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SUPPLEMENTARY MATERIAL

Model simulations of the ecological dynamics induced by climate and nutrient load changes for deep subalpine Lake Maggiore (Italy/Switzerland)

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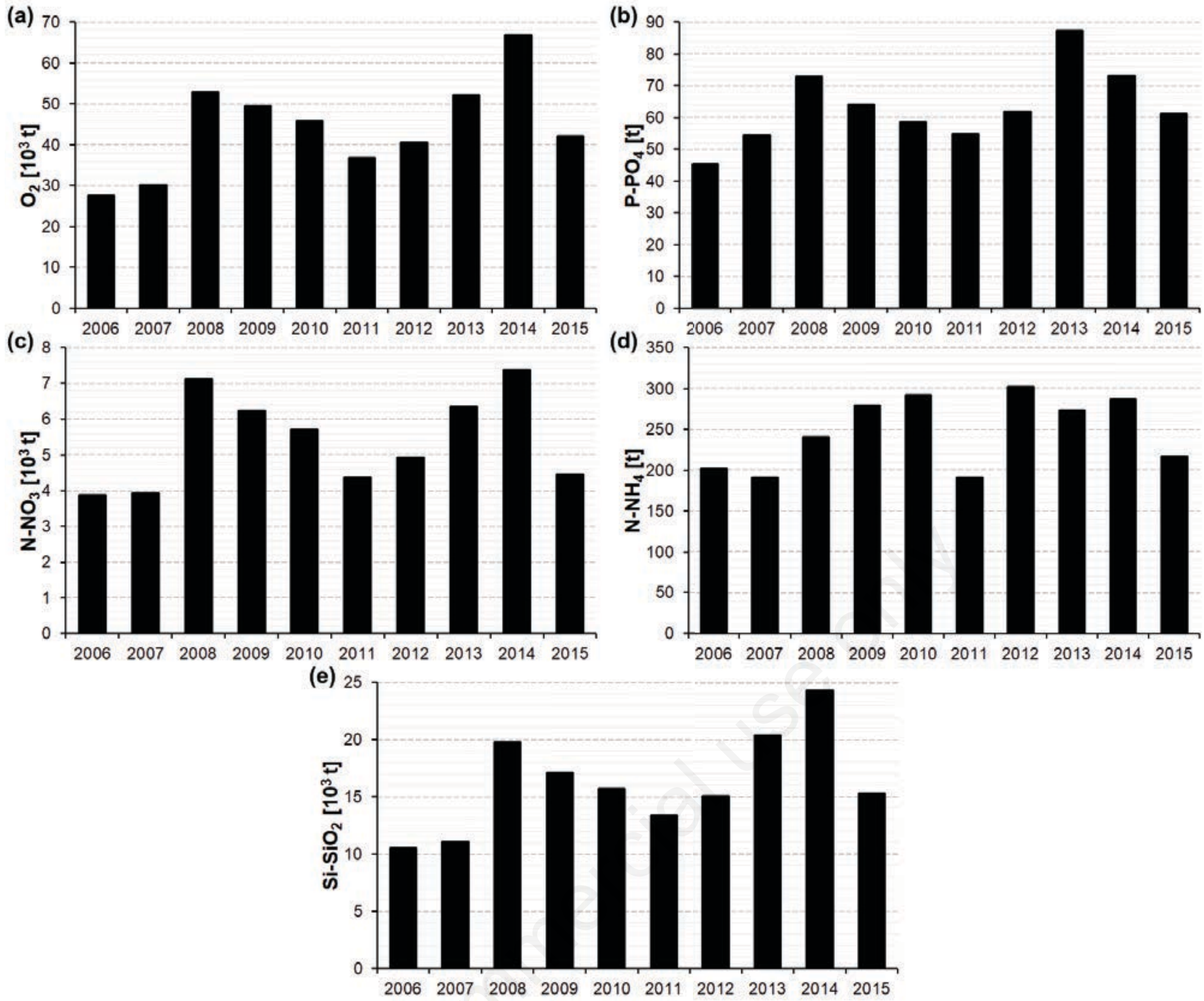

Fig. S1. Annual total input loads of O_2 (a), PO_4 (b), NO_3 (c), NH_4 (d), SiO_2 (e) to Lake Maggiore from the 12 main tributaries over 2006-2015, obtained from the mean monthly values calculated for the numerical simulations.

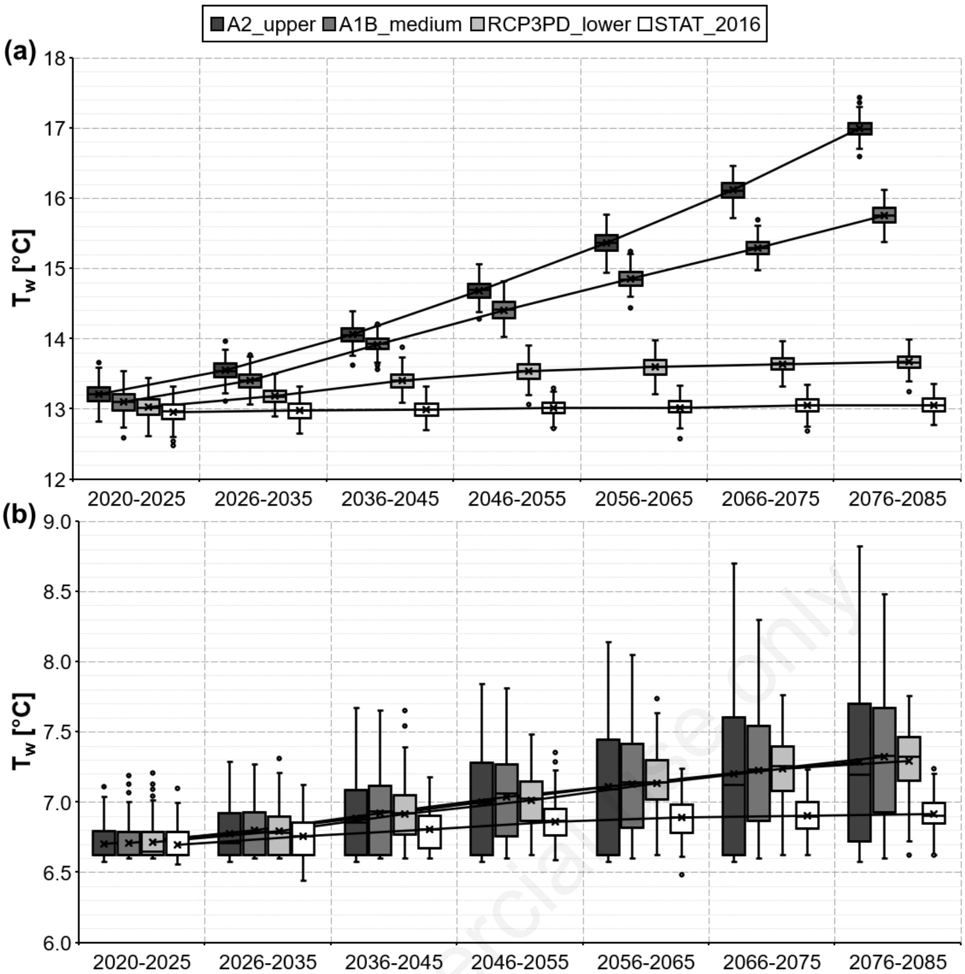

Fig. S2. Distributions over the 200 realisations of the mean annual water temperatures averaged over decades in the 0 – 20 m (a) and 200 – 370 m (b) layers (crosses and solid lines identify the mean values and their trends).

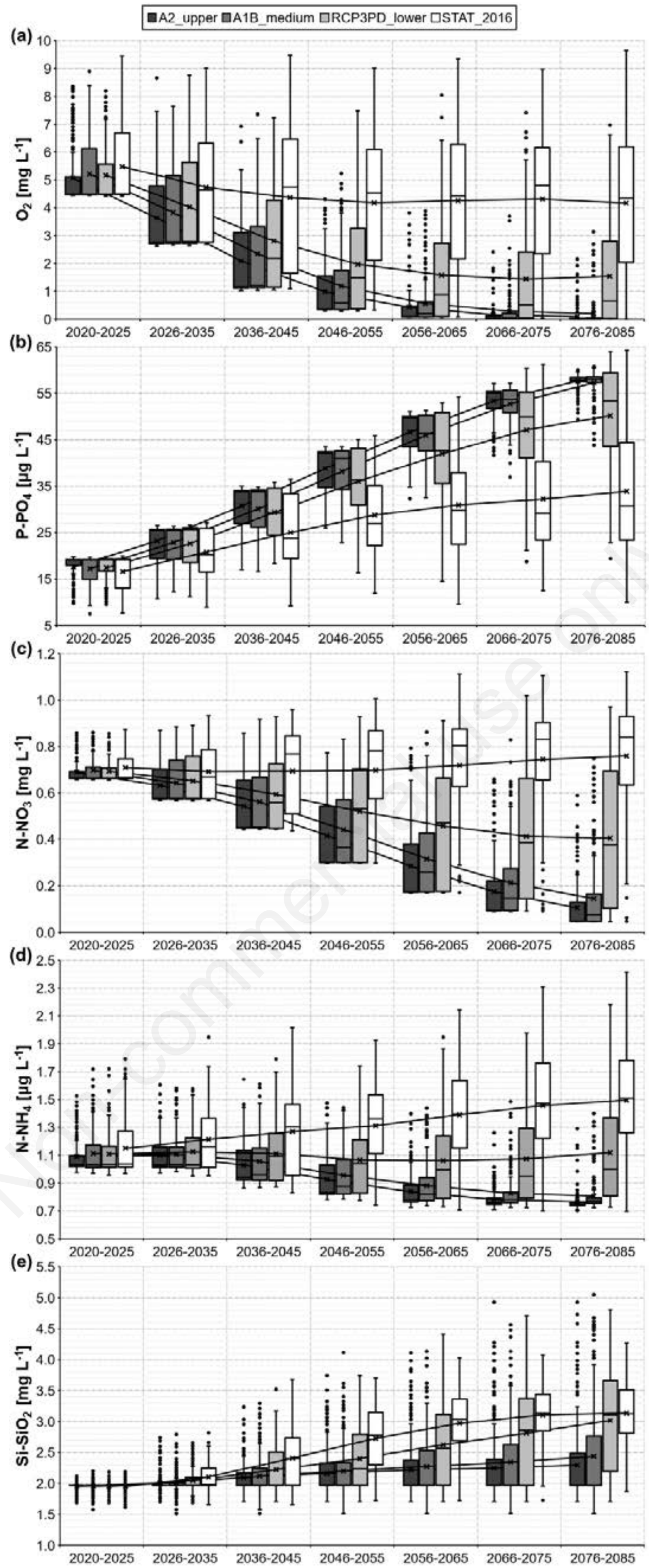

Fig. S3. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of O_2 (a), PO_4 (b), NO_3 (c), NH_4 (d), SiO_2 (e) in the 200 – 370 m layer for +30% linear increase of nutrient loads (crosses and solid lines identify the mean values and their trends).

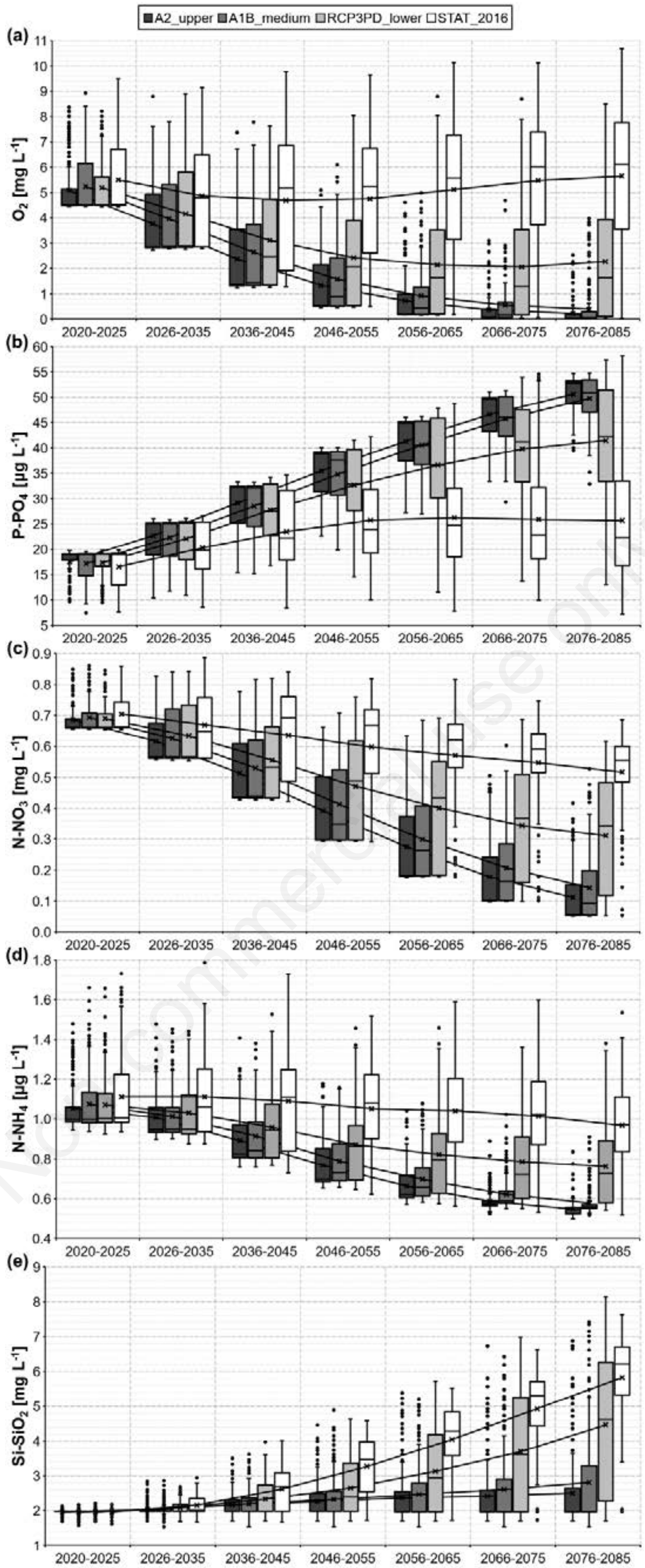

Fig. S4. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of O_2 (a), PO_4 (b), NO_3 (c), NH_4 (d), SiO_2 (e) in the 200 – 370 m layer for -30% linear decrease of nutrient loads (crosses and solid lines identify the mean values and their trends).

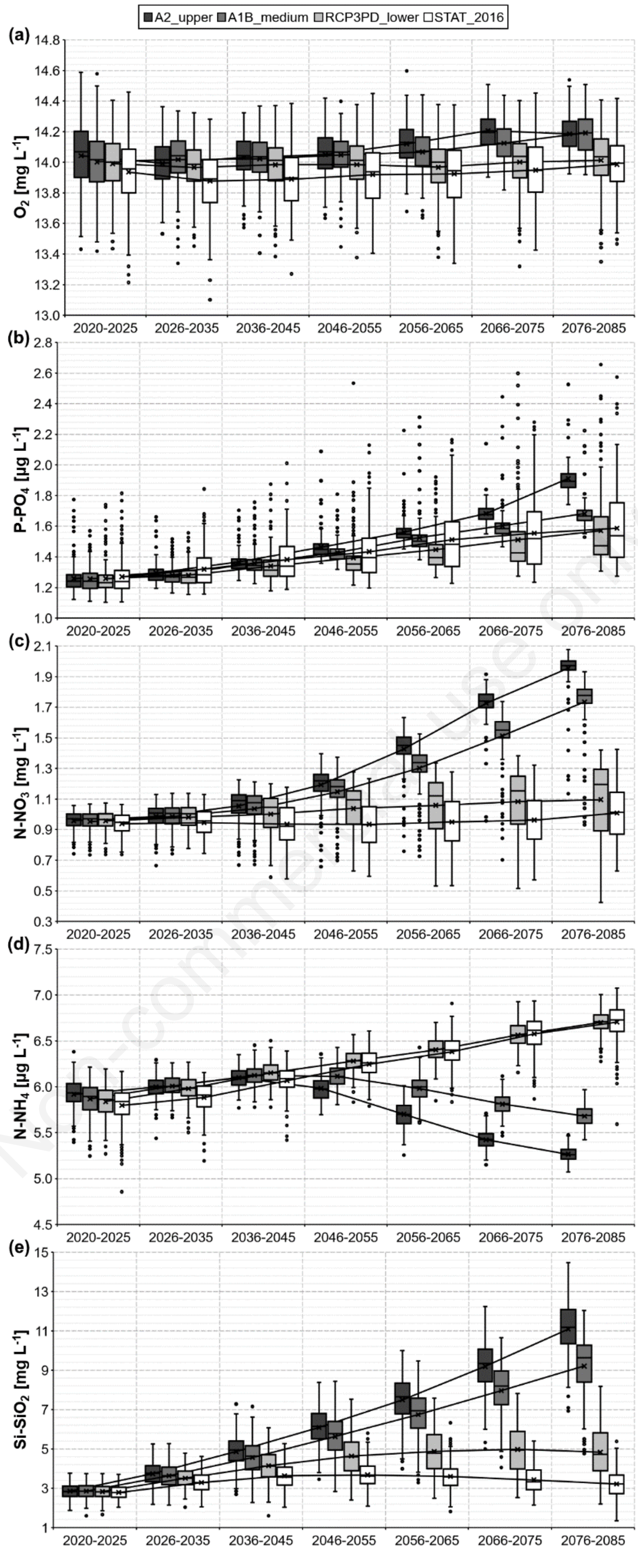

Fig. S5. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of O_2 (a), PO_4 (b), NO_3 (c), NH_4 (d), SiO_2 (e) in the 0 – 20 m layer for +30% linear increase of nutrient loads (crosses and solid lines identify the mean values and their trends).

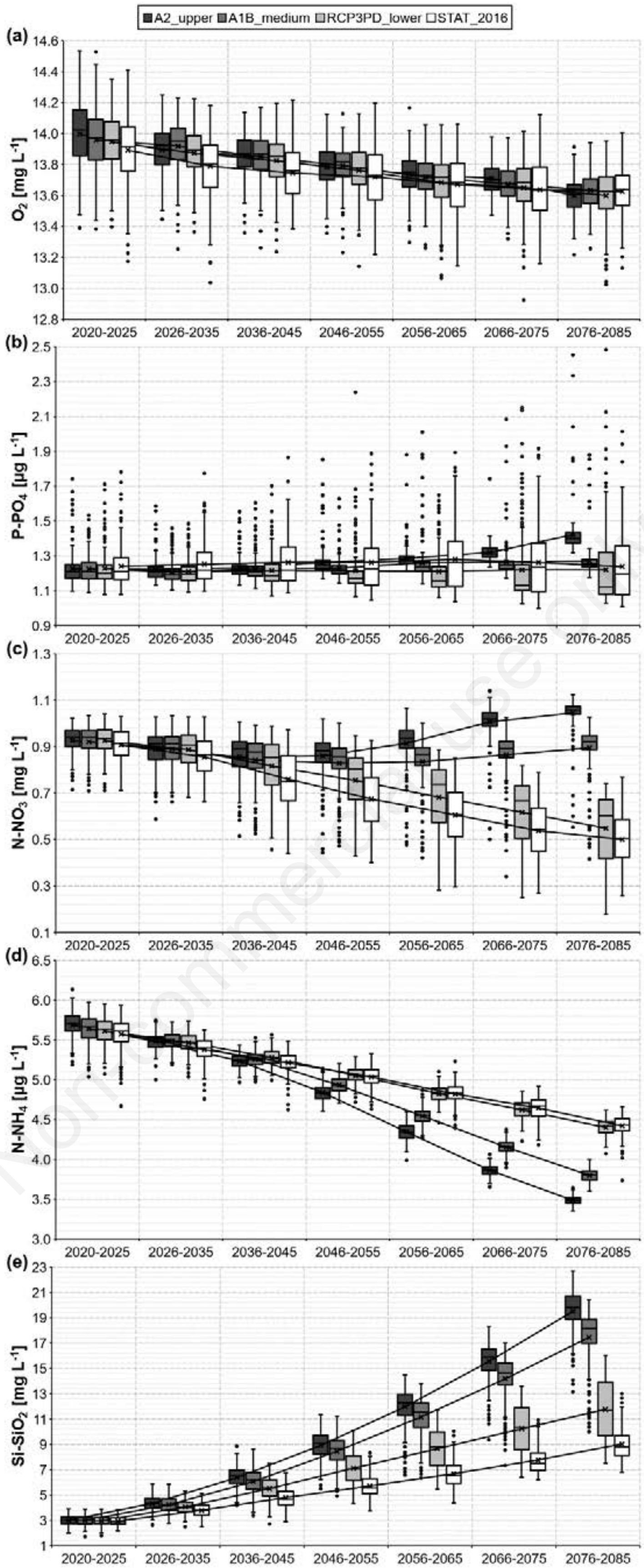

Fig. S6. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of O_2 (a), PO_4 (b), NO_3 (c), NH_4 (d), SiO_2 (e) in the 0 – 20 m layer for -30% linear decrease of nutrient loads (crosses and solid lines identify the mean values and their trends).

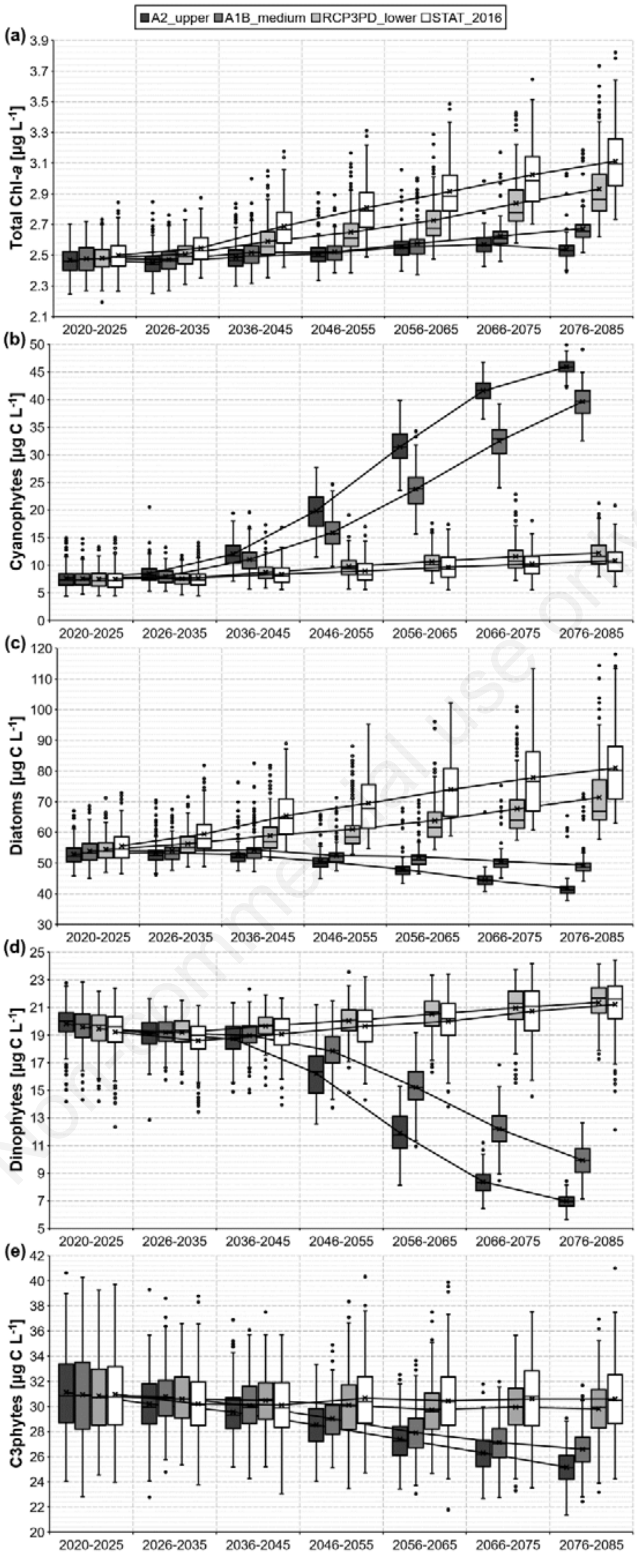

Fig. S7. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of total Chl-*a* (a), cyanophytes (b), diatoms (c), dinophytes (d), c3phytes (e) in the 0 – 20 m layer for +30% linear increase of nutrient loads (crosses and solid lines identify the mean values and their trends).

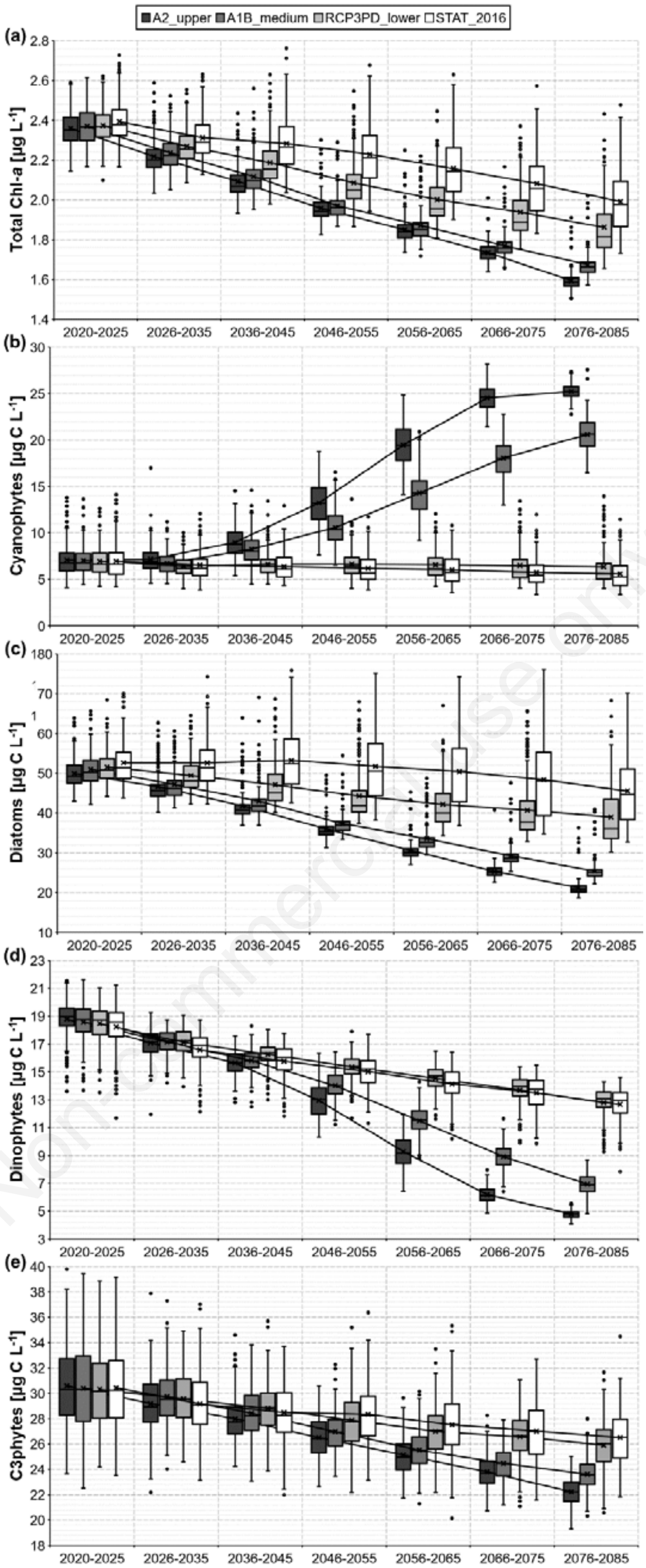

Fig. S8. Distributions over the 200 realisations of the mean annual concentrations averaged over decades of total Chl-*a* (a), cyanophytes (b), diatoms (c), dinophytes (d), c3phytes (e) in the 0 – 20 m layer for -30% linear decrease of nutrient loads (crosses and solid lines identify the mean values and their trends).

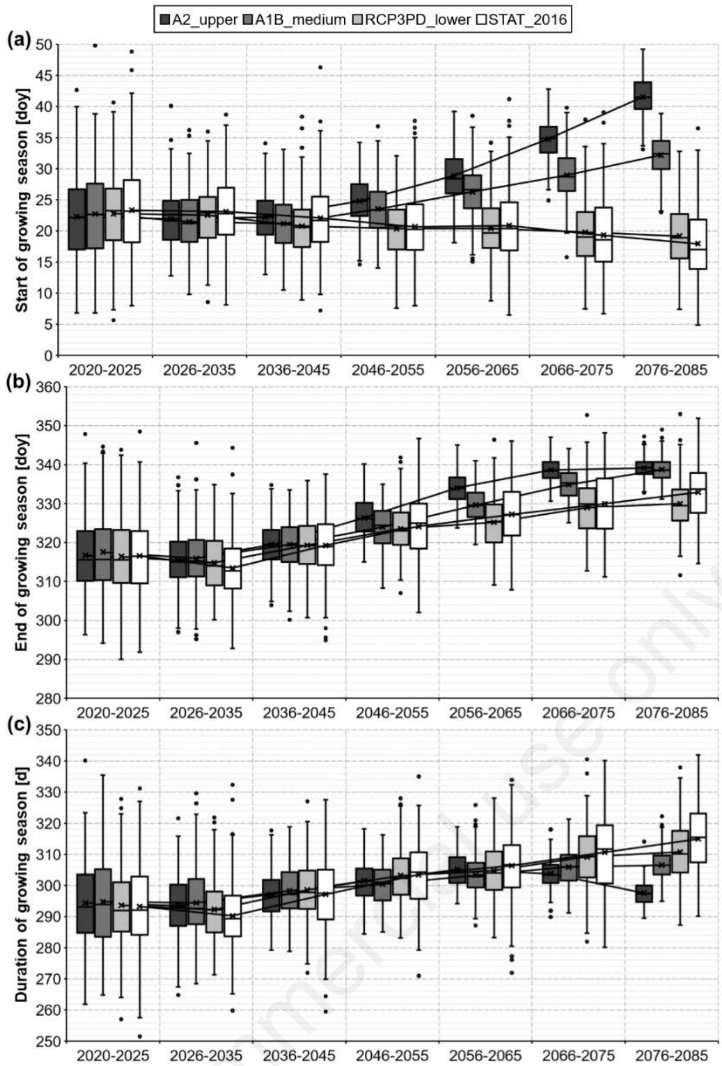

Fig. S9. Distributions over the 200 realisations of the mean decadal beginning (a), end (b) and duration (c) of phytoplankton growing season for +30% linear increase of nutrient loads (crosses and solid lines identify the mean values and their trends).

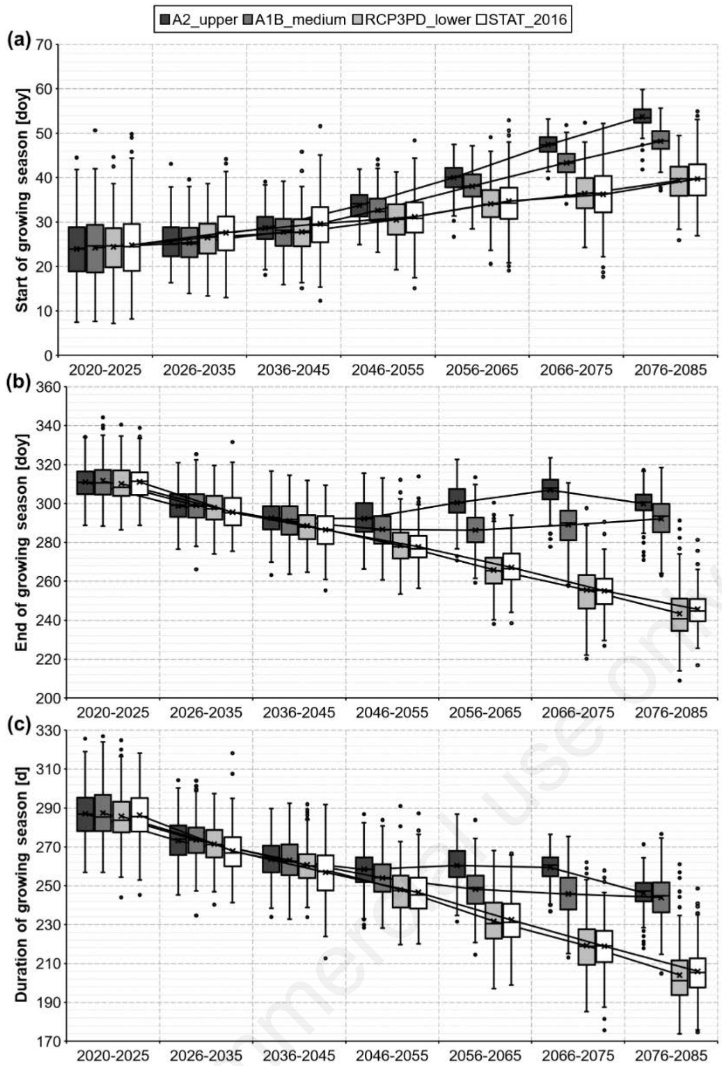

Fig. S10. Distributions over the 200 realisations of the mean decadal beginning (a), end (b) and duration (c) of phytoplankton growing season for -30% linear decrease of nutrient loads (crosses and solid lines identify the mean values and their trends).

Tab. S1. Adopted parameters for sediment fluxes and CH_4 oxidation and relative literature ordinary ranges and outliers. Parameters that required specific tuning are indicated with *. Superscript letters refer to literature: [a] = GLM-AED2 default parameter, [b] = AED science manual (Hipsey *et al.*, 2013), [c] = Bruce *et al.* (2006), [d] = Burger *et al.* (2008), [e] = Gal *et al.* (2009), [f] = Kara *et al.* (2012), [g] = Marcé *et al.* (2010), [h] = Özkundakci *et al.* (2011), [i] = Schladow and Hamilton (1997), [j] = Snortheim *et al.* (2017). References for adopted parameters are relative only to employed values in the cited works, while for outliers they refer to both adopted values and given calibration/literature ranges.

Parameter	Description		Value	Range (Outliers)
	Oxygen			
Fsed_oxy [mmol O_2 m^{-2} d^{-1}]	Maximum sediment O_2 flux at 20 °C		-3[a]	-21.875 – -9.375 (-1562.5[i] – -0.625[i])
Ksed_oxy [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment O_2 flux	*	1562.5	12.5 – 156.25 (7.8125[h])
theta_sed_oxy	Arrhenius temperature multiplier for sediment O_2 flux		1.08[a,b,d,e,f]	1.02 – 1.14
	Phosphorus			
Fsed_frp [mmol P m^{-2} d^{-1}]	Maximum sediment PO_4 flux at 20 °C		0.008[a]	0.016 – 0.404 (0.0004[i] – 2.583[d])
Ksed_frp [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment PO_4 flux		1.5625[e]	15.625 – 62.5 (1.5625[e] – 93.75[c])
theta_sed_frp	Arrhenius temperature multiplier for sediment PO_4 flux		1.08[a,b,f]	1.04 – 1.1 (1.02[i] – 1.14[i])
	Nitrogen			
Fsed_amm [mmol N m^{-2} d^{-1}]	Maximum sediment NH_4 flux at 20 °C		1.35[b]	0.714 – 22.132 (0.003[i] – 30[b])
Ksed_amm [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment NH_4 flux		1.5625[b,e]	1.5625 – 62.5 (0.78125[f] – 156.25[h])
theta_sed_amm	Arrhenius temperature multiplier for sediment NH_4 flux		1.08[a,b,f]	1.04 – 1.1 (1.02[i] – 1.14[i])
Fsed_nit [mmol N m^{-2} d^{-1}]	Maximum sediment NO_3 flux at 20 °C		-0.5[a]	-8.567 – -0.714 (-21.4[b] – -0.5[a])
Ksed_nit [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment NO_3 flux		1562.5[f,j]	15.625 – 1562.5 (0.9375[e])
theta_sed_nit	Arrhenius temperature multiplier for sediment NO_3 flux		1.08[a,b,f]	1.04 – 1.1 (1.02[i] – 1.14[i])

		Silica		
Fsed_rsi [mmol Si m^{-2} d^{-1}]	Maximum sediment SiO_2 flux at 20 °C		0.6[b]	0.6 – 1.8 (4[b])
Ksed_rsi [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment SiO_2 flux	*	1.5625	50 – 150 (153.51[j])
theta_sed_rsi	Arrhenius temperature multiplier for sediment SiO_2 flux		1.08[a,b]	1.04 – 1.08 (1.03[j] – 1.1[b])
		Carbon		
Fsed_dic [mmol C m^{-2} d^{-1}]	Maximum sediment DIC flux at 20 °C		3[a]	3 – 4.908
Ksed_dic [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment DIC flux	*	1.5625	20 – 24.338
theta_sed_dic	Arrhenius temperature multiplier for sediment DIC flux		1.08[a]	1.021 – 1.08
Fsed_ch4 [mmol C m^{-2} d^{-1}]	Maximum sediment CH_4 flux at 20 °C		0.5[a]	0.5
Ksed_ch4 [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment CH_4 flux	*	1.5625	100
theta_sed_ch4	Arrhenius temperature multiplier for sediment CH_4 flux		1.08[a]	1.08
Rch4ox [d^{-1}]	Maximum reaction rate of CH_4 oxidation at 20 °C		0.01[a]	0.01
Kch4ox [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling CH_4 oxidation		0.5[a]	0.5
vTch4ox	Arrhenius temperature multiplier for CH_4 oxidation		1.08[a]	1.08
		Organic matter: phosphorus		
Fsed_pop [mmol P m^{-2} d^{-1}]	Maximum sediment POP flux in addition to sedimentation		-0.01[a]	-0.01
Fsed_dop [mmol P m^{-2} d^{-1}]	Maximum sediment DOP flux at 20 °C		0.0003[g]	0.03 – 0.05 (-900[a])
Ksed_dop [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment DOP flux	*	1.5625	15.625 – 40.5 (150[b])
theta_sed_dop	Arrhenius temperature multiplier for sediment DOP flux		1.08[a,b,f]	1.08 (1.04[b] – 1.1[b])

Organic matter: nitrogen				
Fsed_pon [mmol N m^{-2} d^{-1}]	Maximum sediment PON flux in addition to sedimentation		-0.01[a]	-0.01
Fsed_don [mmol N m^{-2} d^{-1}]	Maximum sediment DON flux at 20 °C		0.07[b]	0.07 – 0.57 (0.001[g] – 5.2[b])
Ksed_don [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment DON flux	*	1.5625	4.5 – 15.625 (100[b])
theta_sed_don	Arrhenius temperature multiplier for sediment DON flux		1.08[a,b,f]	1.08 (1.04[b] – 1.1[b])
Organic matter: carbon				
Fsed_poc [mmol C m^{-2} d^{-1}]	Maximum sediment POC flux in addition to sedimentation		-0.01[a]	-0.01
Fsed_doc [mmol C m^{-2} d^{-1}]	Maximum sediment DOC flux at 20 °C		0.01[j]	0.01 – 0.416 (10[a])
Ksed_doc [mmol O_2 m^{-3}]	Half-saturation O_2 concentration controlling sediment DOC flux	*	1.5625	15.625 – 15.625 (4.5[a] – 16.81[j])
theta_sed_doc	Arrhenius temperature multiplier for sediment DOC flux		1.08[a,f]	1.05 – 1.08 (1.085[j])