

## Supplementary Information

### **Macronutrient biogeochemistry in Antarctic land-fast sea ice: Insights from a circumpolar data compilation**

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Table S1. Sampling locations for cruises and field campaigns included in this study, as well as data contributors and references where data are published. Latitudes and longitudes are given in decimal degrees, and their ranges are given as north to south and east to west.

Location name	Latitude / latitude range	Longitude / longitude range	Data contributors (# cores)	References
Dronning Maud Land	-70.1106	5.3638	Sebastien Moreau (n=1)	
Syowa Station	-68.939 to -69.842	39.623 to 38.326	Daiki Nomura et al. (n=15)	Nomura et al., 2018; Sahashi et al., 2022
Davis Station	-68.583	77.967	Florian Deman and François Fripiat (n=6)	Lim et al., 2019; Roukaerts et al., 2021
Casey Station	-66.2186 to -66.301	110.6505 to 110.5	Delphine Lannuzel (n=9)	Lannuzel et al., 2014
SIPEX (RSV Aurora Australis)	-65.5244 to -65.6458	124.7839 to 124.752	Delphine Lannuzel and Klaus Meiners (n=2)	Lannuzel et al., 2011; Meiners et al., 2011
Dumont D'Urville Station	-66.3961 to -66.6667	141.0167 to 139.5953	Bruno Delille (n=49); François Fripiat (n=10)	Fripiat et al., 2015
Victoria Land coast	-74.0041 to -74.8995	166.7785 to 163.7697	Stefano Cozzi (n=52)	Cozzi, 2014
McMurdo Sound	-77.38 to -77.59	166.23 to 165.71	François Fripiat et al. (n=11); Agneta Fransson and Melissa Chierici (n=1)	Roukaerts et al., 2021
Ross Sea	-74.32 to -76.53	172.99 to 165.02	Kevin Arrigo (n=3)	Arrigo et al., 2003
Rothera Station	-67.5583 to -67.623	-68.1228 to -68.1342	Jacqueline Stefels and Maria van Leeuwe (n=39); Elizabeth Jones (n=35); Sian Henley (n=11)	Jones et al., 2022; van Leeuwe et al., 2022
Drescher Inlet	-72.8667	-19.2	David Thomas (n=1)	

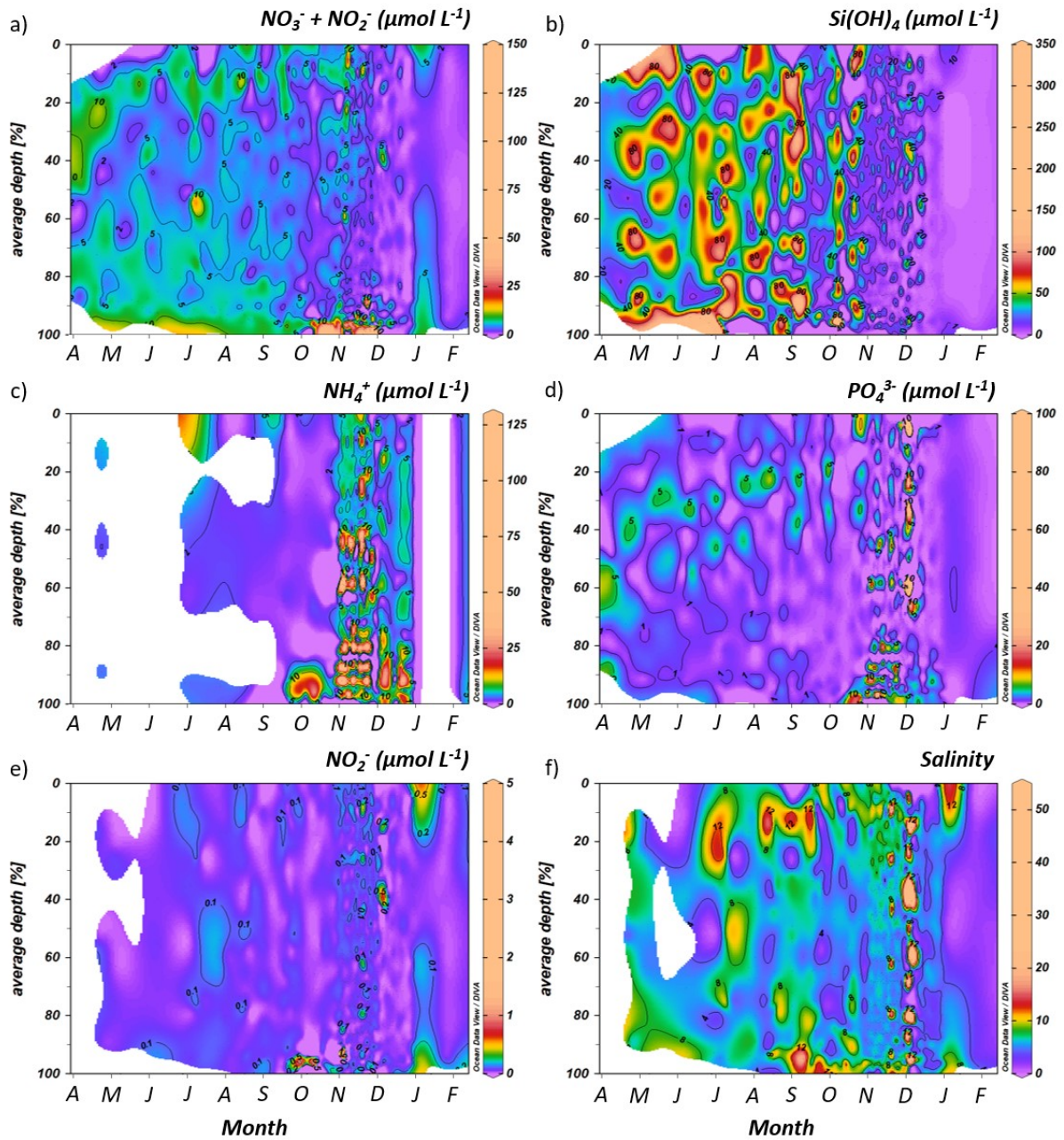


Figure S1. Time-series plots of bulk nutrient concentrations and salinity over the full ice thickness from 1 April to mid-February: (a) nitrate, (b) silicic acid, (c) ammonium, (d) phosphate, (e) nitrite, (f) salinity. Data from all stations, years and ice types are included. Ice core depth is normalised to ice thickness and measured parameters are plotted by sampling date in each year. Note the differences in colour scales between plots.

Table S2. Water column nutrient concentrations from studies associated with fast ice around Antarctica, with references given.

Region/Area	Months	Years	Water type	Depth	Salinity	Pot. Temp.	NO <sub>3</sub> <sup>-</sup>	NH <sub>4</sub> <sup>+</sup>	NO <sub>2</sub> <sup>-</sup>	PO <sub>4</sub> <sup>3-</sup>	Si(OH) <sub>4</sub>	References
				m		°C	μmol L <sup>-1</sup>	μmol L <sup>-1</sup>	μmol L <sup>-1</sup>	μmol L <sup>-1</sup>	μmol L <sup>-1</sup>	
Lutzow-Holm Bay: Syowa Station	Jan.	2010	Coastal waters	1/7 m below fast ice	33.0/29.7	-0.9/0.0	24.4/20.5		0.1/0.1	1.7/1.5	63.4/55.8	Nomura et al., 2011
Lutzow-Holm Bay: Syowa Station	Dec.	2005	Coastal waters	50 m below fast ice	34.0	-1.7	31.2			2.1	76.8	Ichinomiya et al., 2007
Lutzow-Holm Bay: Syowa Station	Dec.	2004	Coastal waters	50 m below fast ice	34.1	-1.75	30.52		0.6	2.07	63.19	Otsuki et al., 2006
Lutzow-Holm Bay: Ongul Strait	Dec. to Feb.	1996-1997	Coastal waters	20-30 m	34.0	-1.67	29-31					Odate and Fukuchi, 2004
Prydz Bay: Davis Station	May to Oct.	1993-1995	Sub-ice water	10 m below fast ice	33.6-34.0	-1.90	25-27			1.9-2.1	50-65	Gibson and Trull, 1999
Prydz Bay: Davis Station	Nov. to Dec.	2015	Sub-ice water	0-10 m below fast ice	32.4-32.7		27.94-30.46	0.01-0.85	0.03-0.08	1.88-2.86	45.65-55.60	Duprat et al., 2019
Prydz Bay	Dec.	2009	Shelf waters	0-500 m	34.40	-1.60	23.33			1.88	58.02	Liang et al., 2016
Prydz Bay	Jan. to Mar.	1990	Shelf waters	0-200 m	33.99	0.40	26.38			1.40		Zhang et al., 2014
Prydz Bay	Dec. to Feb.	1990-1991	Shelf waters	0-200 m	33.83	-0.35	28.25			1.73		Zhang et al., 2014
Prydz Bay	Annual mean - summer	2009-2010-2011-2013	Shelf waters	0-500 m	33.6-34.2	-1.28 to 0.05	17.3-23.9			0.7-2.4	30.2-67.8	Ma et al., 2020
Wilkes Land: Casey Station	Dec.	2016	Summer coastal waters	0 m			2.3	0.3		0.3	16.9	Duprat et al., 2020
Wilkes Land: SIPEX Project (R/V Aurora Australis)	Sep.	2007	Spring shelf waters	0 m and 1 m below fast ice	30.4-31.6	-1.86	25.5-25.9	0.32-0.38	0.1-0.14	1.44-2.42	51.2-53.6	van der Merwe et al., 2009
Adélie Land: Dumont d'Urville	Nov.	1995	Coastal waters	0.5 m below fast ice			7-87				33-75	Riaux-Gobin et al., 2000
Adélie Land: Dumont d'Urville	Nov. to Dec.	1999	Coastal waters	0.5 m below fast ice	34.00		20.00	2.00	0.1-0.3	2.00	20-45	Riaux-Gobin et al., 2005

<b>George V Land</b>	Dec. to Jan.	2000-2001	Coastal waters	50 m below fast ice	34.25	-1.60	29.00				72.00	Vaillancourt et al., 2003
<b>Ross Sea: Terra Nova Bay</b>	Oct. to Dec.	1997, 1999, 2004	Coastal waters	3 m below fast ice	34.76	-1.90	28.00	0.70	0.05	2.00	75.00	Cozzi, 2014
<b>Ross Sea: Terra Nova Bay</b>	Oct. to Feb.	1994-2001	High Salinity Shelf Water	200-800 m	34.88	-1.92	31.00			2.20	80.00	Budillon et al., 2003
<b>Ross Sea: McMurdo Sound</b>	Oct. to Dec.	1989	Coastal waters	1 m below fast ice			32.40	0.50		2.00	77.20	Dieckmann et al., 1992
<b>Ross Sea: McMurdo Sound</b>	Oct. to Dec.	1989	Coastal waters	1 m below fast ice			31.00	0.50	0.20	2.00	60-80	Arrigo et al., 1995
<b>Ross Sea: western region</b>	Oct. to Feb.	1967-2016	Subsurface waters	15 m			29.20			2.06	78.00	Smith and Kaufman, 2018
<b>Amundsen Sea</b>	Dec. to Jan.	2010-2011	Amundsen Sea Polynya	170 m		-1.6	29.4	0.39		1.91		Sipler and Connelly, 2015
<b>Amundsen Sea</b>	Feb. to Mar.	2012	Coastal waters	Light Depth 1%			22.6	1.26		1.85	75.65	Kim et al., 2016
<b>Amundsen Sea</b>	Jan. to Feb.	2017	Seawater down nutricline	200-400 m	34.5	1.0	34.2			2.1	75.0	Janssen et al., 2020
<b>Ryder Bay (Rothera Station)</b>	Jan. to Dec.	2013-2016	Coastal waters	0-15 m	33.72	-1.42	27.86	1.70	0.13	1.92	76.76	Henley et al., 2020
<b>Ryder Bay (Rothera Station)</b>	Jul. to Aug.	1997-2006	Winter shelf waters	0-100 m	33.8	-1.9	35	1.3		2.5	65	Clarke et al., 2008
<b>Ryder Bay (Rothera Station)</b>	Nov. to March	2013-2017	Coastal waters	0-5 m	32.97	0.31	11.39		0.12	0.74	53.76	van Leeuwe et al., 2020
<b>Ryder Bay (Rothera Station)</b>	Nov. to March	2013-2017	Coastal waters	15 m	33.21	-0.43	16.23		0.14	1.03	62.01	van Leeuwe et al., 2020
<b>Ryder Bay (Rothera Station)</b>	April to Oct.	2014-2016	Coastal waters	15 m	33.56	-1.70	23.44		0.27	1.54	74.44	van Leeuwe et al., 2020
<b>Weddell Sea: Drescher Inlet</b>	Jan. to Feb.	1995	Coastal waters	1 m below fast ice	33.5		20.58			1.46	44.37	Günther et al., 1999
<b>Weddell Sea: Drescher Inlet</b>	Feb.	1998	Coastal waters	50, 150, 400 m	34.1	-1.2 to -1.8	25.4	1.4	0.1	1.3	65.2	Thomas et al., 2001

<b>Weddell Sea: southern region</b>	Oct. to Dec.	1986	Coastal waters	1 m below fast ice	34.40	-1.80	30.00			2.00	60.00	Smetacek et al., 1992
<b>Weddell Sea: Atka Bay</b>	Jun. to Dec.	1995	Coastal waters	20 m	34.5		29.09	0.06		1.49	63.13	Günther and Dieckmann, 1999

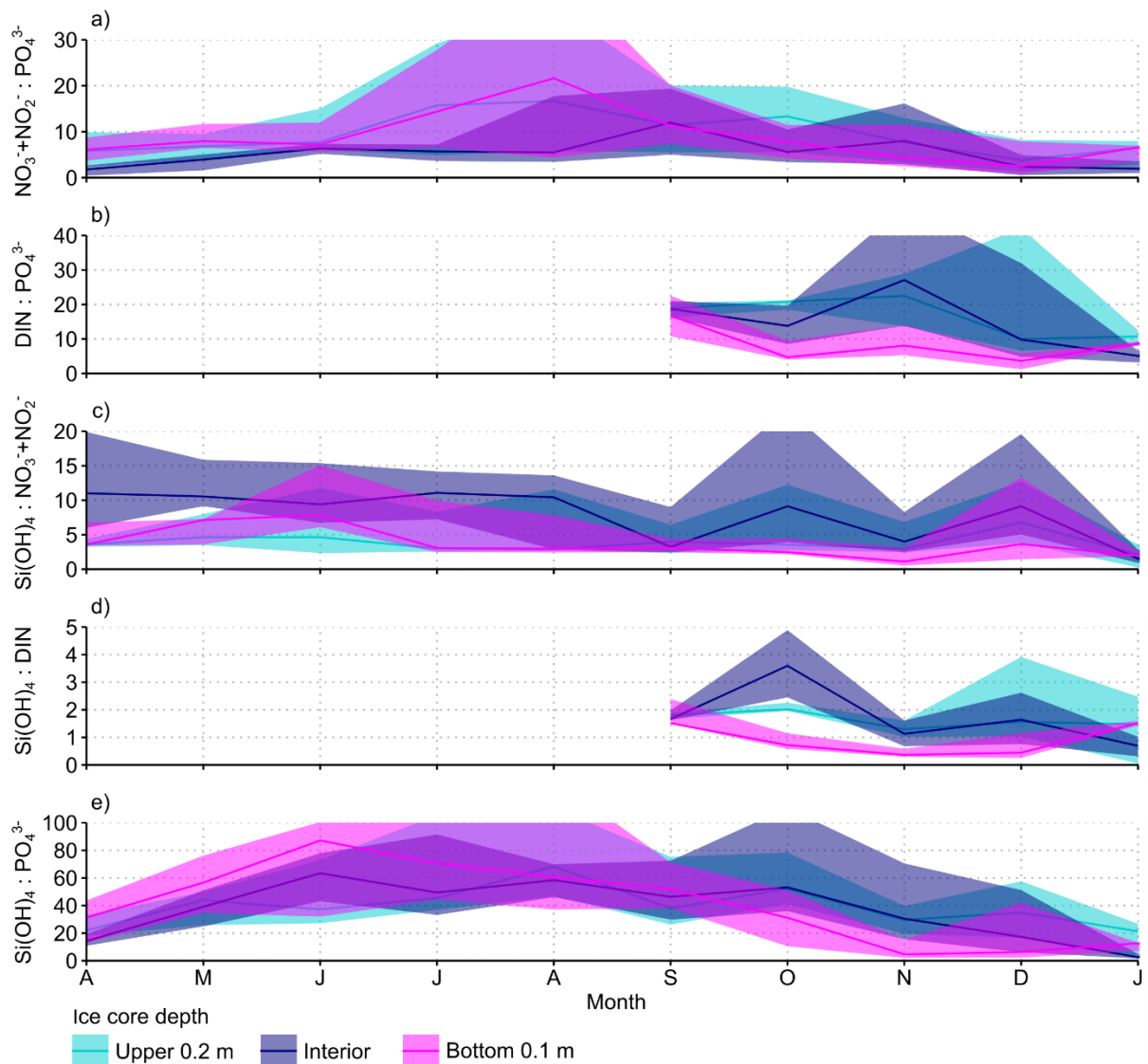


Figure S2. Time-series plots of nutrient stoichiometric ratios: (a)  $\text{NO}_3^- + \text{NO}_2^- : \text{PO}_4^{3-}$ ; (b) Total DIN: $\text{PO}_4^{3-}$ ; (c)  $\text{Si}(\text{OH})_4 : \text{NO}_3^- + \text{NO}_2^-$ ; (d)  $\text{Si}(\text{OH})_4 : \text{DIN}$ ; (e)  $\text{Si}(\text{OH})_4 : \text{PO}_4^{3-}$ . Data are binned by calendar month and shown by ice core depth (where light blue=upper 0.2 m, dark blue=interior, magenta=bottom 0.1 m), with lines connecting monthly median values and shaded areas showing interquartile ranges. In this analysis, ratios based on nitrate give much better data coverage than DIN due to the lack of ammonium data from winter. Substantial variability in these ratios in upper, interior and bottom ice layers over the seasonal cycle supports Figure 11 in showing the coupling and decoupling of DIN species, phosphate and silicic acid within the ice matrix.

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