

## Supplementary Material

To the manuscript: “**Upwelled plankton community modulates surface bloom succession and nutrient availability in a natural plankton assemblage**” by Paul et al. submitted to Biogeosciences Discussions to be a part of the Special Issue “*Ecological and biogeochemical functioning of the coastal upwelling system off Peru: an in situ mesocosm study*”.

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**Table S1. Overview of key variables on Day 1 (mean  $\pm$  s.d.) for each treatment within each deep water treatment. Asterisk (\*) indicates that the mean and s.d. were calculated for n = 3 as some data were missing.**

Variable	Deep water HN (n = 4 per treatment)			Deep water LN (n = 4 per treatment)		
	Organic	Inorganic	Biology	Organic	Inorganic	Biology
[DIN] ( $\mu\text{mol L}^{-1}$ )	8.08 $\pm$ 0.30	7.75 $\pm$ 0.51	7.32 $\pm$ 0.19	2.49 $\pm$ 0.08	2.07 $\pm$ 0.40	3.17 $\pm$ 0.25
[DIP] ( $\mu\text{mol L}^{-1}$ )	2.02 $\pm$ 0.01	1.85 $\pm$ 0.02	2.06 $\pm$ 0.02	2.14 $\pm$ 0.02	2.07 $\pm$ 0.05	2.14 $\pm$ 0.02
[DSi] ( $\mu\text{mol L}^{-1}$ )	10.60 $\pm$ 0.06	5.69 $\pm$ 0.43	11.24 $\pm$ 0.08	17.35 $\pm$ 0.32	5.97 $\pm$ 0.04	17.11 $\pm$ 0.06
DIN:DIP (mol:mol)	4.01 $\pm$ 0.16	4.20 $\pm$ 0.25	3.56 $\pm$ 0.11	1.17 $\pm$ 0.04	1.00 $\pm$ 0.17	1.48 $\pm$ 0.12
[Chl <i>a</i> ] ( $\mu\text{g L}^{-1}$ )	2.61 $\pm$ 0.79	3.06 $\pm$ 0.39	3.16 $\pm$ 0.47	3.41 $\pm$ 0.76	2.89 $\pm$ 1.33	2.99 $\pm$ 0.71
% nanoplankton	34 $\pm$ 15	35 $\pm$ 18	21 $\pm$ 4	23 $\pm$ 7	29 $\pm$ 10	36 $\pm$ 14
% large microplankton	32 $\pm$ 17	24 $\pm$ 18	26 $\pm$ 10	35 $\pm$ 13	27 $\pm$ 19	16 $\pm$ 14
% cryptophytes	10 $\pm$ 5	16 $\pm$ 16	34 $\pm$ 7	18 $\pm$ 6	20 $\pm$ 17	24 $\pm$ 12
% small microplankton	9 $\pm$ 5	7 $\pm$ 4	5 $\pm$ 3	11 $\pm$ 2	11 $\pm$ 3	9 $\pm$ 3
% picoeukaryotes	5 $\pm$ 1	6 $\pm$ 3	3 $\pm$ 1	4 $\pm$ 1	4 $\pm$ 1	4 $\pm$ 1
% <i>Synechococcus</i>	6 $\pm$ 2	7 $\pm$ 4	4 $\pm$ 1	5 $\pm$ 1	5 $\pm$ 2	6 $\pm$ 1
F <sub>v</sub> /F <sub>m</sub>	0.49 $\pm$ 0.01	0.49 $\pm$ 0.03*	0.48 $\pm$ 0.03	0.50 $\pm$ 0.01*	0.48 $\pm$ 0.07*	0.50 $\pm$ 0.03
E <sub>2</sub> :E <sub>3</sub>	5.61 $\pm$ 1.35*	5.00 $\pm$ 0.21	5.31 $\pm$ 0.76	4.83 $\pm$ 0.65*	4.48 $\pm$ 0.66	3.11 $\pm$ 0.53*
LAP activity (AMC L <sup>-1</sup> h <sup>-1</sup> )	1.44 $\pm$ 0.09	1.80 $\pm$ 0.14	1.43 $\pm$ 0.10	1.57 $\pm$ 0.04	1.71 $\pm$ 0.08	1.14 $\pm$ 0.07

**Table S2a: Fixed effects for final simplified model for log-transformed Chl *a* concentrations.**

Source	Numerator df	Denominator df	F-value	p-value
<i>Bloom</i>				
Intercept	1	36	2752.335	<.0001
Treatment	2	18	0.3093	0.7378
Deepwater	1	18	7.7081	0.0125
Day	2	36	113.8446	<.0001
Treatment:Deepwater	2	18	0.0496	0.9518
Treatment:Day	4	36	2.9642	0.0325
Deepwater:Day	2	36	23.6595	<.0001
Treatment:Deepwater:Day	4	36	5.0041	0.0026
<i>Post-bloom</i>				
Intercept	1	36	320.3131	<.0001
Treatment	2	18	2.0019	0.1640
Deepwater	1	18	23.4398	0.0001
Day	2	36	23.5053	<.0001
Treatment:Deepwater	2	18	6.2807	0.0085
Treatment:Day	4	36	0.8018	0.5321
Deepwater:Day	2	36	0.0836	0.9200
Treatment:Deepwater:Day	4	36	2.9089	0.0349

**Table S2b: Posthoc comparisons for Chlorophyll *a* concentrations. Only the significant comparisons ( $p_{\text{adjusted}} < 0.05$ ) are reported. Df = degrees of freedom. Note Chlorophyll *a* concentrations were log transformed to satisfy assumptions.**

Contrast	Deepwater	Treatment	Day	Estimate	Standard error (SE)	Df	t	$p_{\text{adjusted}}$
biology – organic	low nitrate		4	-0.4990	0.1801	18	-2.7701	0.0322
high nitrate – low nitrate	--	organic	4	1.0917	0.1801	18	6.0599	0.0000
high nitrate – low nitrate	--	inorganic	4	0.5962	0.1801	18	3.3095	0.0040
organic – biology	low nitrate	--	8	-1.1857	0.2673	18	-4.4355	0.0009
organic - inorganic	low nitrate	--	8	-1.1344	0.2673	18	-4.2437	0.0014
high nitrate – low nitrate	--	biology	8	1.0268	0.2673	18	3.8410	0.0012
high nitrate – low nitrate	--	inorganic	8	0.8524	0.2673	18	3.1888	0.0051
high nitrate – low nitrate	--	biology	10	0.7376	0.2673	18	2.7591	0.0129
high nitrate – low nitrate	--	inorganic	10	0.7867	0.2673	18	2.9431	0.0087

**Table S3a: Fixed effects for final simplified model for DIN:DIP drawdown**

Source	Numerator df	Denominator df	F-value	p-value
<i>Bloom</i>				
Intercept	1	37	661.4329	<.0001
Treatment	2	20	3.6151	0.0457
Deepwater	1	20	0.1659	0.6881
Day	2	37	21.2439	<.0001
Treatment:Day	4	37	2.6674	0.0473
Deepwater:Day	2	37	8.3095	0.001
<i>Post-bloom</i>				
Intercept	1	90	1838.958	<.0001
Treatment	2	18	1.0413	0.3733
Deepwater	1	18	61.412	<.0001
Day	5	90	1.4199	0.2247
Treatment:Deepwater	2	18	3.0637	0.0716
Treatment:Day	10	90	0.7285	0.6958
Deepwater:Day	5	90	0.6753	0.6432
Treatment:Deepwater:Day	10	90	1.4655	0.1655

**Table S3b: Posthoc comparisons for DIN:DIP drawdown. Only the significant comparisons ( $p_{\text{adjusted}} < 0.05$ ) are reported. Df = degrees of freedom.**

Contrast	Deepwater	Treatment	Day	Estimate	Standard error (SE)	Df	t	$p_{\text{adjusted}}$
organic – biology	low nitrate	--	2	-15.2994	3.4607	18	-4.4209	0.0009
biology - inorganic	low nitrate	--	2	10.6771	3.4607	18	3.0852	0.0167
high nitrate – low nitrate	--	biology	2	-12.6025	3.6845	18	-3.4204	0.0031
organic – biology	high nitrate	--	9	5.9585	1.7337	18	3.4369	0.0079
organic – inorganic	high nitrate	--	9	5.4998	1.7337	18	3.1723	0.0139
high nitrate – low nitrate	--	inorganic	5	4.7862	1.7337	18	2.7607	0.0129
high nitrate – low nitrate	--	biology	6	6.1251	1.7337	18	3.5330	0.0024
high nitrate – low nitrate	--	organic	7	3.9095	1.7337	18	2.2550	0.0368
high nitrate – low nitrate	--	organic	8	3.8552	1.7337	18	2.2237	0.0392
high nitrate – low nitrate	--	organic	9	8.2249	1.7337	18	4.7441	0.0002
high nitrate – low nitrate	--	organic	10	5.3546	1.7337	18	3.0886	0.0063
high nitrate – low nitrate	--	inorganic	10	4.4265	1.7337	18	2.5532	0.0200

**Table S4a: Fixed effects for final simplified model for leucine aminopeptidase (LAP) activity.**

Source	Numerator	Denominator	F-value	p-value
<i>Bloom</i>				
Intercept	1	18	2279.311	<.0001
Treatment	2	18	16.8631	0.0001
Deepwater	1	18	0.0434	0.8373
Day	1	18	98.3344	<.0001
Treatment:Deepwater	2	18	8.8878	0.0021
Treatment:Day	2	18	7.3699	0.0046
Deepwater:Day	1	18	7.147	0.0155
Treatment:Deepwater:Day	2	18	3.4128	0.0554
<i>Post-bloom</i>				
Intercept	1	54	188.6426	<.0001
Treatment	2	18	2.6025	0.1017
Deepwater	1	18	36.5563	<.0001
Day	3	54	45.5477	<.0001
Treatment:Deepwater	2	18	0.1743	0.8415
Treatment:Day	6	54	3.6863	0.0038
Deepwater:Day	3	54	7.1365	0.0004
Treatment:Deepwater:Day	6	54	3.0033	0.0132

**Table S4b: Posthoc comparisons for leucine aminopeptidase (LAP) activity. Here only the significant comparisons ( $p_{\text{adjusted}} < 0.05$ ) are reported. Df = degrees of freedom.**

Contrast	Deepwater	Treatment	Day	Estimate	Standard error (SE)	Df	t	$p_{\text{adjusted}}$
organic – biology	low nitrate	--	10	-0.7329	0.1811	18	-4.0475	0.0021
biology - inorganic	high nitrate	--	5	-0.5784	0.1811	18	-3.1942	0.0133
high nitrate – low nitrate	--	organic	5	0.3942	0.1811	18	2.1769	0.0430
high nitrate – low nitrate	--	inorganic	5	0.4950	0.1811	18	2.7338	0.0136
high nitrate – low nitrate	--	organic	7	0.6376	0.1811	18	3.5210	0.0024
high nitrate – low nitrate	--	biology	7	0.9808	0.1811	18	5.4165	0.0000
high nitrate – low nitrate	--	inorganic	7	0.4420	0.1811	18	2.4407	0.0252
high nitrate – low nitrate	--	biology	9	0.5415	0.1811	18	2.9906	0.0078



**Table S5a: Fixed effects for final simplified model for excess phosphate (P\*).**

Source	Numerator df	Denominator df	F-value	p-value
<i>Bloom</i>				
Intercept	1	69	28582.4480	<.0001
Treatment	2	18	7.2710	0.0048
Deepwater	1	18	446.9850	<.0001
Day	3	69	7.3840	0.0002
Treatment:Deepwater	2	18	5.8080	0.0113
<i>Post-bloom</i>				
Intercept	1	115	11792.2510	<.0001
Treatment	2	18	6.2280	0.0088
Deepwater	1	18	410.6420	<.0001
Day	5	115	2.7170	0.0233
Treatment:Deepwater	2	18	2.5610	0.1050

**Table S5b: Posthoc output with adjusted p-values for P\* during the Bloom phase. Df = degrees of freedom.**

Contrast	Deepwater	Treatment	Day	Estimate	Standard error (SE)	Df	t	P <sub>adjusted</sub>
organic – biology	high nitrate	--	1	-0.1088	0.0348	18	-3.1280	0.0153
biology - inorganic	high nitrate	--	1	0.1738	0.0348	18	4.9976	0.0003
organic – biology	high nitrate	--	2	-0.1088	0.0348	18	-3.1280	0.0153
biology - inorganic	high nitrate	--	2	0.1738	0.0348	18	4.9976	0.0003
organic – biology	high nitrate	--	3	-0.1088	0.0348	18	-3.1280	0.0153
biology - inorganic	high nitrate	--	3	0.1738	0.0348	18	4.9976	0.0003
organic – biology	high nitrate	--	4	-0.1088	0.0348	18	-3.1280	0.0153
biology - inorganic	high nitrate	--	4	0.1738	0.0348	18	4.9976	0.0003
high nitrate – low nitrate	--	organic	1	-0.4531	0.0348	18	-13.0333	0.0000
high nitrate – low nitrate	--	biology	1	-0.3300	0.0348	18	-9.4918	0.0000
high nitrate – low nitrate	--	inorganic	1	-0.4900	0.0348	18	-14.0939	0.0000
high nitrate – low nitrate	--	organic	2	-0.4531	0.0348	18	-13.0333	0.0000
high nitrate – low nitrate	--	biology	2	-0.3300	0.0348	18	-9.4918	0.0000
high nitrate – low nitrate	--	inorganic	2	-0.4900	0.0348	18	-14.0939	0.0000
high nitrate – low nitrate	--	organic	3	-0.4531	0.0348	18	-13.0333	0.0000
high nitrate – low nitrate	--	biology	3	-0.3300	0.0348	18	-9.4918	0.0000
high nitrate – low nitrate	--	inorganic	3	-0.4900	0.0348	18	-14.0939	0.0000
high nitrate – low nitrate	--	organic	4	-0.4531	0.0348	18	-13.0333	0.0000
high nitrate – low nitrate	--	biology	4	-0.3300	0.0348	18	-9.4918	0.0000
high nitrate – low nitrate	--	inorganic	4	-0.4900	0.0348	18	-14.0939	0.0000

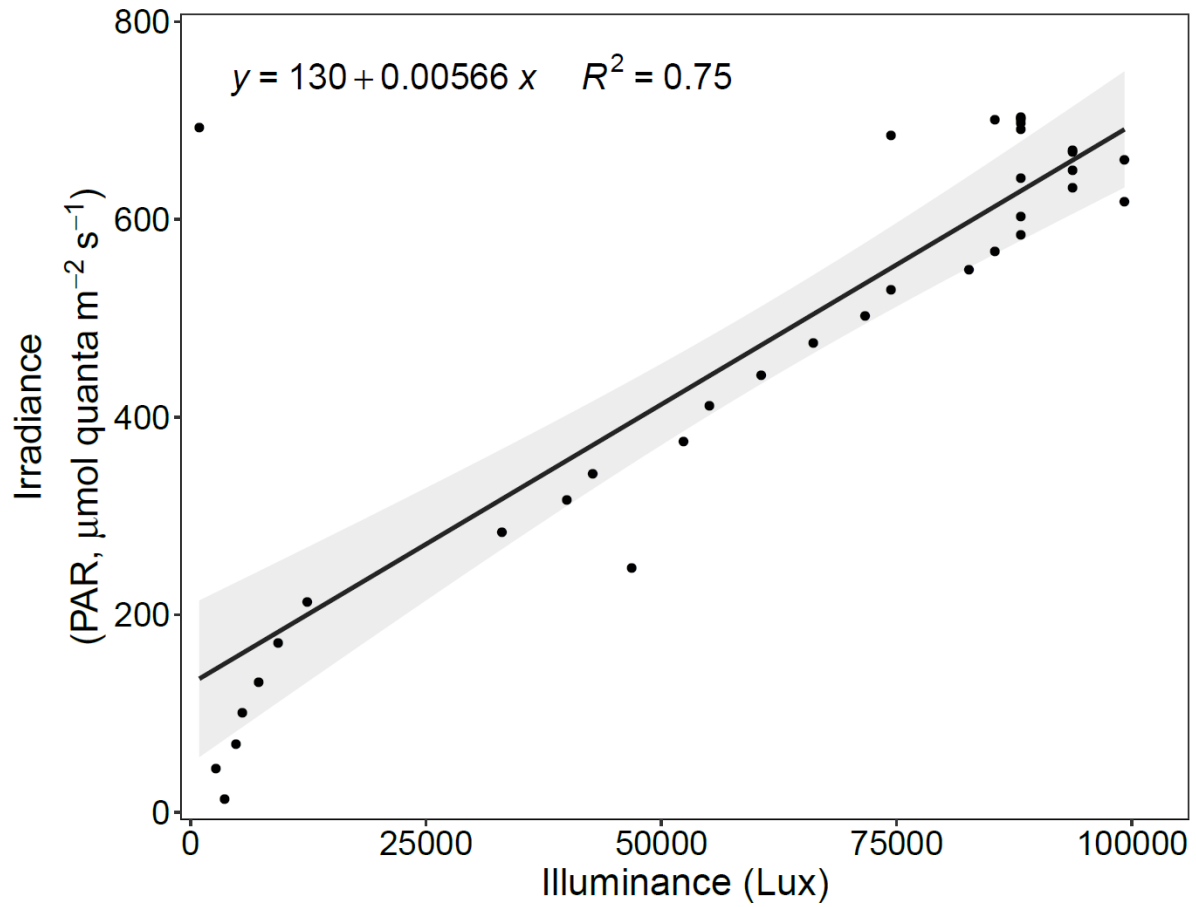
**Table S5c: Posthoc output with adjusted p-values for P\* during the Post-bloom phase. Df = degrees of freedom**

Contrast	Deepwater	Treatment	Day	Estimate	Standard error (SE)	Df	t	P <sub>adjusted</sub>
organic - inorganic	high nitrate	--	5	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	5	0.1346	0.0454	18	2.9647	0.0215
organic - inorganic	high nitrate	--	6	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	6	0.1346	0.0454	18	2.9647	0.0215
organic - inorganic	high nitrate	--	7	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	7	0.1346	0.0454	18	2.9647	0.0215
organic - inorganic	high nitrate	--	8	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	8	0.1346	0.0454	18	2.9647	0.0215
organic - inorganic	high nitrate	--	9	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	9	0.1346	0.0454	18	2.9647	0.0215
organic - inorganic	high nitrate	--	10	0.1642	0.0454	18	3.6164	0.0053
biology - inorganic	high nitrate	--	10	0.1346	0.0454	18	2.9647	0.0215
high nitrate – low nitrate	--	organic	5	-0.5096	0.0454	18	-11.2254	0.0000
high nitrate – low nitrate	--	biology	5	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	5	-0.6121	0.0454	18	-13.4833	0.0000
high nitrate – low nitrate	--	organic	6	-0.5096	0.0454	18	-11.2254	0.0000
high nitrate – low nitrate	--	biology	6	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	6	-0.6121	0.0454	18	-13.4833	0.0000
high nitrate – low nitrate	--	organic	7	-0.5096	0.0454	18	-11.2254	0.0000
high nitrate – low nitrate	--	biology	7	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	7	-0.6121	0.0454	18	-13.4833	0.0000
high nitrate – low nitrate	--	organic	8	-0.5096	0.0454	18	-11.2254	0.0000
high nitrate – low nitrate	--	biology	8	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	8	-0.6121	0.0454	18	-13.4833	0.0000
high nitrate – low nitrate	--	organic	9	-0.5096	0.0454	18	-11.2254	0.0000

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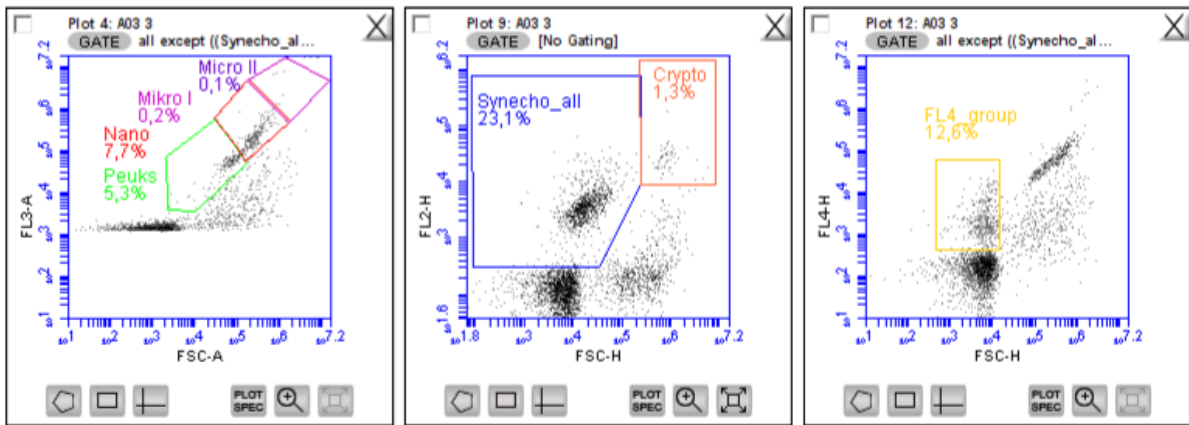
high nitrate – low nitrate	--	biology	9	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	9	-0.6121	0.0454	18	-13.4833	0.0000
high nitrate – low nitrate	--	organic	10	-0.5096	0.0454	18	-11.2254	0.0000
high nitrate – low nitrate	--	biology	10	-0.4717	0.0454	18	-10.3901	0.0000
high nitrate – low nitrate	--	inorganic	10	-0.6121	0.0454	18	-13.4833	0.0000

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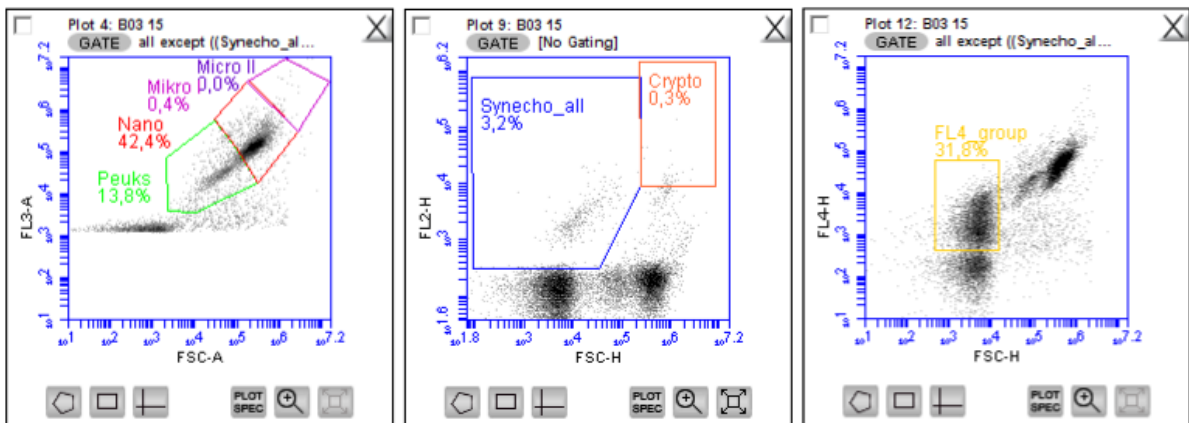


**Figure S1: Relationship between PAR and measured Lux over a six hour period submersed in ~1 m water depth to estimate PAR from the incubators. The black line indicates the linear regression with the corresponding equation and  $R^2$  included in the figures panel and the grey shaded band indicating the 95% Confidence Interval (CI).**

### Day 1: low nitrate/biology



### Day 4: high nitrate/inorganic



**Figure S2: Flow cytometry cytograms to indicate gating of different groups by size (Plot 4), taxonomic groups (Plot 9) and morphology (Plot 12). Note the Micro II group (large microphytoplankton) is barely visible on the cytogram.**