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Supporting Information for

Seasonal snowpack microbial ecology and biogeochemistry on a High Arctic ice cap reveals negligible autotrophic activity during spring and summer melt

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Introduction

Text S1.

For the allometric conversions (Table 4) , i.e. between carbon and volume with a scaling factor, one model each was chosen from Felip et al. (2007) which employed carbon estimates for freshwater bacteria and Posch et al. (2001). The allometric carbon calculations were as follows:

$$C = 120 \, x \, V^{0.72} \text{ (Felip et al., 2007)} \quad (4)$$

Where, C is the carbon content (pg C $cell^{-1}$)
V is the mean biovolume of the cell (μm^3)

In this case, the mean bacterial biovolume in snow and superimposed ice and glacial ice for T2 (June – Early July) are 8.3 μm^3 and 59.4 μm^3.

Briefly, the total biovolume for each sampled snow layer per stake was calculated. The combined average of all the sampled snow layers for each stake gave the mean bacterial volume used in the formulae below:

Equations 1 and 2 were then modified to estimate bacterial carbon production where the Bacterial Carbon Content (BCC; 11 fg C $cell^{-1}$) is replaced by 551 x 10^3 fg C $cell^{-1}$, 2271 x 10^3 fg C $cell^{-1}$ and 1718 x 10^3 fg C $cell^{-1}$, respectively. This results in the numbers presented below.

$$C_{snow} = 120\ x\ 8.3^{0.72} = 551\ pg\ C\ cell^{-1} = 551\ x\ 10^3\ fg\ C\ cell^{-1} \tag{5}$$

$$C_{sup\ ice} = 120\ x\ 59.4^{0.72} = 2271\ pg\ C\ cell^{-1} = 2271\ x\ 10^3\ fg\ C\ cell^{-1} \tag{6}$$

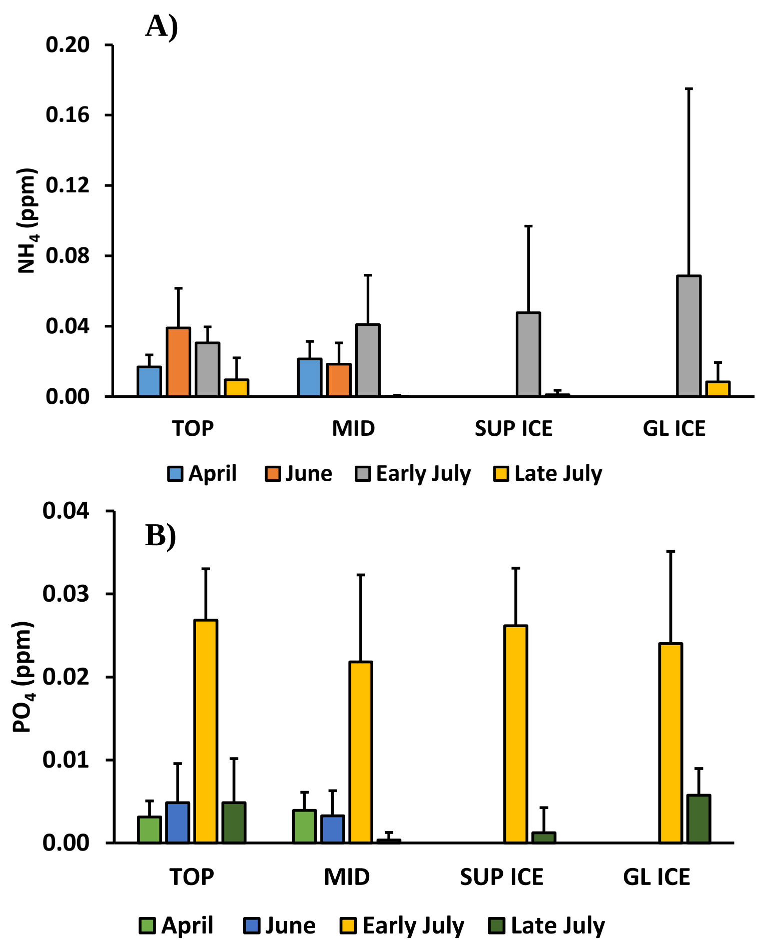

Figure S1. Seasonal and temporal change in NH_4^+ and PO_4^{3-} concentrations (ppm) on Foxfonna.

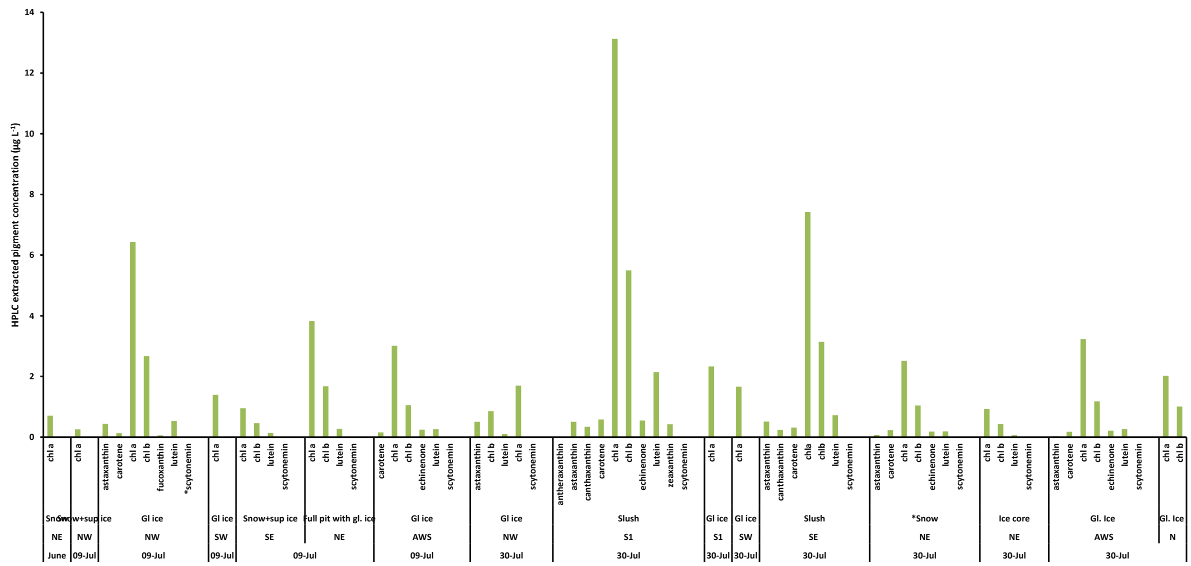

Figure S1. HPLC extracted pigment yield (µg L^{-1}) on Foxfonna.
Note: Out of the 42 samples analysed, 26 had no measurable pigment concentrations. However, an internal standard for checking the effectiveness of the extraction as well as pigment standards returned good results.

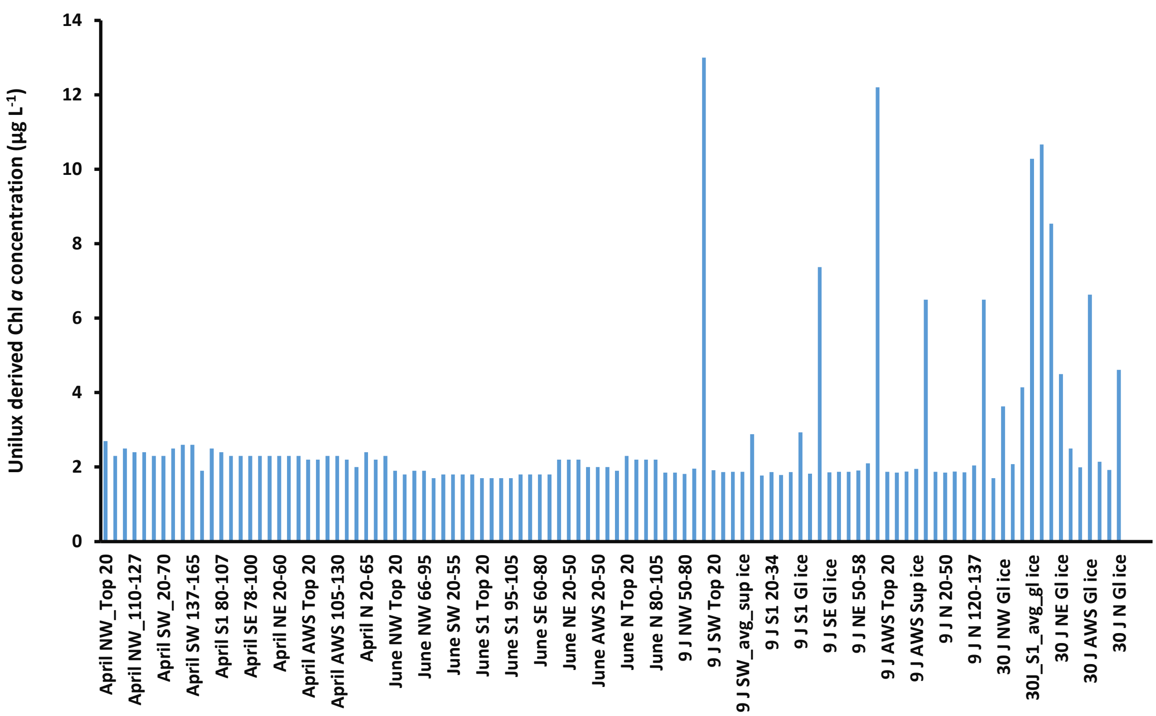

Figure S2. Unilux derived Chl *a* concentration changes through the melt season on Foxfonna.

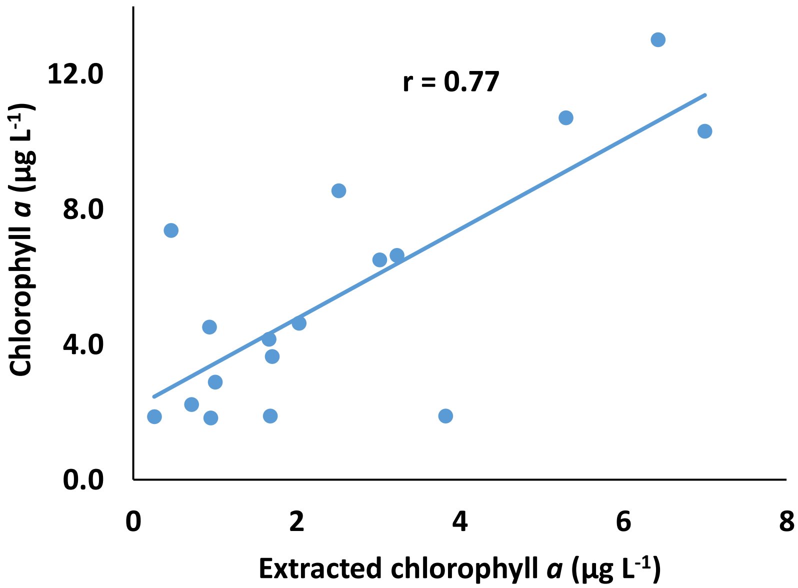

Figure S3. Correlation between extracted and Unilux measured chlorophyll *a* concentrations (µg L^{-1}).

Table S1. Concentrations of cations Na^+, K^+, Mg^{2+}, Ca^{2+}, anions F^-, SO_4^{2-}, Si and DOC in ppm for each sample in April.

Sample	Na^+	K^+	Mg^{2+}	Ca^{2+}	F^-	SO_4^{2-}	Si	DOC
April NW Top 20	0.86	0.07	0.27	0.40	0.24	0.45	0.01	0.44
April NW 20-72	1.18	0.08	0.19	0.31	0.05	0.56	0.00	0.35
April NW 72-110	0.57	0.06	0.10	0.38	n.a.	0.12	0.01	0.61
April NW110-127	1.59	0.11	0.23	0.35	n.a.	0.00	0.00	0.38
April NW 127-165	1.00	0.14	0.17	0.35	n.a.	0.50	0.00	0.39
April SW Top 20	0.85	0.07	0.15	0.35	n.a.	0.34	0.00	0.30
April SW 20-70	1.13	0.06	0.21	0.26	n.a.	0.63	0.00	0.29
April SW 70-100	0.92	0.07	0.16	0.33	0.17	0.35	0.00	0.98
April SW 100-137	1.48	0.20	0.20	0.45	0.10	0.54	0.00	0.95
April SW 137-165	1.33	0.13	0.19	0.31	0.03	0.72	0.00	0.76
April S1 Top 20	0.78	0.06	0.16	0.41	0.02	0.47	0.00	0.29
April S1 20-80	1.11	0.06	0.22	0.32	0.24	0.42	0.00	0.29
April S1 80-107	0.47	0.04	0.11	0.26	n.a.	0.23	0.00	0.26
April SE Top 20	2.41	0.09	0.38	0.62	0.01	0.48	0.00	0.26
April SE 20-78	1.27	0.06	0.24	0.39	0.45	0.35	0.00	0.002
April SE 78-100	0.79	0.05	0.15	0.30	n.a.	0.22	0.00	0.25
April SE 100-126	0.56	0.06	0.12	0.32	0.18	0.20	0.00	0.38
April NE Top 20	1.16	0.07	0.20	0.28	0.26	0.54	0.00	0.18
April NE 20-60	1.02	0.05	0.15	0.20	0.01	0.44	0.00	0.32
April NE 60-98	1.13	0.05	0.21	0.21	n.a.	0.40	0.00	0.17
April NE 98-127	0.49	0.03	0.12	0.16	0.12	0.24	0.00	0.21
April AWS Top 20	0.75	0.06	0.13	0.15	0.03	0.58	0.00	0.27
April AWS 20-75	0.89	0.06	0.13	0.11	0.02	0.62	0.00	0.31
April AWS 75-105	0.82	0.05	0.14	0.14	0.04	0.29	0.00	0.31
April AWS 105-130	0.96	0.08	0.14	0.28	0.02	0.34	0.00	0.36
April AWS 130-168	1.25	0.07	0.15	0.12	0.04	0.55	0.00	0.35
April N Top 20	1.24	0.07	0.18	0.32	0.05	0.51	0.00	0.23
April N 20-65	1.06	0.06	0.19	0.30	0.04	0.61	0.00	0.43
April N 65-90	0.84	0.06	0.17	0.31	0.03	0.31	0.00	
April N 90-100	1.05	0.10	0.15	0.32	0.03	0.45	0.00	0.44

Table S2. Concentrations of cations Na^+, K^+, $Mg^{2+,}$ Ca^{2+}, anions F^-, SO_4^{2-}, Si and DOC in ppm for each sample in June.

Sample	Na^+	K^+	Mg^{2+}	Ca^{2+}	F^-	SO_4^{2-}	Si	DOC
June NW Top 20	0.81	0.11	0.03	0.13	0.15	0.62	0.00	0.25
June NW 20-54	1.24	0.08	0.02	0.32	n.a.	0.55	0.00	0.19
June NW 54-66	0.83	0.03	0.02	0.24	0.02	0.29	0.01	0.25
June NW 66-95	0.84	0.06	0.02	0.26	n.a.	0.32	0.00	0.48
June NW 95-100	2.65	0.03	0.04	0.65	0.02	0.86	0.00	0.52
June SW Top 20	0.65	0.09	0.02	0.14	0.02	0.45	0.00	0.19
June SW 20-55	0.81	0.07	0.02	0.16	0.02	0.64	0.01	0.20
June SW 55-85	1.36	0.04	0.02	0.32	0.02	0.36	0.00	0.14
June SW 85-110	0.84	0.04	0.02	0.20	n.a.	0.40	0.00	0.21
June S1 Top 20	0.72	0.08	0.03	0.14	n.a.	0.65	0.00	0.18
June S1 20-58	1.00	0.03	0.02	0.29	0.01	0.50	0.00	0.14
June S1 58-95	0.79	0.03	0.01	0.24	0.03	0.27	0.01	0.12
June S1 95-105	0.55	0.04	0.13	0.21	n.a.	0.18	0.01	0.25
June SE Top 20	0.51	0.09	0.02	0.13	n.a.	0.48	0.01	0.16
June SE 20-60	0.74	0.05	0.12	0.18	n.a.	0.75	0.01	0.24
June SE 60-80	1.40	0.06	0.25	0.19	n.a.	0.39	0.01	0.14
June SE 80-115	0.24	0.02	0.07	0.23	n.a.	0.17	0.02	0.14
June NE Top 20	0.80	0.02	0.11	0.14	n.a.	0.74	0.02	0.23
June NE 20-50	1.26	0.07	0.19	0.20	n.a.	0.44	0.03	0.16
June NE 50-80	0.95	0.05	0.17	0.13	n.a.	0.40	0.00	0.16
June AWS Top 20	0.68	0.06	0.12	0.19	n.a.	0.50	0.00	0.15
June AWS 20-50	0.76	0.04	0.13	0.14	n.a.	0.47	0.00	0.12
June AWS 50-80	0.82	0.04	0.13	0.12	n.a.	0.39	0.01	0.11
June AWS 80-95	1.18	0.07	0.21	0.18	n.a.	0.33	0.00	0.17
June N Top 20	0.21	0.04	0.02	0.11	n.a.	0.52	0.00	0.15
June N 20-50	0.86	0.05	0.12	0.10	n.a.	0.30	0.01	0.24
June N 50-80	1.24	0.06	0.22	0.17	n.a.	0.53	0.01	0.14
June N 80-105	0.69	0.04	0.15	0.12	n.a.	0.34	0.01	0.15

Table S3. Concentrations of cations Na^+, K^+, $Mg^{2+,}$ Ca^{2+}, anions F^-, SO_4^{2-}, Si and DOC in ppm for each sample in early July.

Sample	Na^+	K^+	Mg^{2+}	Ca^{2+}	F^-	SO_4^{2-}	Si	DOC
9 J NW Top 20	0.82	0.09	0.12	0.16	0.04	0.00	0.00	0.23
9 J NW 20-50	0.50	0.02	0.02	0.19	0.02	0.00	0.03	0.29
9 J NW 50-80	0.49	0.03	0.02	0.16	0.02	0.07	0.03	0.17
9 J NW Sup ice	0.68	0.06	0.07	0.15	0.02	0.09	0.03	0.19
9 J NW Gl ice	0.96	0.06	0.01	0.25	0.01	0.26	0.03	0.62
9 J SW Top 20	0.68	0.00	0.01	0.06	0.02	0.03	0.03	0.39
9 J SW 20-50	0.26	0.07	0.00	0.03	n.a.	0.04	0.03	0.13
9 J SW 50-80	0.38	0.02	0.02	0.11	0.02	0.00	0.03	0.20
9 J SW Sup ice	0.54	0.06	0.05	0.13	0.02	0.00	0.02	0.16
9 J SW Gl ice	1.14	0.03	0.01	0.24	0.04	0.07	0.00	0.30
9 J S1 Top 20	0.24	0.04	0.01	0.03	0.01	0.00	0.00	0.16
9 J S1 20-34	0.26	0.02	0.01	0.02	n.a.	0.03	0.00	0.15
9 J S1 34-40	0.32	0.70	0.01	0.02	0.01	0.00	0.00	0.15
9 J S1 Sup ice	0.33	0.07	0.01	0.05	0.02	0.02	0.00	0.21
9 J S1 Gl ice	0.76	0.12	0.02	0.19	0.02	0.00	0.00	0.21
9 J SE Top 20	0.35	0.11	0.02	0.03	0.02	0.00	0.00	0.17
9 J SE Sup ice	0.95	0.33	0.03	0.22	0.02	0.26	0.00	0.43
9 J SE Gl ice	0.59	0.81	0.03	0.12	0.02	0.15	0.04	0.21
9 J NE Top 20	0.46	0.01	0.01	0.04	0.02	0.00	0.04	0.12
9 J NE 20-50	0.36	0.02	0.01	0.04	0.02	0.00	0.04	0.31
9 J NE 50-58	0.35	0.04	0.05	0.14	0.01	0.06	0.04	0.19
9 J NE Sup ice	0.21	0.06	0.08	0.27	0.01	0.18	0.04	0.15
9 J NE Gl ice	0.83	0.02	0.03	0.21	0.02	0.49	0.04	0.31
9 J AWS Top 20	0.54	0.00	0.01	0.04	0.02	0.00	0.04	0.18
9 J AWS 20-50	0.46	0.00	0.01	0.05	0.02	0.03	0.04	0.12
9 J AWS 50-80	0.49	0.00	0.01	0.04	n.a.	0.00	0.03	0.09
9 J AWS Sup ice	0.46	0.03	0.03	0.15	0.02	0.00	0.03	0.19
9 J AWS Gl ice	1.26	0.00	0.01	0.27	0.03	0.34	0.03	0.58
9 J N Top 20	0.34	0.11	0.03	0.13	n.a.	0.00	0.03	0.22
9 J N 20-50	0.12	0.03	0.01	0.09	0.02	0.00	0.03	0.18
9 J N 50-80	0.50	0.02	0.01	0.03	n.a.	0.00	0.03	0.12
9 J N 80-120	0.45	0.02	0.03	0.13	n.a.	0.00	0.03	0.19
9 J N 120-137	0.26	0.02	0.04	0.15	0.02	0.00	0.03	0.16
9 J N Sup ice	0.71	0.04	0.02	0.49	n.a.	1.82	0.00	0.39

Table S4. Concentrations of cations Na^+, K^+, Mg^{2+}, Ca^{2+}, anions F^-, SO_4^{2-}, Si and DOC in ppm for each sample in late July.

Sample	Na^+	K^+	Mg^{2+}	Ca^{2+}	F^-	SO_4^{2-}	Si	DOC
30 J NW Top 20	0.56	0.02	0.02	0.20	0.04	0.00	0.00	0.14
30 J NW Gl ice	0.61	0.08	0.07	0.18	0.09	0.19	0.01	0.24
30 J SW Top 20	0.30	0.06	0.03	0.13	0.04	0.00	0.00	0.26
30 J SW Gl ice	0.62	0.03	0.11	0.36	0.04	0.17	0.00	0.14
30 J S1 Gl ice	0.99	0.12	0.36	0.85	0.04	0.25	0.00	1.81
30 J SE Gl ice	0.81	0.03	0.19	0.50	0.06	0.11	0.00	0.63
30 J NE Top	0.67	0.03	0.08	0.31	0.04	0.00	0.00	0.50
30 J NE Gl ice	0.75	0.03	0.11	0.36	0.05	0.30	0.00	0.18
30 J AWS Top	0.44	0.02	0.06	0.36	0.07	0.19	0.01	0.60
30 J AWS Sup ice	0.37	0.03	0.06	0.30	0.03	0.13	0.00	0.20
30 J AWS Gl ice	1.69	0.07	0.25	1.21	0.04	0.58	0.00	0.27
30 J N Top 20	1.39	0.04	0.05	0.35	0.08	0.00	0.00	0.32
30 J N 20-35	0.82	0.04	0.03	0.22	0.04	0.00	0.00	0.14
30 J N Gl ice	0.61	0.03	0.08	0.23	0.06	0.33	0.00	0.27

References From The Supporting Information

Felip, M. *et al.* (2007) 'Suitability of flow cytometry for estimating bacterial biovolume in natural plankton samples: Comparison with microscopy data', *Applied and Environmental Microbiology*, 73(14), pp. 4508–4514. doi: 10.1128/AEM.00733-07.

Posch, T. *et al.* (2001) 'Precision of bacterioplankton biomass determination: A comparison of two fluorescent dyes, and of allometric and linear volume-to-carbon conversion factors', *Aquatic Microbial Ecology*, 25(1), pp. 55–63. doi: 10.3354/ame025055.