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Supplementary Materials for

Nutrient regulation of biological nitrogen fixation across the tropical western North Pacific

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The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

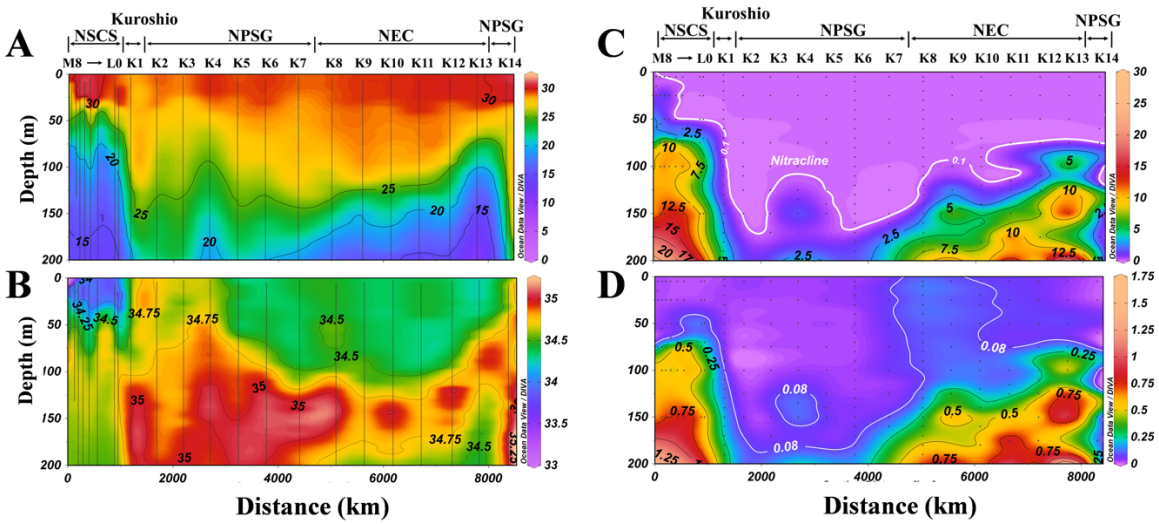

Fig. S1. Temperature, salinity and nutrient distributions. (**A**) temperature (°C), (**B**) salinity, (**C**) nitrate plus nitrite (N+N, μmol L^{-1}) and (**D**) phosphate (DIP, μmol L^{-1}). The nitracline depth in (C) was defined as the depth at which N+N was 0.1 μM.

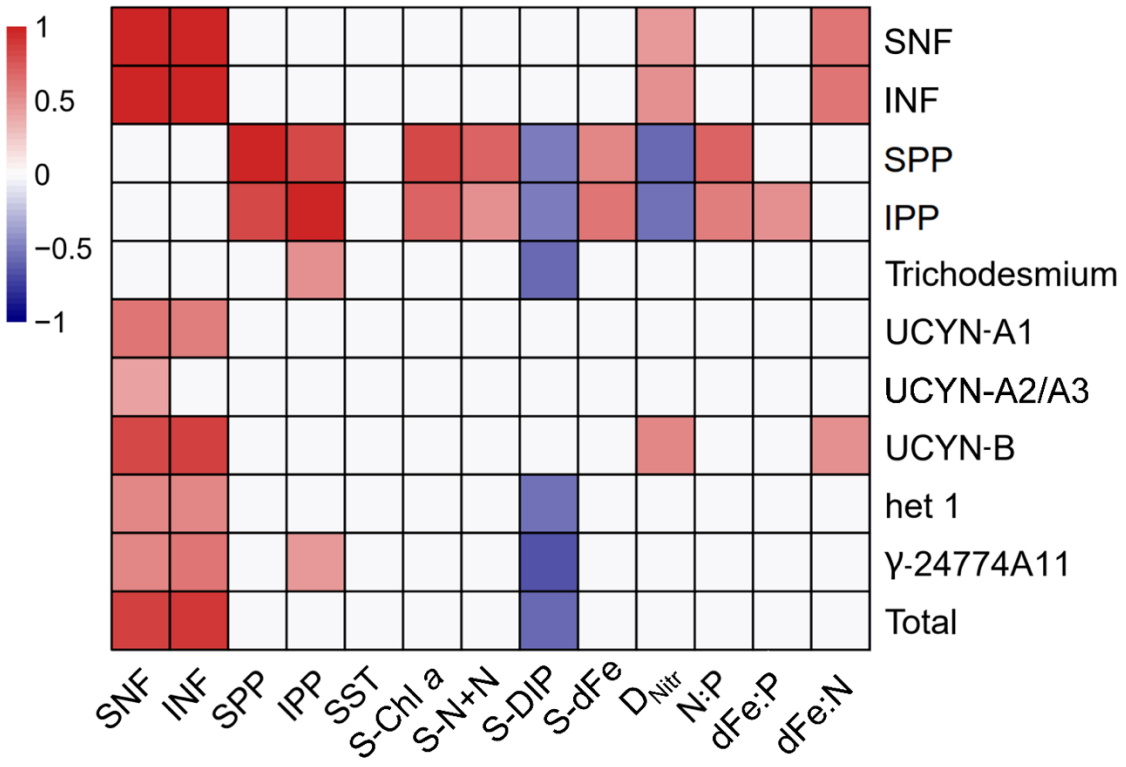

Fig. S2. Pairwise correlations between N_2 fixation rates, surface diazotroph abundances and environmental factors. Color gradient denotes Pearson correlation coefficients. Only the significant correlations ($p \leq 0.05$) are colored and the whites indicate $p > 0.05$. SNF, surface N_2 fixation rate; INF, depth-integrated N_2 fixation rate; SPP, surface primary production; IPP, depth-integrated primary production; SST, surface sea temperature; S-Chl*a*, surface Chl*a* concentration; S-N+N, surface nitrate plus nitrite concentration; S-DIP, surface phosphate concentration; S-dFe, surface dissolved Fe concentration; D_{Nitr}, depth of nitracline; N:P, dFe:P and dFe:N are ratios of surface nutrient concentrations. Total represents total *nifH* gene abundance of six diazotrophs that surveyed.

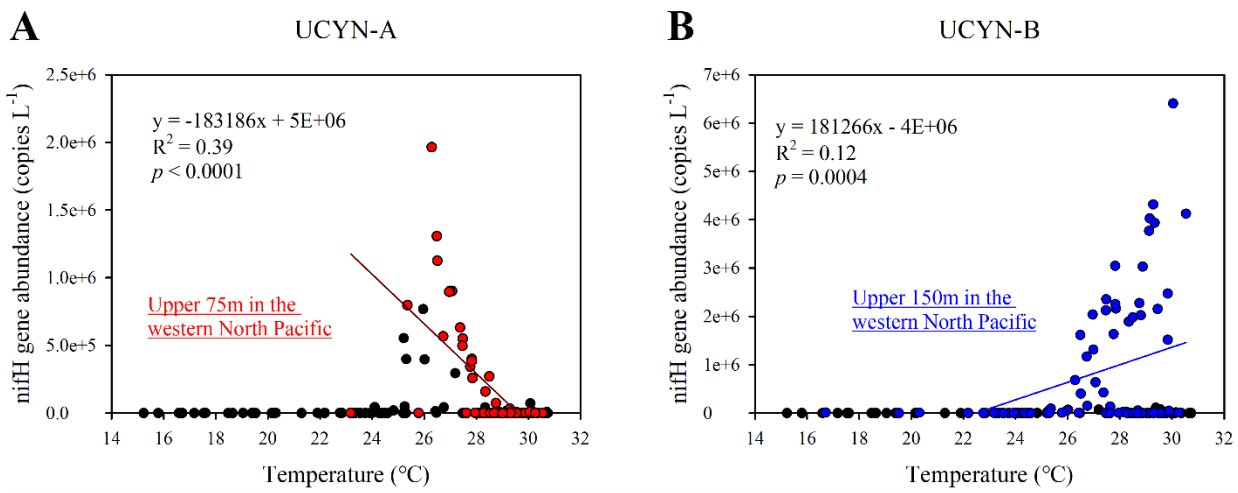

Fig. S3. Correlations between *nifH* gene abundance and temperature for unicellular diazotrophs at each depth. (**A**) UCYN-A (A1+A2/A3), a significant correlation was found in the upper 75 m at the western North Pacific stations (red dots) (**B**) UCYN-B, a significant correlation was found in the upper 150 m at the western North Pacific stations (blue dots).

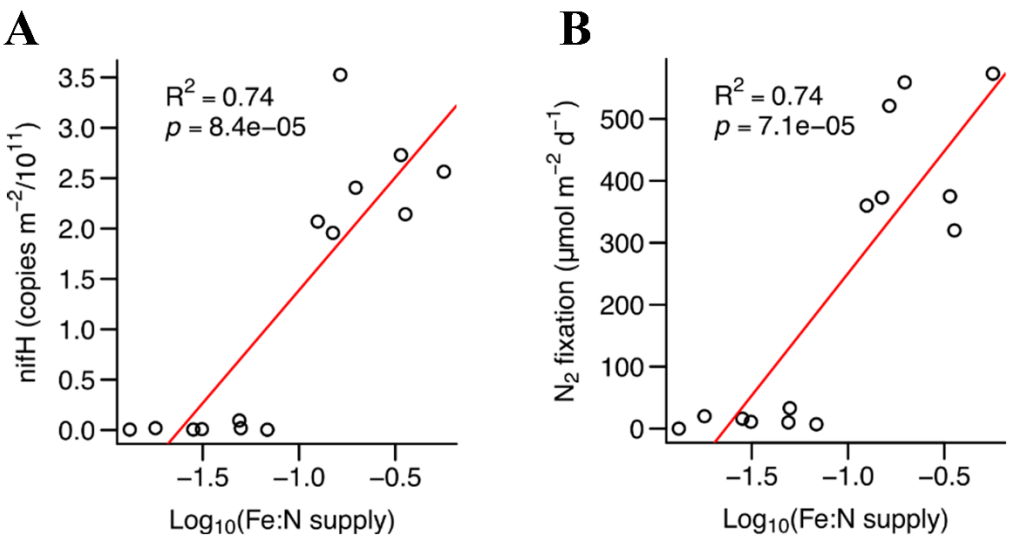

Fig. S4. Correlation between diazotrophs and N_2 fixation with calculated Fe:N supply ratios. Basin scale coherence of calculated Fe:N supply rates with (**A**) depth-integrated *nifH* and (**B**) N_2 fixation rates.

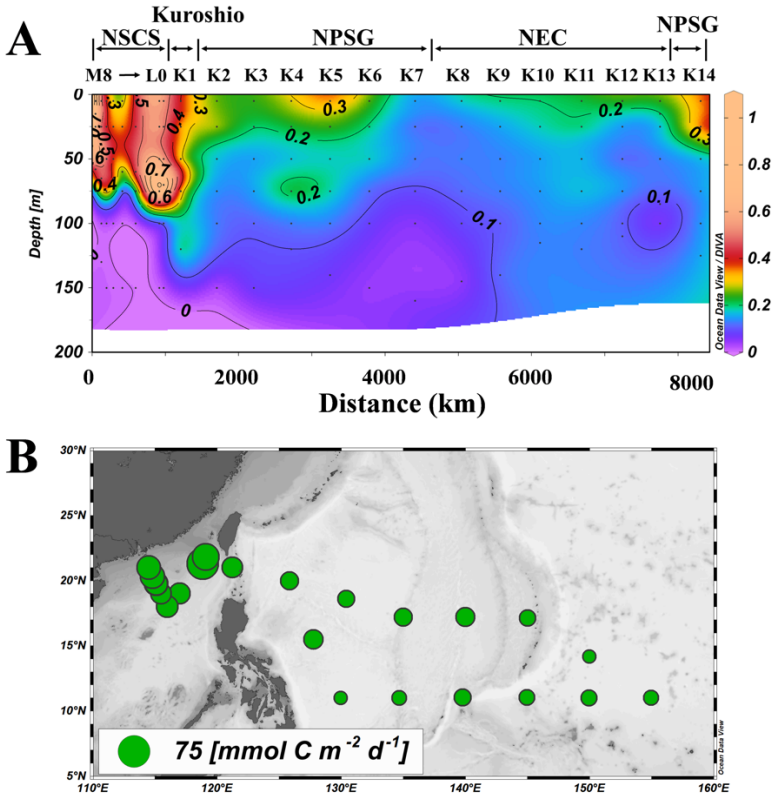

Fig. S5. Distribution of primary production throughout the tropical western North Pacific. (**A**) Vertical profiles of primary production (μmol C L^{-1} d^{-1}). (**B**) Spatial distribution of depth-integrated primary production (IPP, mmol C m^{-2} d^{-1}) for the upper 150 m water column.

Table S1. Measured $^{15}N_2$ atom% in the incubation bottle in a following cruise to the western North Pacific during winter 2020.

Station	Longitude (degrees_east)	Latitude (degrees_north)	Depth (m)	$A^{15}N_2$ (atom %)
K11	118.5	21.5	5	1.37
K11	118.5	21.5	15	1.41
K11	118.5	21.5	25	1.43
K11	118.5	21.5	40	1.33
K11	118.5	21.5	90	1.41
K11	118.5	21.5	140	1.42
K11<10 μm	118.5	21.5	5	1.53
K11<10 μm	118.5	21.5	25	1.52
K11<10 μm	118.5	21.5	140	1.56
K8a	155.0	12.5	5	1.28
K8a	155.0	12.5	25	1.31
K13a	131.0	11.0	5	1.41
K13a	131.0	11.0	150	1.35
UW-127	137.6	13.4	Surface	1.39
ZH-56	126.0	20.2	Surface	1.39
ZH-58	124.0	20.4	Surface	1.35
ZH-61	121.0	21.0	Surface	1.33

Table S2. Depth-integrated *nifH* gene abundance of six targeted diazotrophs.

Station	Region	Depth-integrated *nif*H gene abundance ($\times 10^9$ copies m^{-2})						
		Trichodesmium	UCYN-A1	UCYN-A2/A3	UCYN-B	het-1	γ-24774A11	Total
M8	NSCS	0.55	0.06	0.06	0.15	0.03	0.06	0.91
M6	NSCS	0.72	1.19	0.23	0.36	0.09	0.66	3.25
M4	NSCS	4.37	12.2	0.53	0.58	0.08	2.29	20.0
M2	NSCS	5.44	7.67	0.62	0.96	0.12	1.32	16.1
SEATS	NSCS	6.29	1.76	0.39	0.40	0.07	1.12	10.0
L3	NSCS	1.41	0.03	0.05	0.06	0.03	2.30	3.88
L1	NSCS	2.36	6.88	0.89	5.58	0.14	5.01	20.9
L0	NSCS	4.99	0.05	0.11	1.04	0.16	0.59	6.94
K1	Kuroshio	1.51	52.2	4.42	150	0.32	5.28	214
K2	NPSG	1.78	40.1	1.70	209	0.27	2.82	256
K3	NPSG	2.06	88.0	5.11	174	0.23	3.48	273
K4	NPSG	4.11	46.8	2.64	140	0.21	1.80	196
K5	NPSG	1.14	22.3	1.27	213	0.11	1.98	241
K6	NPSG	0.40	12.2	1.01	190	0.16	3.00	207
K7	NPSG	0.04	0.06	0.04	8.23	0.24	0.91	9.51
K8	NEC	0.03	0.08	0.04	0.27	0.03	0.45	0.90
K9	NEC	1.24	0.02	0.05	0.06	0.05	0.41	1.82
K10	NEC	0.01	0.01	0.04	0.15	0.02	0.29	0.51
K11	NEC	0.01	0.01	0.05	0.06	0.04	0.30	0.46
K12	NEC	0.01	0.01	0.04	0.09	0.02	0.16	0.34
K13	NEC	0.09	0.04	0.04	1.34	0.04	0.35	1.91
K14	NPSG	2.59	66.4	5.31	274	0.13	4.04	353

Table S3. Contribution of N and Fe sources to derived Fe:N supply ratios. Values in brackets indicates percentage contribution to the respective N or Fe flux.

Station	Turbulent N ($\mu mol\ m^{-2}\ d^{-1}$)	Turbulent Fe ($nmol\ m^{-2}\ d^{-1}$)	Aerosol N ($\mu mol\ m^{-2}\ d^{-1}$)	Aerosol Fe ($nmol\ m^{-2}\ d^{-1}$)
K1	43.7 (71)	0.1 (0)	18.1 (29)	22.0 (100)
K2	12.4 (54)	1.8 (14)	10.7 (46)	11.2 (86)
K3	5.9 (44)	1.0 (22)	7.6 (56)	3.6 (78)
K4	36.9 (85)	2.5 (39)	6.7 (15)	4.0 (61)
K5	22.5 (77)	1.1 (18)	6.8 (23)	4.7 (82)
K6	28.4 (82)	0.2 (6)	6.2 (18)	4.1 (94)
K7	77.4 (88)	0.1 (3)	10.3 (12)	4.2 (97)
K8	114.4 (90)	0.6 (14)	12.5 (10)	3.4 (86)
K9	57.7 (84)	0.5 (15)	10.9 (16)	2.9 (85)
K10	102.2 (91)	0.3 (10)	10.3 (9)	2.9 (90)
K11	192.7 (95)	0.4 (13)	9.1 (5)	2.3 (87)
K12	70.7 (89)	3.0 (56)	8.9 (11)	2.4 (44)
K13	146.6 (95)	0.0 (0)	8.0 (5)	2.8 (100)
K14	21.1 (73)	1.7 (36)	7.9 (27)	3.0 (64)

Table S4. Quantitative PCR primers and probes used in this study.

Species/clone	Forward primer	Probe	Reverse primer	Standard clone	References
Trichodesmium	GACGAAGTATTGAAGCCAGGTTTC	CATTAAGTGTGTTGAATCTGGTGGTCCTGAGC	CGGCCAGCGCAACCTA	AY528677	(*52*)
UCYN-A1	AGCTATAACAACGTTTTATGCGTTGA	TCTGGTGGTCCTGAGCCTGGA	ACCACGACCAGCACATCCA	AF059642	(*52*)
UCYN-A2/A3	GGTTACAACAACGTTTTATGTGTTGA	TCTGGTGGTCCTGAGCCCGGA	ACCACGACCAGCACATCCA	KF806604	(*53*)
UCYN-B	TGGTCCTGAGCCTGGAGTTG	TGTGCTGGTCGTGGTAT	TCTTCTAGGAAGTTGATGGAGGTGAT	AF299418	(*52*)
het-1	CGGTTTCCGTGGTGTACGTT	TCCGGTGGTCCTGAGCCTGGTGT	AATACCACGACCCGCACAAC	AY706898	(*54*)
24774A11	CGGTAGAGGATCTTGAGCTTGAA	AAGTGCTTAAGGTTGGCTTTGGCGACA	CACCTGACTCCACGCACTTG	EU052413	(*55*)

Table S5. Variables/parameters in the resource competition model. Values in brackets are those used by Ward et al. (*12*).

Variable/Parameter	Value(s)
Deep water nitrate (μM)	0-2 (1.6)
Deep water phosphate (μM)	0-0.125 (variable)
Deep water Fe (nM)	0.01 (0.01)
Atmospheric Fe supply (pM d^{-1})	0-0.768 (variable)
Mixing coefficient (d^{-1})	0.001 (0.1)
Non-diazotroph maximum growth rate (d^{-1})	2.5 (2.5)
Non-diazotroph half-saturation constant for nitrate (μM)	0.056 (0.056)
Non-diazotroph half-saturation constant for phosphate (μM)	0.035 (0.035)
Non-diazotroph half-saturation constant for Fe (nM)	0.35 (0.35)
Non-diazotroph P:N ratio	0.0625 (0.0625)
Non-diazotroph Fe:N ratio	6.25×10^{-5} (6.25×10^{-5})
Diazotroph maximum growth rate (d^{-1})	1.25 (1.25)
Diazotroph half-saturation constant for phosphate (μM)	0.35 (0.035)
Diazotroph half-saturation constant for Fe (nM)	1 (1.1)
Diazotroph P:N ratio	0.025 (0.025)
Diazotroph Fe:N ratio	4.75×10^{-4} (7.5×10^{-4})
Mortality rate (d^{-1})	0.1 (0.05)

Data S1. Sampling date, location and depth, PON and the $^{15}N_2$ atom% at times zero and final, N_2 fixation rate and the limit of detection, and *nifH* gene abundance of six targeted diazotrophs of each sample.