kiloniellales        | Kiloniellaceae         | Kiloniellaceae_uncl         |  | 3 |
| Proteobacteria    | Alphaproteobacteria  | Defluviicoccales     | Defluviicoccales_uncl  | Defluviicoccales_uncl       |  | 2 |
| Cyanobacteria     | Cyanobacteriia       | Cyanobacteriia_uncl  | Cyanobacteriia_uncl    | Cyanobacteriia_uncl         |  | 2 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Crocinitomicaceae      | Crocinitomix                |  | 2 |
| Verrucomicrobiota | Verrucomicrobiae     | Verrucomicrobiales   | DEV007                 | DEV007_uncl                 |  | 2 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Crocinitomicaceae      | Fluviicola                  |  | 2 |
| Nitrospinota      | Nitrospina           | Nitrospinales        | Nitrospinaceae         | Nitrospina                  |  | 2 |
| Proteobacteria    | Gammaproteobacteria  | Alteromonadales      | Pseudoalteromonadaceae | Pseudoalteromonas           |  | 2 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Flavobacteriaceae      | Ulvibacter                  |  | 2 |
| Planctomycetota   | Planctomycetota_uncl | Planctomycetota_uncl | Planctomycetota_uncl   | Planctomycetota_uncl        |  | 2 |
| Proteobacteria    | Gammaproteobacteria  | Cellvibrionales      | Cellvibrionaceae       | Cellvibrionaceae_uncl       |  | 1 |
| Bacteroidota      | Bacteroidia          | Cytophagales         | Cyclobacteriaceae      | Marinoscillum               |  | 1 |
| Proteobacteria    | Gammaproteobacteria  | Oceanospirillales    | Nitrincolaceae         | Nitrincolaceae_uncl         |  | 1 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Flavobacteriaceae      | NS4_marine_group            |  | 1 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Flavobacteriaceae      | NS5_marine_group            |  | 1 |
| Proteobacteria    | Gammaproteobacteria  | SAR86_clade          | SAR86_clade_uncl       | SAR86_clade_uncl            |  | 1 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Flavobacteriaceae      | NS2b_marine_group           |  | 1 |
| Bacteroidota      | Bacteroidia          | Bacteroidia_uncl     | Bacteroidia_uncl       | Bacteroidia_uncl            |  | 1 |
| Myxococcota       | Polyangia            | Polyangiales         | Eel-36e1D6             | Eel-36e1D6_uncl             |  | 1 |
| Crenarchaeota     | Nitrososphaeria      | Nitrosopumilales     | Nitrosopumilaceae      | Candidatus_Nitrosopelagicus |  | 1 |
| Dadabacteria      | Dadabacteriia        | Dadabacteriales      | Dadabacteriales_uncl   | Dadabacteriales_uncl        |  | 1 |
| Proteobacteria    | Gammaproteobacteria  | Burkholderiales      | Methylophilaceae       | OM43_clade                  |  | 1 |
| Proteobacteria    | Alphaproteobacteria  | SAR11_clade          | Clade_I                | Clade_Ib                    |  | 1 |
| Actinobacteriota  | Actinobacteria       | Propionibacteriales  | Propionibacteriaceae   | Cutibacterium               |  | 1 |
| Bdellovibrionota  | Oligoflexia          | Oligoflexales        | Oligoflexales_uncl     | Oligoflexales_uncl          |  | 1 |
| Firmicutes        | Bacilli              | Staphylococcales     | Staphylococcaceae      | Staphylococcus              |  | 1 |
| Acidobacteriota   | Vicinamibacteria     | Subgroup_9           | Subgroup_9_uncl        | Subgroup_9_uncl             |  | 1 |
| Proteobacteria    | Gammaproteobacteria  | Thiohalorhabdadales  | Thiohalorhabdaceae     | Thiohalorhabdaceae_uncl     |  | 1 |
| Bacteroidota      | Bacteroidia          | Flavobacteriales     | Cryomorphaceae         | Vicingus                    |  | 1 |
| Chloroflexi       | Anaerolineae         | Anaerolineales       | Anaerolineaceae        | Anaerolineaceae_uncl        |  | 1 |
| Proteobacteria    | Gammaproteobacteria  | Alteromonadales      | Colwelliaceae          | Colwelliaceae_uncl          |  | 1 |

|                              |                                   |                                   |                                   |                                   |  |   |
|------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|--|---|
| Nanoarchaeota                | Nanoarchaeia                      | Woesearchaeales                   | GW2011_GWC1_47_15                 | GW2011_GWC1_47_15_uncl            |  | 1 |
| Proteobacteria               | Gammaproteobacteria               | HOC36                             | HOC36_uncl                        | HOC36_uncl                        |  | 1 |
| Proteobacteria               | Gammaproteobacteria               | Legionellales                     | Legionellaceae                    | Legionellaceae_uncl               |  | 1 |
| Proteobacteria               | Alphaproteobacteria               | Rhodospirillales                  | Magnetospiraceae                  | Magnetospiraceae_uncl             |  | 1 |
| Thermoplasmatota             | Thermoplasmata                    | Thermoplasmata_or                 | Thermoplasmata_fa                 | Marine_Group_III                  |  | 1 |
| Actinobacteriota             | Acidimicrobiia                    | Microtrichales                    | Microtrichaceae                   | Microtrichaceae_uncl              |  | 1 |
| Proteobacteria               | Gammaproteobacteria               | Methylococcales                   | Methylomonadaceae                 | Milano-WF1B-03                    |  | 1 |
| Proteobacteria               | Alphaproteobacteria               | Kiloniellales                     | Kiloniellaceae                    | Pelagibius                        |  | 1 |
| SAR324_clade(Marine_group_B) | SAR324_clade(Marine_group_B)_uncl | SAR324_clade(Marine_group_B)_uncl | SAR324_clade(Marine_group_B)_uncl | SAR324_clade(Marine_group_B)_uncl |  | 1 |
| Nanoarchaeota                | Nanoarchaeia                      | Woesearchaeales                   | SCGC_AAA011-D5                    | SCGC_AAA011-D5_uncl               |  | 1 |
| Proteobacteria               | Gammaproteobacteria               | UBA10353_marine_group             | UBA10353_marine_group_uncl        | UBA10353_marine_group_uncl        |  | 1 |
| Firmicutes                   | Clostridia                        | Oscillospirales                   | Oscillospiraceae                  | UCG-005                           |  | 1 |

**Supplementary Table 4: Estimated sources contribution to PA communities by ‘SourceTracker’.** The values represent the mean estimated contribution of different FL microbes to the PA communities along the water column (SRF - surface (10 - 30 m), EPI - epipelagic (100 m), MESO - mesopelagic (1000 m) and BATHY - bathypelagic (~50 m above the seafloor)). The values after  $\pm$  represent standard deviation.

| Station | Ice covered? | Type  | Fraction | SRF             | EPI             | MESO         | BATHY           | Unknown         |
|---------|--------------|-------|----------|-----------------|-----------------|--------------|-----------------|-----------------|
| EG1     | Yes          | SRF   | PA       | 0.48 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.52 $\pm$ 0    |
| EG1     | Yes          | EPI   | PA       | 0.37 $\pm$ 0.01 | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.63 $\pm$ 0.01 |
| EG1     | Yes          | MESO  | PA       | 0.04 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.96 $\pm$ 0    |
| EG4     | Yes          | SRF   | PA       | 0.97 $\pm$ 0    | 0.01 $\pm$ 0    | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.02 $\pm$ 0    |
| EG4     | Yes          | EPI   | PA       | 0.63 $\pm$ 0.01 | 0.01 $\pm$ 0    | 0.01 $\pm$ 0 | 0 $\pm$ 0       | 0.36 $\pm$ 0.01 |
| EG4     | Yes          | MESO  | PA       | 0.27 $\pm$ 0    | 0 $\pm$ 0       | 0.01 $\pm$ 0 | 0 $\pm$ 0       | 0.72 $\pm$ 0.01 |
| EG4     | Yes          | BATHY | PA       | 0.02 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0.02 $\pm$ 0.01 | 0.96 $\pm$ 0.01 |
| N4      | Yes          | SRF   | PA       | 0.77 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.23 $\pm$ 0    |
| N4      | Yes          | EPI   | PA       | 0.09 $\pm$ 0.01 | 0.18 $\pm$ 0.01 | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.72 $\pm$ 0    |
| N4      | Yes          | MESO  | PA       | 0.11 $\pm$ 0    | 0.01 $\pm$ 0    | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.88 $\pm$ 0    |
| N4      | Yes          | BATHY | PA       | 0.08 $\pm$ 0.01 | 0 $\pm$ 0       | 0.01 $\pm$ 0 | 0.32 $\pm$ 0    | 0.6 $\pm$ 0.01  |
| N5      | Yes          | SRF   | PA       | 0.99 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0       |
| N5      | Yes          | EPI   | PA       | 0.89 $\pm$ 0    | 0.01 $\pm$ 0    | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.1 $\pm$ 0     |
| N5      | Yes          | MESO  | PA       | 0.16 $\pm$ 0.01 | 0 $\pm$ 0       | 0 $\pm$ 0    | 0.24 $\pm$ 0.01 | 0.58 $\pm$ 0.01 |
| N5      | Yes          | BATHY | PA       | 0.99 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0       |
| HG1     | No           | SRF   | PA       | 0.73 $\pm$ 0    | 0.01 $\pm$ 0    | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.26 $\pm$ 0    |
| HG1     | No           | EPI   | PA       | 0.09 $\pm$ 0.01 | 0 $\pm$ 0       | 0 $\pm$ 0    | 0.02 $\pm$ 0    | 0.89 $\pm$ 0.01 |
| HG1     | No           | MESO  | PA       | 0.99 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.01 $\pm$ 0    |
| HG1     | No           | BATHY | PA       | 0.94 $\pm$ 0    | 0.03 $\pm$ 0    | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.03 $\pm$ 0    |
| HG2     | No           | SRF   | PA       | 0.09 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.9 $\pm$ 0     |
| HG2     | No           | EPI   | PA       | 0.09 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.91 $\pm$ 0    |
| HG2     | No           | BATHY | PA       | 0.99 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.01 $\pm$ 0    |
| HG4     | No           | SRF   | PA       | 0.87 $\pm$ 0    | 0 $\pm$ 0       | 0 $\pm$ 0    | 0 $\pm$ 0       | 0.12 $\pm$ 0    |
| HG4     | No           | EPI   | PA       | 0.31 $\pm$ 0    | 0 $\pm$ 0       | 0.02 $\pm$ 0 | 0.01 $\pm$ 0    | 0.66 $\pm$ 0    |
| HG4     | No           | BATHY | PA       | 0.32 $\pm$ 0.01 | 0 $\pm$ 0       | 0 $\pm$ 0    | 0.03 $\pm$ 0    | 0.65 $\pm$ 0.01 |

|     |    |       |    |           |        |        |        |           |
|-----|----|-------|----|-----------|--------|--------|--------|-----------|
| HG9 | No | SRF   | PA | 0.99±0    | 0±0    | 0±0    | 0±0    | 0.01±0    |
| HG9 | No | EPI   | PA | 0.85±0    | 0.01±0 | 0±0    | 0±0    | 0.14±0    |
| HG9 | No | MESO  | PA | 0.31±0.01 | 0±0    | 0.01±0 | 0±0    | 0.68±0.01 |
| HG9 | No | BATHY | PA | 0.19±0.01 | 0±0    | 0±0    | 0.02±0 | 0.78±0.01 |
| S3  | No | SRF   | PA | 0.67±0.01 | 0±0    | 0±0    | 0±0    | 0.32±0.01 |
| S3  | No | MESO  | PA | 0.02±0    | 0±0    | 0±0    | 0±0    | 0.98±0    |
| S3  | No | BATHY | PA | 0±0       | 0±0    | 0±0    | 0.02±0 | 0.97±0    |