

Supplement
Exploring Silicon Isotope Fractionation by Silicoflagellates:
Results from a KOSMOS Experiment off Peru
Grasse et al.

Figures

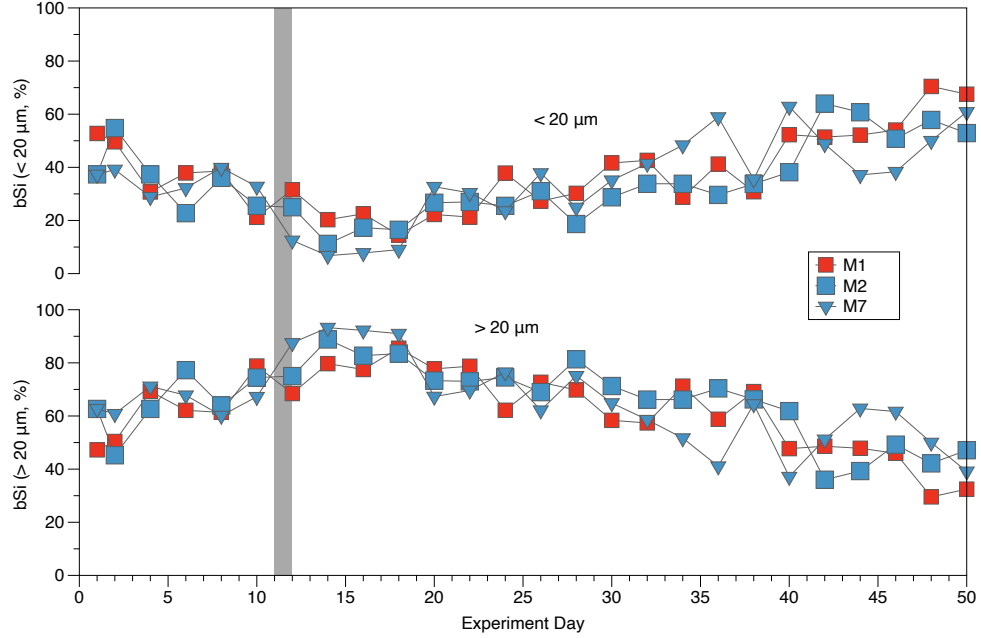


Figure S1: BSi size fraction separated for sizes smaller (a) and larger (b) than 20 μm for M1 (red square), M2 (blue square) and M7 (blue triangle). The grey bar indicates the DW addition on day 12.

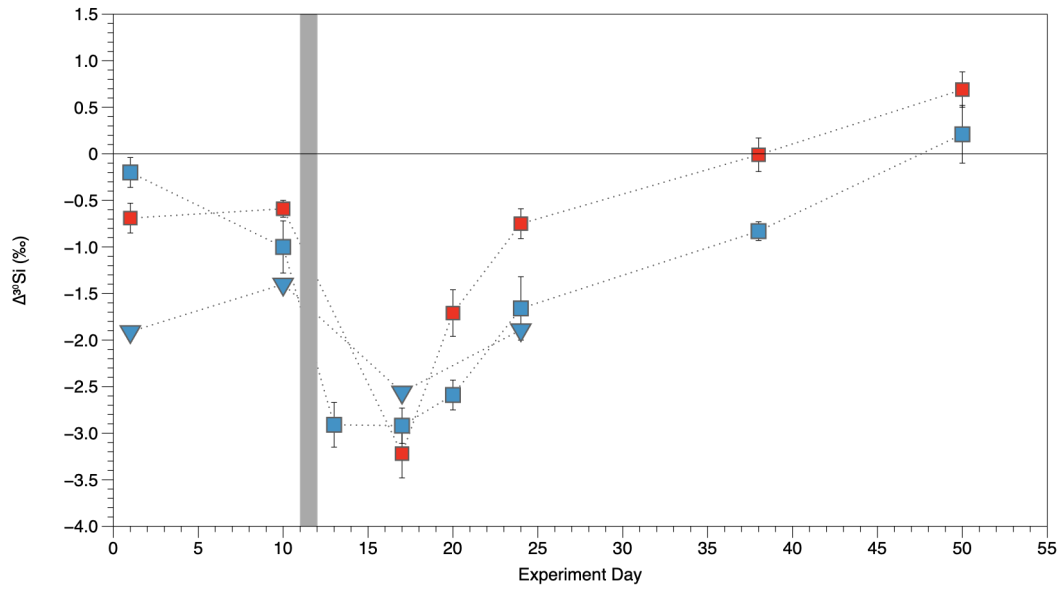


Figure S2: The apparent fractionation factor between $\delta^{30}\text{Si}_{\text{bSi}}$ and $\delta^{30}\text{Si}_{\text{dSi}}$ ($\Delta^{30}\text{Si}$) during the course of the experiment. The grey bar indicates the addition of DW on day 12 in surface water. For values above the horizontal line, the bSi fraction is isotopically heavier compared to the dissolved fraction and vice versa. Error bars are the propagated error according to equation (8).

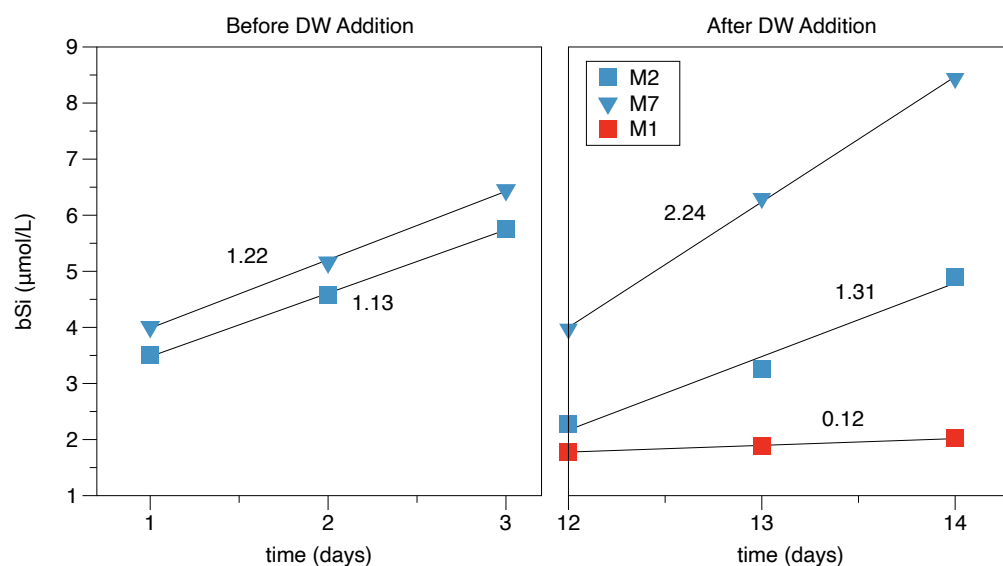


Figure S3: Net bSi growth rate per day for samples before (left figure) and after DW addition (right figure). Numbers indicate the bSi growth rate ranging between 0.12 and 2.4 $\mu\text{mol/day}$.

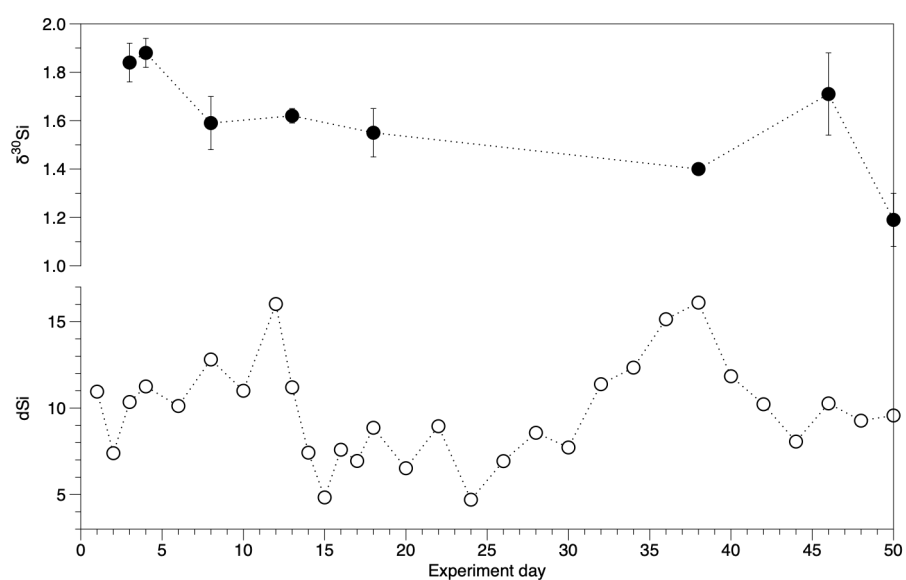


Figure S4: (a) $\delta^{30}\text{Si}_{\text{dSi}}$ in Pacific surface samples outside of the mesocosms (black closed circles). (b) dSi (in $\mu\text{mol L}^{-1}$; open circles).

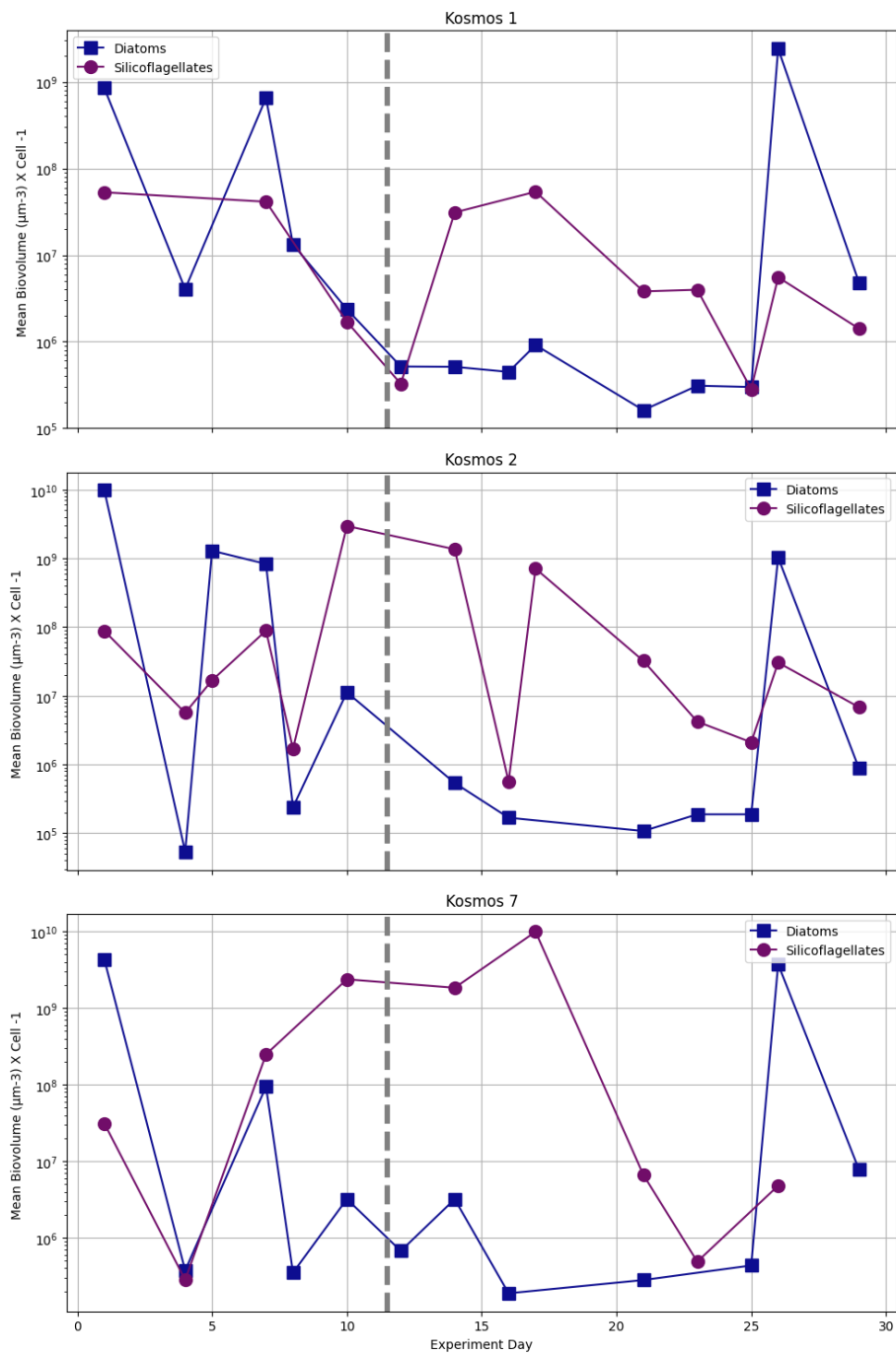


Figure S5:
Mean Biovolume (μm^3) times the amount of diatom (blue line, blue square) and silicoflagellates (purple line, purple dots) cells during the experiment in Kosmos 1, Kosmos 2 and Kosmos 7.

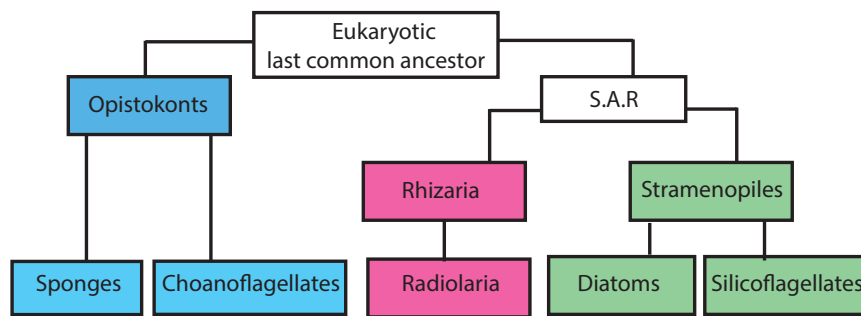


Figure S5:
Simplified presentation of the eukaryotic phylogeny of the most important marine silicifier groups based on Marron et al., 2016. S.A.R. describes the group of Stramenopiles, Alveolats and Rhizaria

Table S1:

The table includes a complete list of the nutrient data, particulate data, phytoplankton data as well as the as the silicon isotope data from KOSMOS experiments (M1, M2, M7) and the sample from surrounding water (Pacific) and will be uploaded to Pangaea.

Table S2:

Taxa list for diatoms and silicoflagellates on day 13 and 17 with mean diameter (μm), mean Biovolume (μm^3), minimum biovolume and maximum biovolume.

KOSMOS	Day		Species	comment	Cell count	Diatoms Cell Count (%)	Silicofl. Cell Count (%)	Mean Diameter (μm)	Mean Biovolume (μm^3)	Min Biovolume (μm^3)	Max Biovolume (μm^3)	Mean Biovolume*Cell count (μm^3)	Diatom Biovolume %	Silicos Biovolume %
1	13	Diatom	<i>Cylindrotheca closterium</i>		2560	97.69		3.8	168	72	317	430694	96.02	
	13	Diatom	<i>Chaetoceros affinis</i>		480			12.8	2222	1005	3533	1066360		
	13	Diatom	<i>Centrales</i>		80			64	232472	64	1373436	18597777		
	13	Diatom	<i>Entomoneis paludosa</i>	<i>Amphirara paludosa</i> var <i>paludosa</i>	480			45	16133	4220	28046	7743840		
	13	Diatom	<i>Skeletonema costatum</i>	<i>Skeletonema marinoi</i>	5200			5.7	331	13	1649	1720316		
	13	Diatom	<i>Group Pseudo-nitzschia delicatissima</i>		160			NAN	169	50	122	27104		
	13	Diatom	<i>Guinardia delicatula</i>		1120			45	8761	2355	12364	9812096		
	13	Diatom	<i>Planktoniella sol</i>		80			14.3	19233	19233	19233	1538600		
	13	Silicoflagellates	<i>Dictyocha octonaria</i>		240		2.31	23	7069	7069	7069	1696464		3.98
2	13	Diatom	<i>Amphora</i>		80	7.65		32.5	10619	1086	30069	849520	2.75	
	13	Diatom	<i>Chaetoceros curvisetus</i>		1200			22.5	3707	1325	2512	4448010		
	13	Diatom	<i>Cylindrotheca closterium</i>		3920			3.8	168	72	317	659501		
	13	Diatom	<i>Entomoneis paludosa</i>	<i>Amphirara paludosa</i> var <i>paludosa</i>	960			45	16133	4220	28046	15487680		
	13	Diatom	<i>Guinardia delicatula</i>		80			14.3	8761	2355	12364	3504320		
	13	Diatom	<i>Navicula</i>		400			46.3	4124.0	210.0	14400.0	1979520		
	13	Diatom	<i>Nitzschia</i>		480			NAN	2734	45	10500	4374400		
	13	Diatom	<i>Group Pseudo-nitzschia delicatissima</i>		1600			NAN	169	50	122	271040		
	13	Diatom	<i>Leptocylindrus danicus</i>		1280			5.7	1339	50	122	1713650		
	13	Diatom	<i>Skeletonema costatum</i>	<i>Skeletonema marinoi</i>	23840			5.7	372	13	1649	8877394		
	13	Diatom	<i>Thalassiosira anguste-lineata</i>		160			55	64293	6204	167500	10286875		
	13	Diatom	<i>Centrales</i>		80			64	232472	64	1373436	18597777		
	13	Diatom	<i>Dactylosolen fragilissimus</i>		600			21194	667	36797	12716400			
	13	Silicoflagellates	<i>Dictyocha octonaria</i>		418000		92.35		7068.6	7068.6	7068.6	2954674800		97.25
	13	Silicoflagellates	<i>Dictyocha fibula</i>		800			23	4068	1072	7065	3254720		
7	13	Diatom	<i>Skeletonema costatum</i>	<i>Skeletonema marinoi</i>	6480	3.28		5.7	372.373913	13	1649	2412983	3.43	
	13	Diatom	<i>Entomoneis paludosa</i>	<i>Amphirara paludosa</i> var <i>paludosa</i>	1440			45	16133	4220	28046	23231520		
	13	Diatom	<i>Chaetoceros</i>		480			9.7	966.88	8	5299	464102		
	13	Diatom	<i>Guinardia delicatula</i>		120			14.3	7621.233333	2355	12364	914548		
	13	Diatom	<i>Cylindrotheca closterium</i>		880			3.8	168.24	72	317	148051		
	13	Diatom	<i>Centrales</i>		160			64	232472.2176	64	1373436	37195555		
	13	Diatom	<i>Pennates small</i>	<i>Values form Pennates</i>	320			NAN	3344.6	36	19688	1070272		
	13	Diatom	<i>Actinocyclus</i>		80			46.4	118259.7	6280	510250	9460776		
	13	Diatom	<i>Leptocylindrus danicus</i>		480			5.7	1338.788889	550	3925	642619		
	13	Diatom	<i>Group Pseudo-nitzschia delicatissima</i>		720			NAN	169	50	122	121968		
	13	Diatom	<i>Pleurosigma</i>		80			NAN	49207.6	10838	88200	3936608		
	13	Diatom	<i>Thalassiosira angulata</i>		160			40	30049.8			4807968		
	13	Silicoflagellates	<i>Dictyocha octonaria</i>		335000		96.72	30.00	7068.6	7068.6	7068.6	2367981000		96.57
	13	Silicoflagellates	<i>Dictyocha fibula</i>		1200			23	4068	1072	7065	4882080		
1	17	Diatom	<i>Cylindrotheca closterium</i>		3040	37.74		3.8	168.24	72	317	510720	8.98	
	17	Diatom	<i>Thalassiosira angulata</i>		160			40	30049.6	4292	71633	4807940		
	17	Silicoflagellates	<i>Dictyocha fibula</i>		2080		62.26	30.00	7068.6	7068.6	7068.6	12042760		91.02
	17	Silicoflagellates	<i>Dictyocha octonaria</i>		3200			23	4068	1072	7065	41846112		
2	17	Diatom	<i>Cylindrotheca closterium</i>		3200	1.71		3.8	168.24	72	317	538240	0.31	
	17	Diatom	<i>Planktoniella sol</i>		40			35	19233	19233	19233	769300		
	17	Diatom	<i>Detonula pumila</i>		160			18	5595	5595	5595	895280		
	17	Silicoflagellates	<i>Dictyocha octonaria</i>		188000			30	7068.6	7068.6	7068.6	664448400		99.69
	17	Silicoflagellates	<i>Dictyocha fibula</i>		7240		98.29	23.00	4068	1072	7065	44428020		
7	17	Diatom	<i>Pennates</i>		160	2.64		NAN	3344.6	36	19688	3200	0.25	
	17	Diatom	<i>Cylindrotheca closterium</i>		6720			3.8	168.24	72	317	1130304		
	17	Diatom	<i>Thalassiosira</i>		240			40.4	46734.5	64	235500	11216276		
	17	Silicoflagellates	<i>Dictyocha octonaria</i>		258000		97.36	30.00	7068.6	7068.6	7068.6	4948020000		99.75
	17	Silicoflagellates	<i>Dictyocha fibula</i>		4240			23	4068	1072	7065	11229060		

Text S1: Description of silicoflagellates

Silicoflagellates were first described by Ehrenberg (1839). They are a small group of single celled freshwater and marine heterokont algae (widely distributed in all oceans) that belong to the genus of *Dictyocha*. The cells range from 20 to 100 μm in size and have up to two external flagellums per cell with an external, basket-like siliceous skeleton. Living silicoflagellates in the uninulceate stage may occur in at least two morphotypes: the skeleton-bearing and naked forms (Van Valkenburg & Norris 1970; Moestrup & Thomsen 1990; Henriksen et al. 1993). Blooms are frequently observed in environments enriched by organic matter, which suggests that these organisms are capable of mixotrophy (Quéguiner 2016). The knowledge about silicoflagellates is very limited. Despite several publications on paleo records (e.g., McCartney et al., 2022; Murray & Schrader, 1983), only very few culture studies (Valkenburg & Norris, 1970) or field observations exist (e.g., Hernández-Becerril & Bravo-Sierra, 2001; Murray & Schrader, 1983; Pérez-Cruz & Molina-Cruz, 1988). These studies have shown controversial results in regard to controlling environmental conditions. Whereas a culture study has indicated that optimal growth conditions are at 10°C and a salinity of 24 (Valkenburg & Norris, 1970), well below the surface temperature and salinity in the Peruvian Upwelling (SST: >17°C, Salinity: 35; Graco et al., 2017). There are few

indications that specific species are rather adapted to cold waters (e.g., *Distephanus speculum*; Murray, 1982, Ignatiades 1970), whereas other are indicators for warm water masses and El Niño events (among other, *Dyctiocha fibula*, the species found during the experiment; Pisias et al. 1986; Pérez-Cruz & Molina-Cruz 1988). The silicoflagellate bloom during the mesocosm experiment was associated with rather high surface temperatures (21°C to 24°C) and high salinities (35.2 Sal.; see Bach et al., 2020). However, besides a possible dependence on the temperature and salinity, there might be other controlling factors.

Dictyocha fibula (Ehrenberg)

A well-characterized taxon, which has a robust skeleton, subcircular to broadly elliptical in shape. Skeletons look coarse and rather symmetrical. The radial spines are longer in the major axis, as the other spines are reduced. The basal ring is constricted at the junction of the lateral and basal rods; the basal rods are smoothly curved. The windows next to the apical bridge are larger than those opposite the apical bridge, which are more rhomboid in shape. The apical bridge is parallel or slightly oblique and shows no conspicuous apical spine. Supporting spines are inconspicuous or absent (Hernández-Becerril & Bravo-Sierra 2001).

The optimum temperature for growth is 10°C at a salinity 24. Average generation time is 49 hrs (Valkenburg & Norris 1970).

Dictyocha octonaria (Ehrenberg)

Octactis octonaria (Ehrenberg) Hovasse (conspecific with *O. pulchra* J. Schiller) (Throndsen 1997) and *Distephanus speculum* var. *octonarius* (Ehrenberg) Jörgensen (Jörgensen 1899) are synonyms of *Dictyocha octonaria*.

The specimens have a nearly circular to slightly elliptical skeleton (octagonal basal ring) with usually eight radial spines (specimens having seven or nine were also found) which are variable in length. The radial spines on the axis of elongation may be slightly longer. The apical ring, supported by lateral rods arising from the basal ring between the radial spines, is more delicate than the basal ring. No apical spines or supporting spines were seen in our material. The apical ring may be missing, probably due to breakage, or may be shorter. This fact and the relative length of the basal spines are the major source of morphological variation.

References

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