

1 **Understanding the effects of climate change via disturbance on pristine arctic lakes; multi-**  
2 **trophic level response and recovery to a twelve-year, low-level fertilization experiment.**

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18 **Electronic Supplementary Material**

19 Supplemental Table S1: Number of samples collected over the summer (15 June-15 August) per year for four limnological variables  
 20 from four lakes in arctic Alaska near Toolik Field Station. Zooplankton data include only samples from July.

Lake	Variable	Year																		
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
E5 (deep, fertilized)	Chl a	8	8	9	8	7	6	5	5	5	5	5	6	6	5	5	5	3	3	1
	Secchi depth	7	7	9	8	7	6	4	4	5	5	5	6	6	5	5	5	3	3	1
	Zooplankton biomass	1	6	1	3	3	1	1	3	3	3	3	3	1	2	4	3	0	2	1
	Dissolved oxygen	7	8	8	7	7	6	3	4	6	5	5	6	6	5	5	5	3	3	1
Fog2 (deep, reference)	Chl a	2	3	3	3	1	2	2	2	2	2	2	2	2	2	4	4	2	4	4
	Secchi depth	2	3	3	0	1	2	2	2	2	2	2	2	2	2	3	4	2	3	3
	Zooplankton biomass	1	1	2	2	1	1	1	2	2	2	1	1	1	1	2	1	2	2	1
	Dissolved oxygen	2	3	3	2	1	2	0	2	2	2	2	2	2	2	3	4	2	3	4
E6 (shallow, fertilized)	Chl a	8	8	9	8	7	6	5	5	6	5	5	6	6	5	5	5	3	3	1
	Secchi depth	8	8	8	7	7	6	3	5	5	4	4	6	6	5	5	5	3	3	1
	Zooplankton biomass	1	5	1	1	3	1	1	1	3	3	3	3	2	3	4	3	1	2	0
	Dissolved oxygen	8	7	9	7	4	6	5	5	6	5	5	6	6	5	5	5	3	3	1
Fog4	Chl a	3	3	3	3	1	2	2	2	2	2	2	2	2	2	4	4	1	2	2

(shallow,  
reference)

Secchi depth	3	3	3	2	1	2	2	2	2	2	2	2	2	2	4	4	1	1	2
Zooplankton biomass	1	1	2	1	3	1	1	1	3	3	3	3	2	3	4	3	1	2	1
Dissolved oxygen	3	3	2	2	1	2	1	2	2	2	2	2	3	2	4	4	1	2	2

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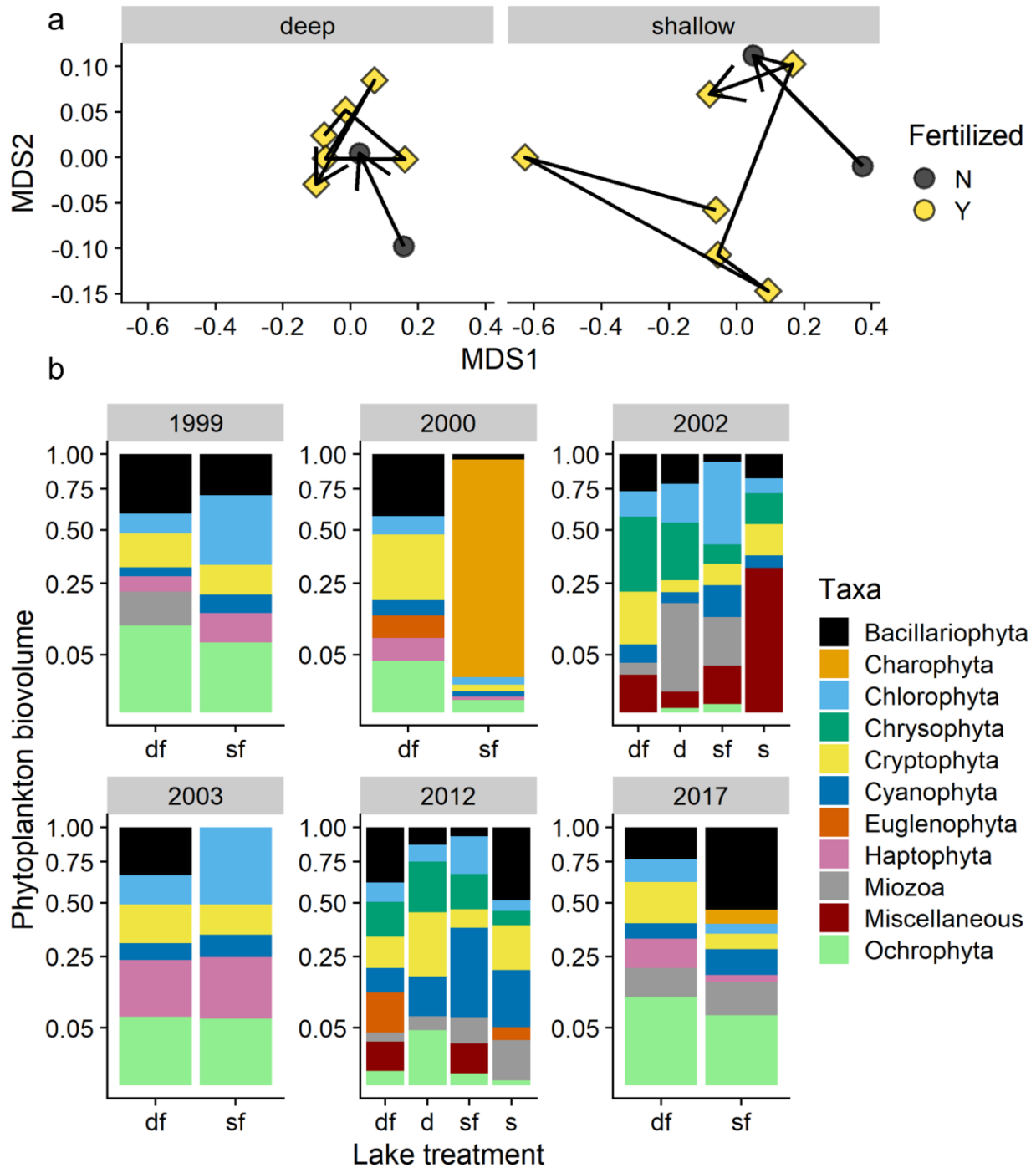
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24 Supplemental Table S2: Phytoplankton proportional biovolume from four lakes in arctic Alaska near Toolik Field Station. The  
 25 miscellaneous category includes microflagellates, unidentifiable cysts, and *Gonyostomum semen* which is in the division  
 26 Chloromonadophyta. This designation also includes other miscellaneous forms and divisions that were not identified further.

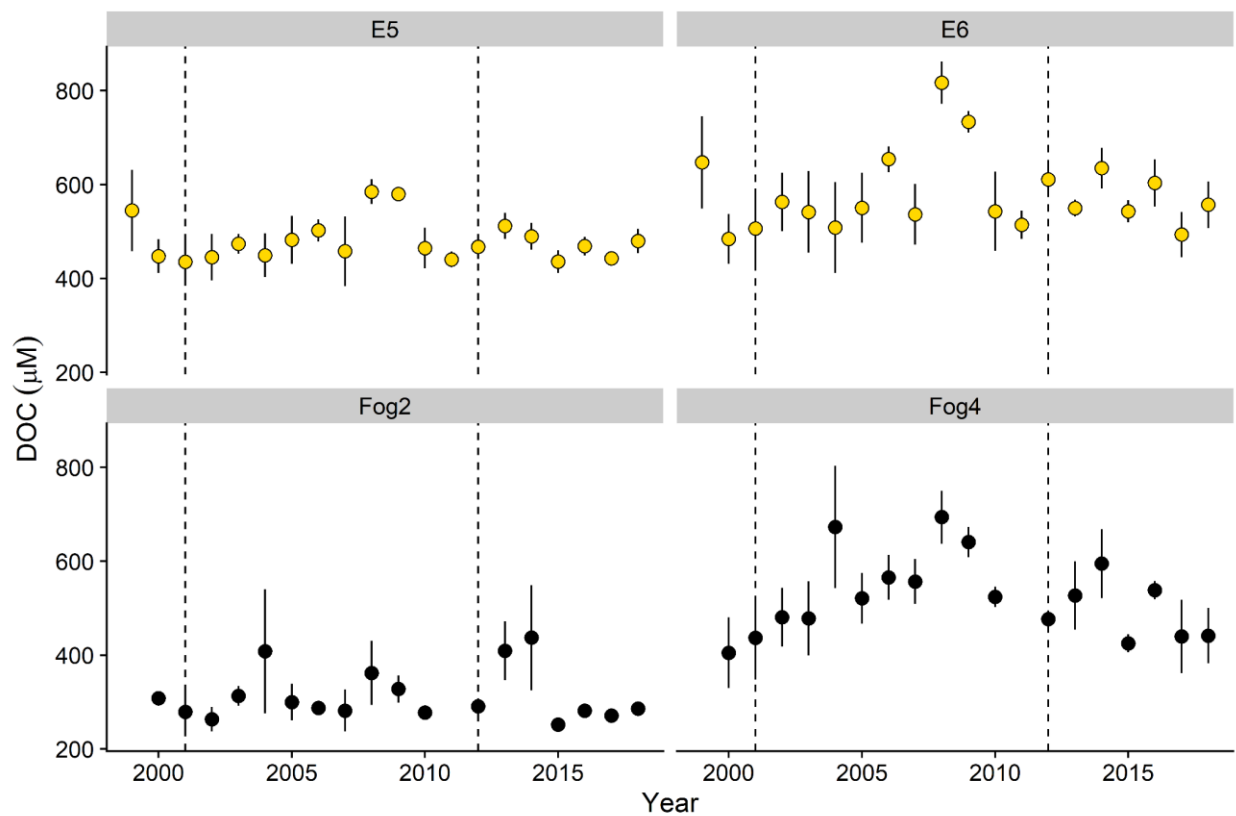
Algal division												
Lake	Year	Bacillariophyta	Charophyta	Chlorophyta	Chrysophyta	Cryptophyta	Cyanophyta	Euglenophyta	Haptophyta	Miozoa	Misc.	Ochrophyta
E5	1999	0.25		0.03		0.08	<0.01		0.02	0.08		0.53
	2000	0.31		0.03		0.35	0.02	0.04	0.04			0.22
	2002	0.11		0.05	0.45	0.23	0.03			0.01	0.12	
	2003	0.18		0.07		0.12	0.02		0.25			0.36
	2012	0.34		0.04	0.13	0.11	0.07	0.18		<0.01	0.09	0.02
	2017	0.08		0.04		0.13	0.02		0.06	0.06		0.60
E6	1999	0.12		0.36		0.07	0.03		0.06	0.00		0.36
	2000	<0.01	0.99	<0.01		<0.01	<0.01		<0.01	0.00		<0.01
	2002	<0.01		0.54	0.03	0.04	0.08			0.19	0.12	<0.01
	2003			0.38		0.06	0.03		0.25	0.00		0.28
	2012	<0.01		0.11	0.10	0.03	0.62			0.05	0.07	0.01
	2017	0.48	0.01	<0.01		0.02	0.05		<0.01	0.08		0.35
Fog2	2002	0.06		0.10	0.24	0.01	<0.01			0.56	0.02	<0.001
	2012	0.03		0.02	0.21	0.34	0.13			0.02		0.25
Fog4	2002	0.02		<0.01	0.04	0.04	<0.01				0.88	
	2012	0.42		<0.01	0.02	0.16	0.26	0.01		0.13		<0.00

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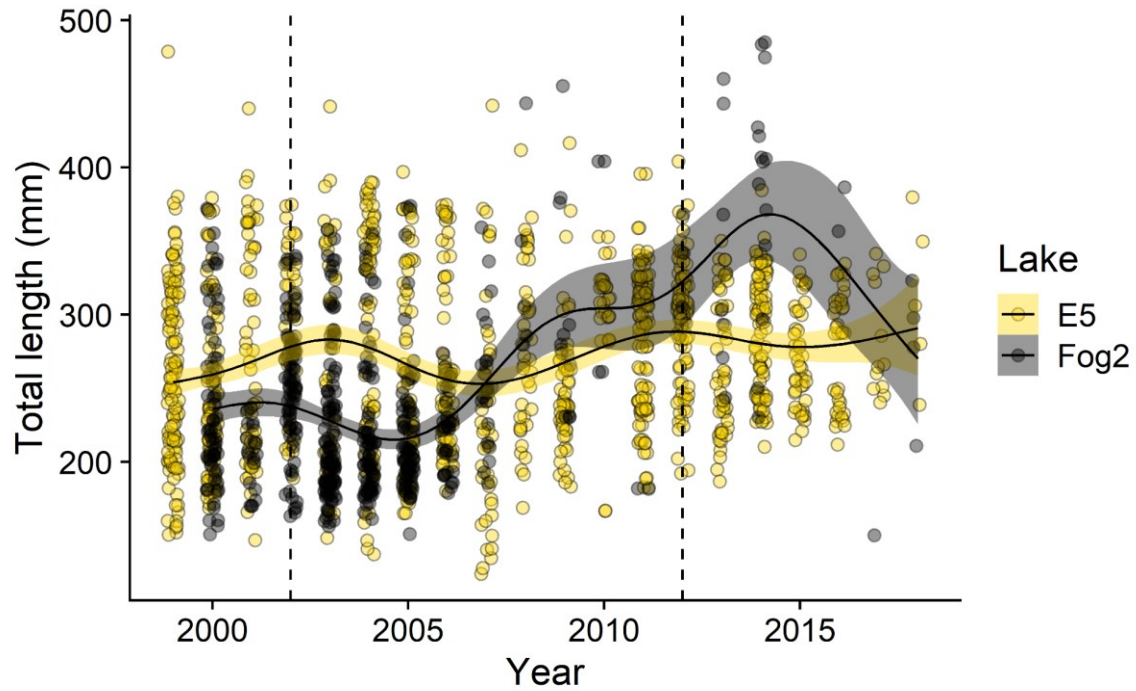


Supplemental Figure S1: a) Non-metric multidimensional scaling ordinations (stress = 0.09) of phytoplankton composition in deep (left) and shallow (right) lakes based on Morisita-Horn distance of taxa biovolume. Arrows depict order of samples through time; Fertilized: N = no, Y

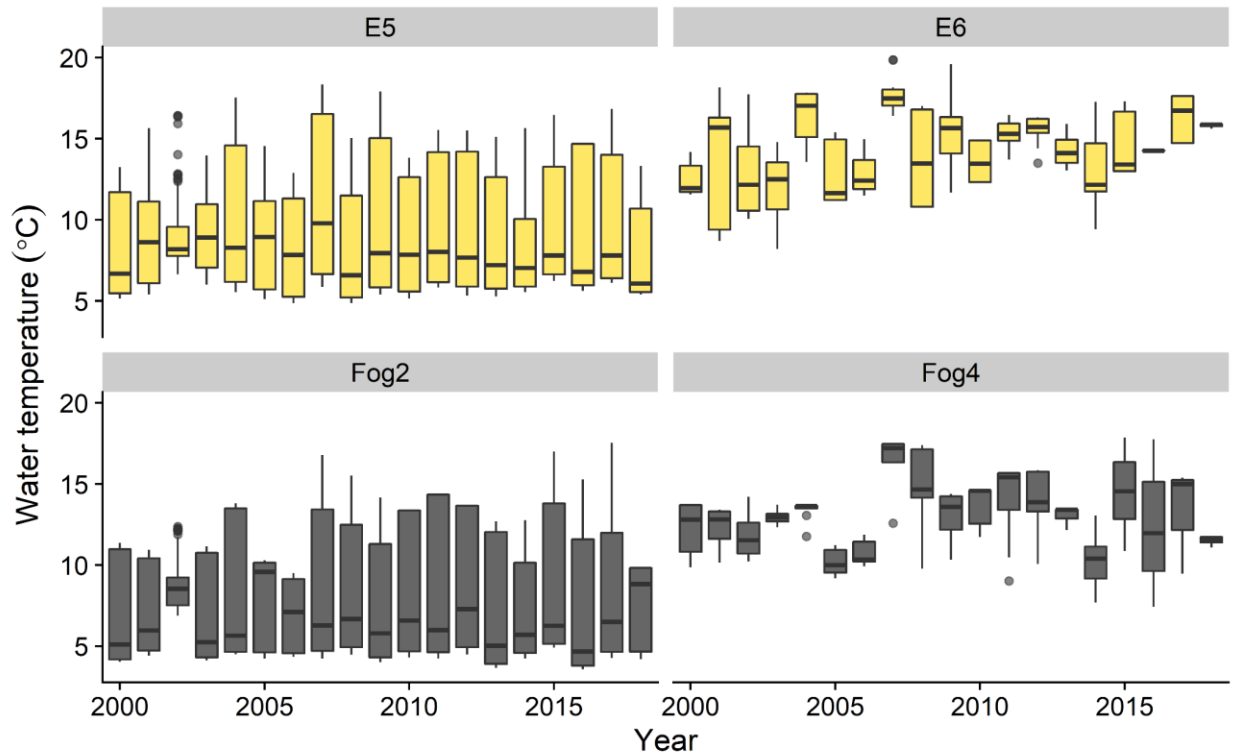
= yes. b) Proportional phytoplankton biovolume over time. All four lakes were sampled in 2002 and 2012 in the early and late fertilization period. A natural thermokarst event impacted lake Fog4 from 2002-2004. Abbreviations on x-axis stand for lake type and treatment (deep fertilized = df, deep = d, shallow fertilized = sf, shallow = s). Proportional abundance of represented taxa are presented in the Supplemental Table S2.



Supplemental Figure S2: Dissolved organic carbon (DOC) in fertilized (yellow) and reference (black) lakes (Kling et al. 2000). Deep lakes are on the left and shallow lakes are on the right. Dots represent averages and errors bars are  $\pm 1$  SD. The dashed vertical lines indicate the start and end of the fertilization.



Supplemental Figure S3. Fish total length over time in the fertilized deep lake E5 (yellow) and reference lake Fog2 (black). The dashed vertical lines indicate the start and end of the fertilization. Lines are smoothing splines with 95% confidence intervals from generalized additive models.



Supplemental Figure S4: July water-column temperatures in the fertilized (gold) and reference (black) lakes. Deep lakes are on the left and shallow lakes on the right. Temperatures were measured throughout the entire water column. The lower and upper edges of boxes correspond to the 25<sup>th</sup> and 75<sup>th</sup> percentiles. The whiskers extend from the box edges to the largest (upper) and smallest (lower) values that are no further than 1.5 times the interquartile range from the box edge. Maximum or minimum points above or below whiskers represent outliers.

### Supplemental Literature Cited

Kling, G. W., G. W. Kipphut, M. C. Miller, and W. J. O'Brien. 2000. Integration of lakes and streams in a landscape perspective: the importance of material processing on spatial patterns and temporal coherence. *Freshw. Biol.* **43**: 477-497. doi:10.1046/j.1365-2427.2000.00515.x