Supporting Information

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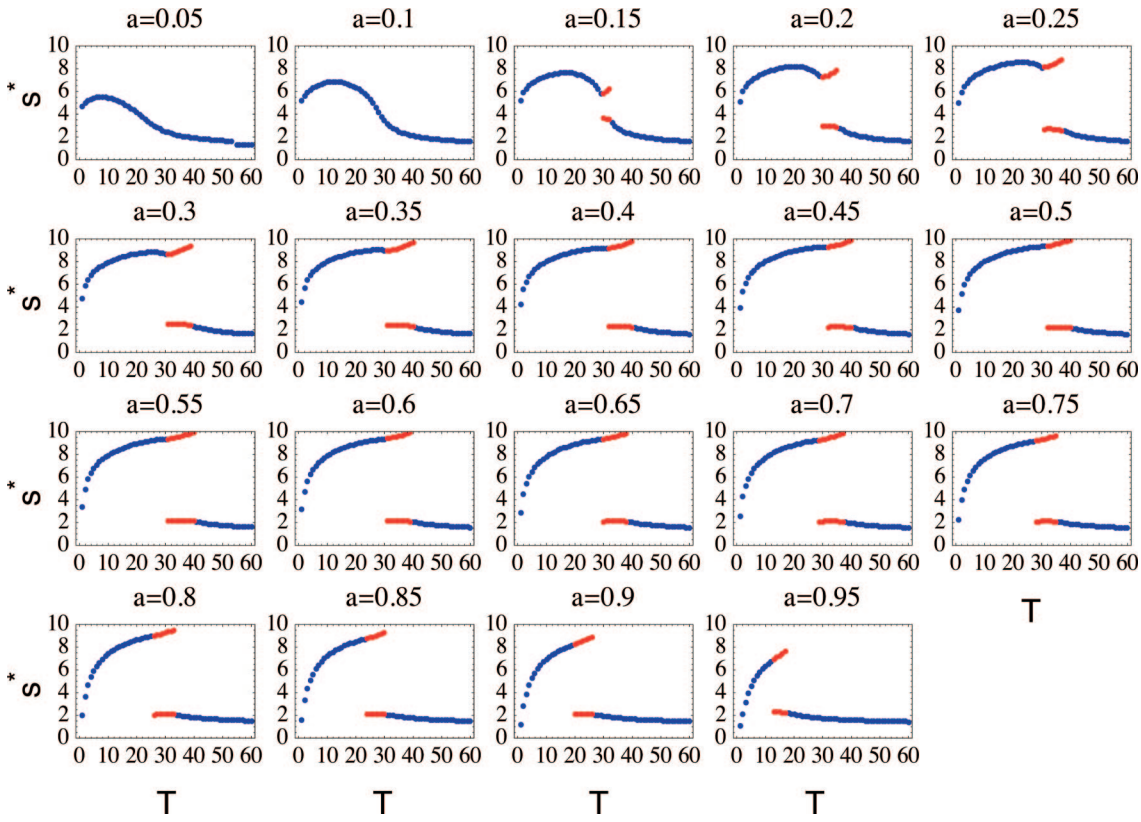

Fig. S1. Evolutionarily stable strategy (ESS) size s^* ($\log_{10}$ cell volume) as a function of pulse period T (days) for marine nitrogen limitation for a range of a, the fraction of the upper mixed layer water replaced by the deep water with nutrient concentration $R_{in} = 40$ μmol·L^{-1}. Blue circles represent single species ESS's, red circles represent two species ESS's.

1. Geritz SAH, Metz JAJ, Kisdi E, Meszena G (1998) Evolutionary singular strategies and the adaptive growth and branching of the evolutionary tree. *Evolutionary Ecology* 12:35–57.
2. Montagnes DJS, Franklin DJ (2001) Effect of temperature on diatom volume, growth rate, and carbon and nitrogen content: Reconsidering some paradigms. *Limnol Oceanogr* 46:2008–2018.
3. Grover JP (1991) Resource competition in a variable environment: Phytoplankton growing according to the variable-internal-stores model. *Am Nat* 138(4):811–835.

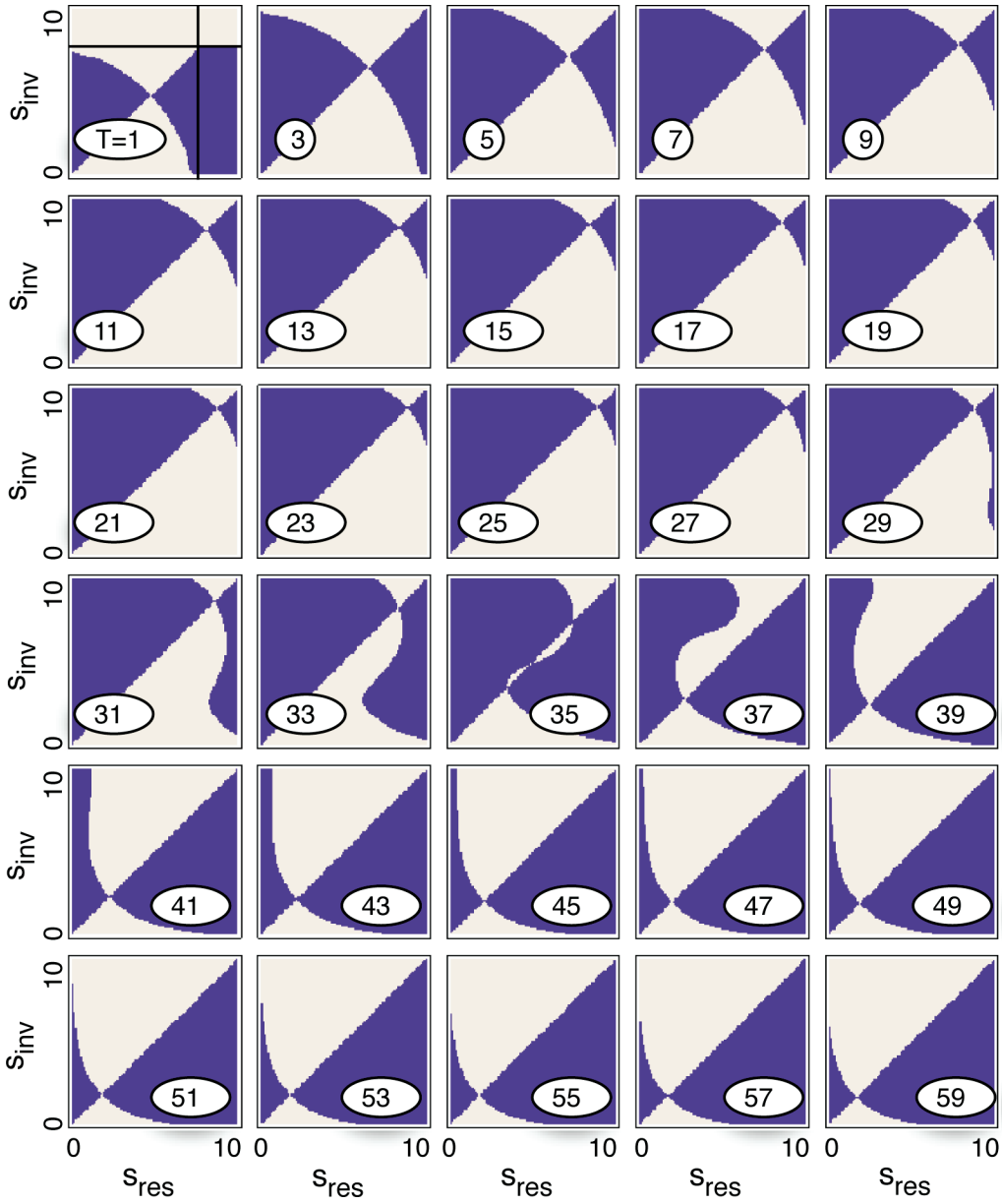

Fig. S2. Pairwise invasibility plots (PIPs) (1) for marine N limitation with $a = 0.3$ and varying period T (day). Resident size is size s_{res} and invader size is s_{inv}, expressed as $\log_{10}$ of cell volume (μm^3). Purple indicates successful invasion (positive growth rate). For $T = 1$–29 there is a single globally stable ESS. For $T = 31$, 33 this single ESS loses global stability but remains a local ESS. For $T = 35$ there are three singular strategies, two branching points separated by a repellor. For $T = 37$, 39 the original singular strategy disappears, leaving one local-but-not-global ESS. For $T = 41$–59 there is again a single globally stable ESS. $R_{in} = 40$ $\mu mol \cdot L^{-1}$. Lines in the $T = 1$ PIP mark the maximum s that can persist alone or in competition.

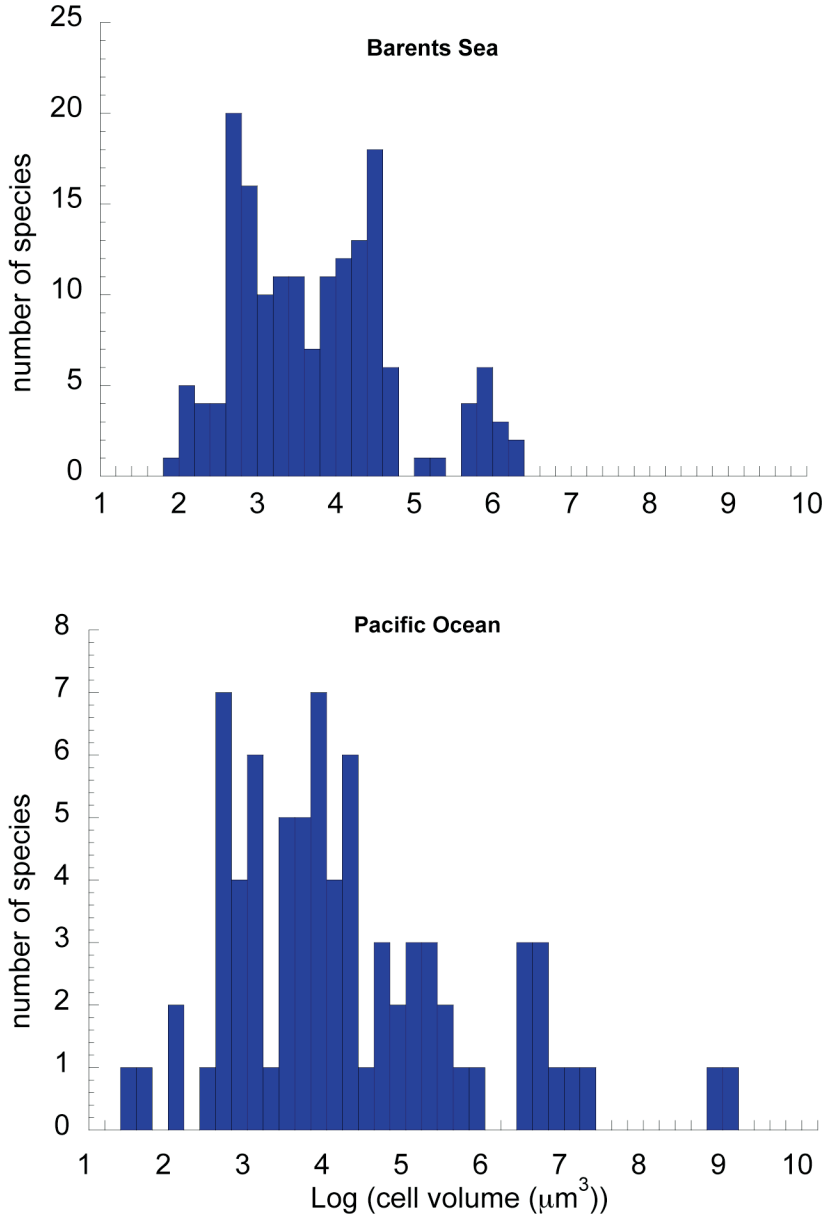

Fig. S3. Histograms of diatom size distributions in Barents Sea and Pacific Ocean. Number of species with a given cell volume is shown. Data sources are given in Materials and Methods.

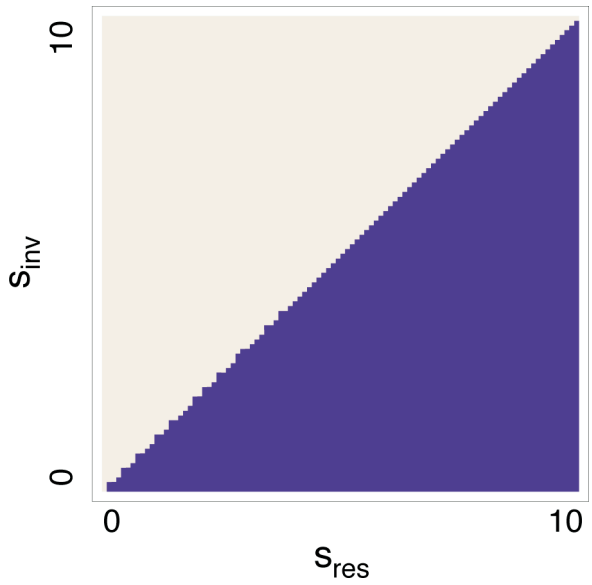

Fig. S4. Pairwise invasibility plot (PIP) (1) for marine phosphorus limitation with $a = 0.3$ and period $T = 20$ days. $R_{in} = 40/16$ μmol·L^{-1}. Resident size is size s_{res} and invader size is s_{inv}, expressed as $\log_{10}$ of cell volume (μm^3). Tan color indicates invasion failing (negative growth rate of the invader). Very small sizes (cell volume $<10^0$ μm^3) are selected for, as no species with $s_{inv} > s_{res}$ can invade. The PIPs for other combinations of a values and T values were the same.

Table S1. Allometric relationships between physiological parameters and cell volume used in the model

Parameter	*a*	*b*	R^2	*P*	*n*	Source
Marine diatoms, N (nitrate)						
V_{max}^{hi}	−7.8 ± 0.32	0.67 ± 0.11	0.85	0.0004	9	This study
K_N	−0.49 ± 0.07	0.17 ± 0.03	0.62	0.0009	14	This study
Q_{min}	−8.59 ± 0.30	0.56 ± 0.12	0.80	0.0064	7	This study
Q_{max}	−8.39 ± 0.04	0.81 ± 0.011	0.98	<0.0001	112	1
μ_∞	0.74 ± 0.06	−0.14 ± 0.01	0.91	<0.0001	16	This study
Marine Diatoms, P						
V_{max}^{hi}	−7.95 ± 0.76	0.81 ± 0.31	0.77	0.12	4	This study
K_P*	−1.16 ± 0.83	0.39 ± 0.35	0.30	0.3	5	This study
Q_{min}	−10.6 ± 0.62	0.79 ± 0.21	0.70	0.01	8	This study
Q_{max}	−9.32 ± 0.74	0.80 ± 0.25	0.84	0.08	4	This study
μ_∞	0.65 ± 0.06	−0.13 ± 0.01	0.88	<0.0001	16	This study
Freshwater Diatoms, P						
V_{max}^{hi}	−7.65 ± 0.30	0.45 ± 0.11	0.79	0.008	7	This study
K_P†	−1.16 ± 0.83	0.39 ± 0.35	0.30	0.3	5	This study (using marine allometries)
Q_{min}	−10.9 ± 0.61	1.0 ± 0.21	0.72	0.001	11	This study
Q_{max}‡	−9.32 ± 0.74	0.80 ± 0.25	0.84	0.08	4	This study (using marine allometries)
μ_∞	0.65 ± 0.06	−0.03 ± 0.01	0.88	<0.0001	12	This study

V_{cell} is cell volume (μm^3), *n* is number of data points used to derive allometries, where each point represents a species, except for the Montagnes and Franklin (2) data where some species are represented by multiple data points. Linear OLS regression (JMP, SAS) was fitted to the $\log_{10}$-transformed data: log(parameter) = $a + b\log_{10}(V_{cell})$. Both the means and SE of the estimates are given.

*As the K_P exponent may be inflated due to fewer data points compared to K_N, we also tested the model with the same exponent as the K_N exponent (0.17). The model was robust to the change and produced the same result (selection for small sizes).

†For freshwater diatoms, K_P data were not significantly allometrically scaled with cell size. Consequently, we tested both the marine allometric exponent for K_P and constant K_P (mean of all values available for freshwater diatoms = 0.58 μmol L^{-1}). The results were qualitatively the same (evolution towards small size) for both allometric and non-allometric formulations.

‡For freshwater diatoms, we used the Q_{maxP} allometry derived for marine diatoms, as there are too few data points on Q_{maxP} for freshwater diatoms. We also ran the model using the allometry for diatom and non diatom freshwater phytoplankton derived by Grover (3). The results (evolution towards small cells) were robust for both allometric relationships.