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SUPPLEMENTARY MATERIAL

Assessment of nutrient enrichment in northern Saskatchewan lakes

Paleolimnological assessment of nutrient enrichment on diatom assemblages in *a priori* defined nitrogen- and phosphorus-limited lakes downwind of the Athabasca Oil Sands, Canada

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FIGURE LEGENDS

Supplementary Fig. 1. Gamma activities and age models for: a) reference N- and P-limited lakes; b) impact N- and P-limited lakes.

Supplementary Fig. 2. Total concentration (# valves x 10^8 g^{-1} dry wt) of planktonic diatom taxa for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes. Total concentration for Lake 9C is graphed as # valves x 10^9 g^{-1} dry wt.

Supplementary Fig. 3. Total flux (# valves x 10^8 cm^{-2} yr^{-1}) of planktonic diatom taxa for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

Supplementary Fig. 4. Dominant diatom taxa groups for each of: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

Supplementary Fig. 5. Summary of dominant (>5%) diatom taxa for each lake in each of the lake groups: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

Supplementary Fig. 6. Total concentration (# valves x 10^8 g^{-1} dry wt) of the pennate planktonic taxa (see Fig. 3B for %) for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

Supplementary Fig. 7. Total concentration (# valves x 10^8 g^{-1} dry wt) of *Discostella* and small *Cyclotella* planktonic taxa (see Fig. 3A for %) for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

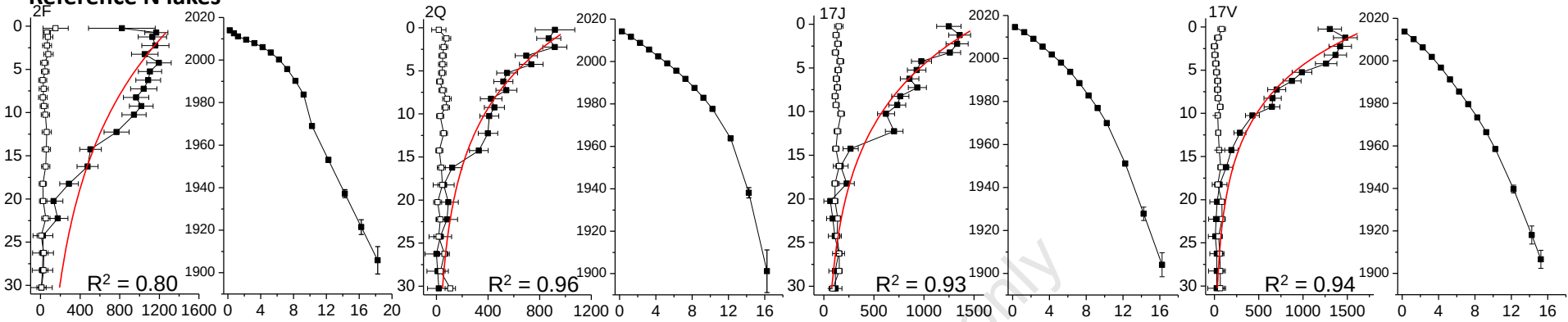
Supplementary Fig. 8. Total flux (# valves x 10^8 cm^{-2} yr^{-1}) of the pennate planktonic taxa (see Fig. 3b for % and Supplementary Fig. 6 for concentration) for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

Supplementary Fig. 9. Total flux (# valves x 10^8 cm^{-2} yr^{-1}) of *Discostella* and small *Cyclotella* planktonic taxa (see Fig. 3A for % and Supplementary Fig. 7 for concentration) for: a) Reference-N limited (Ref N) lakes; b) reference P-limited (Ref P) lakes; c) impact N-limited (Imp N) lakes; d) impact P-limited (Imp P) lakes.

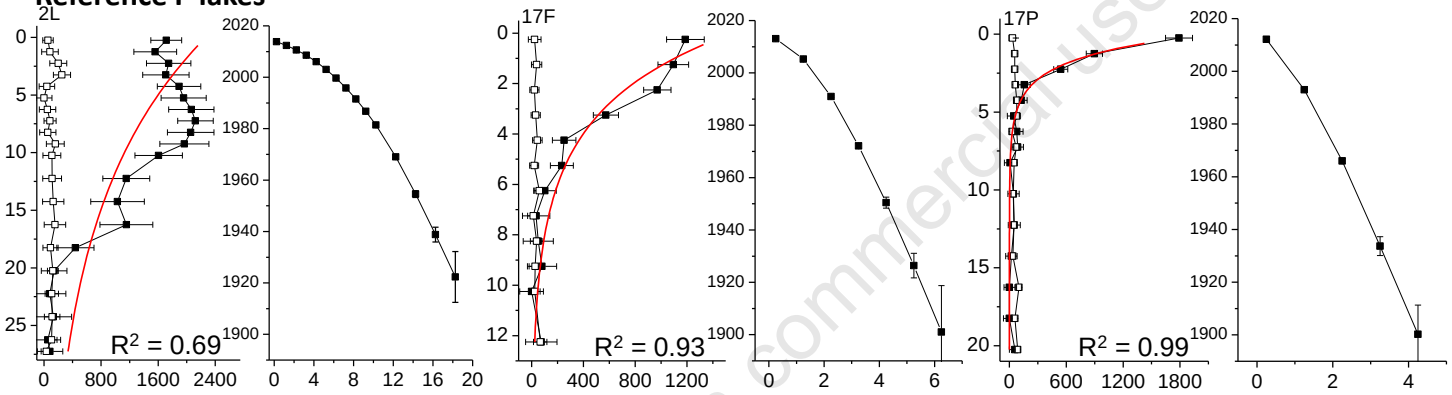
Laird et al. Fig. S1a

Gamma activities and age models

Reference N lakes



Reference P lakes



Depth (cm) vs ^{214}Bi & ^{210}Pb Total activity (Bq Kg^{-1})

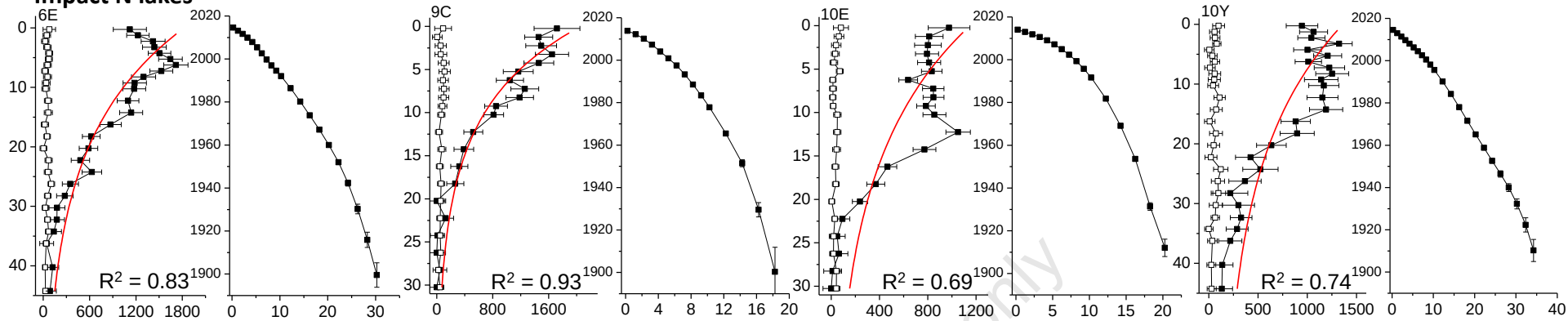
Age (year CE) vs Depth (cm)

Exponential decay in red and R^2 at bottom right

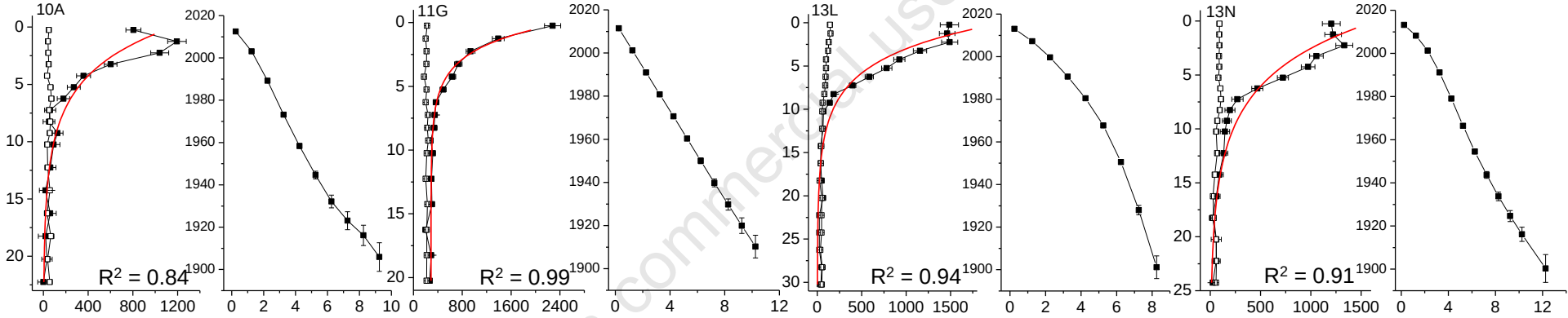
Laird et al. Fig. S1b

Gamma activities and age models

Impact N lakes



Impact P lakes



Depth (cm) vs ^{214}Bi & ^{210}Pb Total activity (Bq Kg^{-1})

Age (year CE) vs Depth (cm)

Exponential decay in red and R^2 at bottom right

Laird et al. Fig. S2

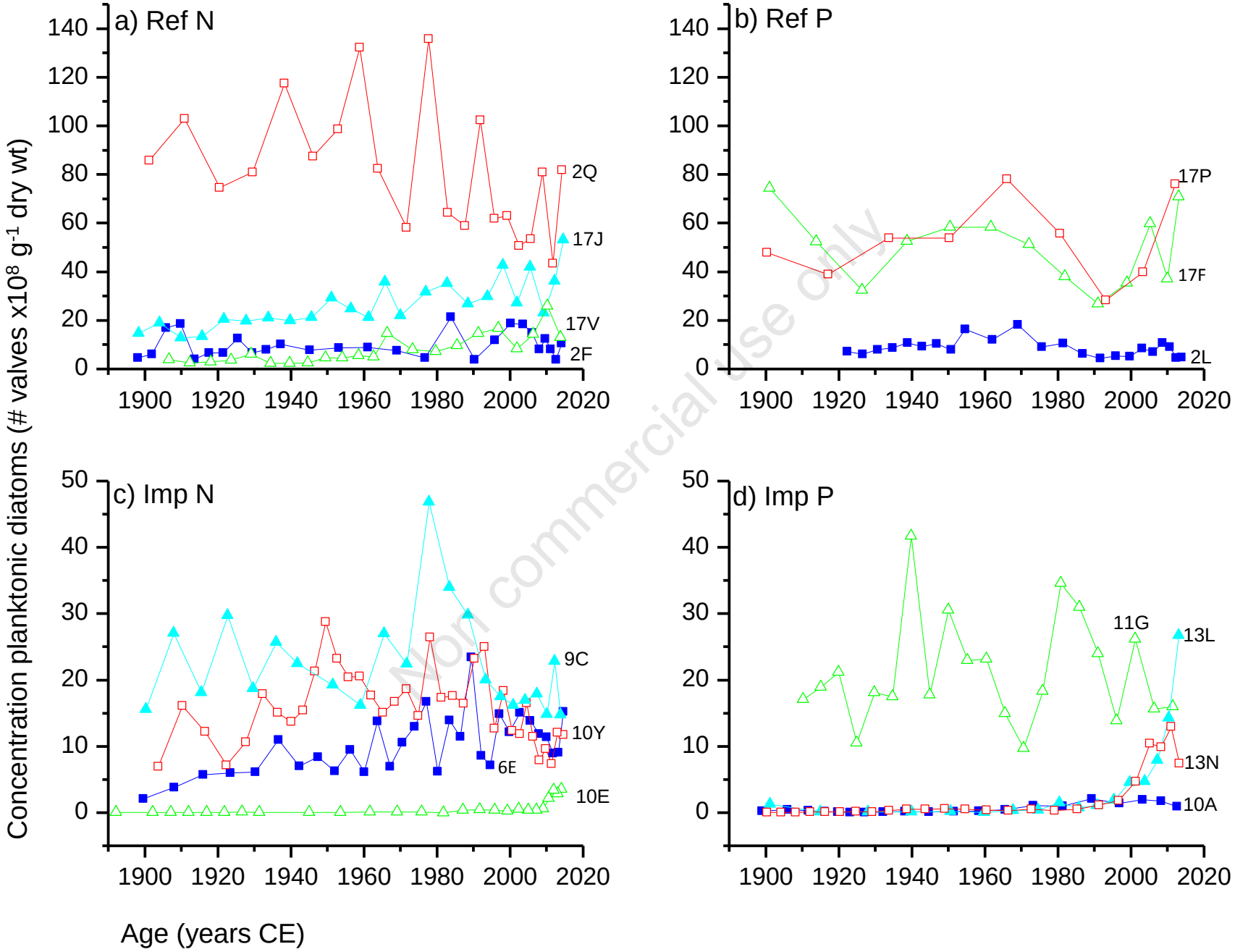
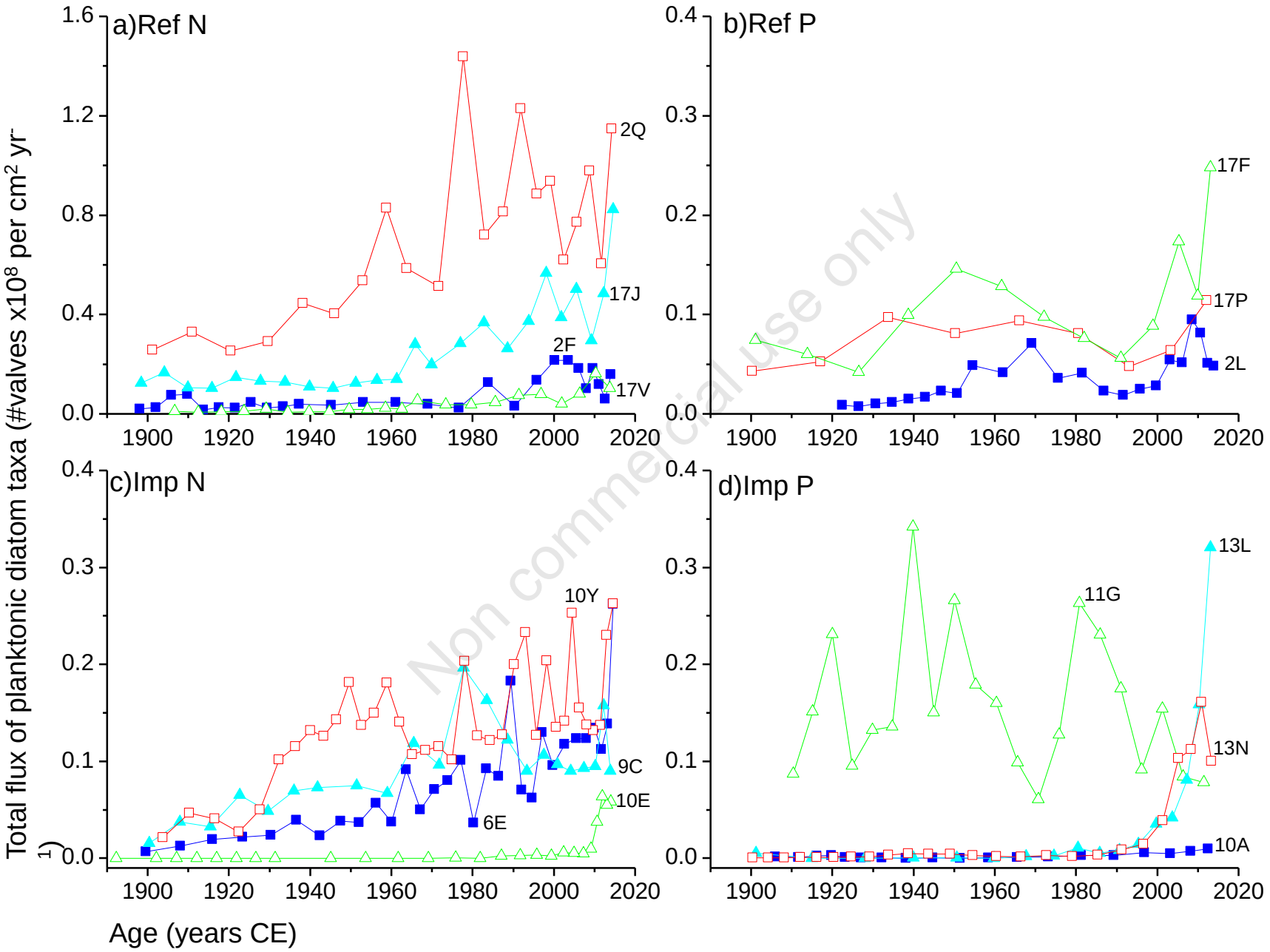


Fig. S3


a)Ref N
b)Ref P
c)Imp N
d)Imp P
2Q
17J
2F
17V
17F
17P
2L
10Y
9C
10E
6E
13L
11G
13N
10A
Total flux of planktonic diatom taxa (#valves x10⁸ per cm² yr⁻¹)
Age (years CE)
1900
1920
1940
1960
1980
2000
2020
Non commercial use only

Laird et al. Fig. S4.

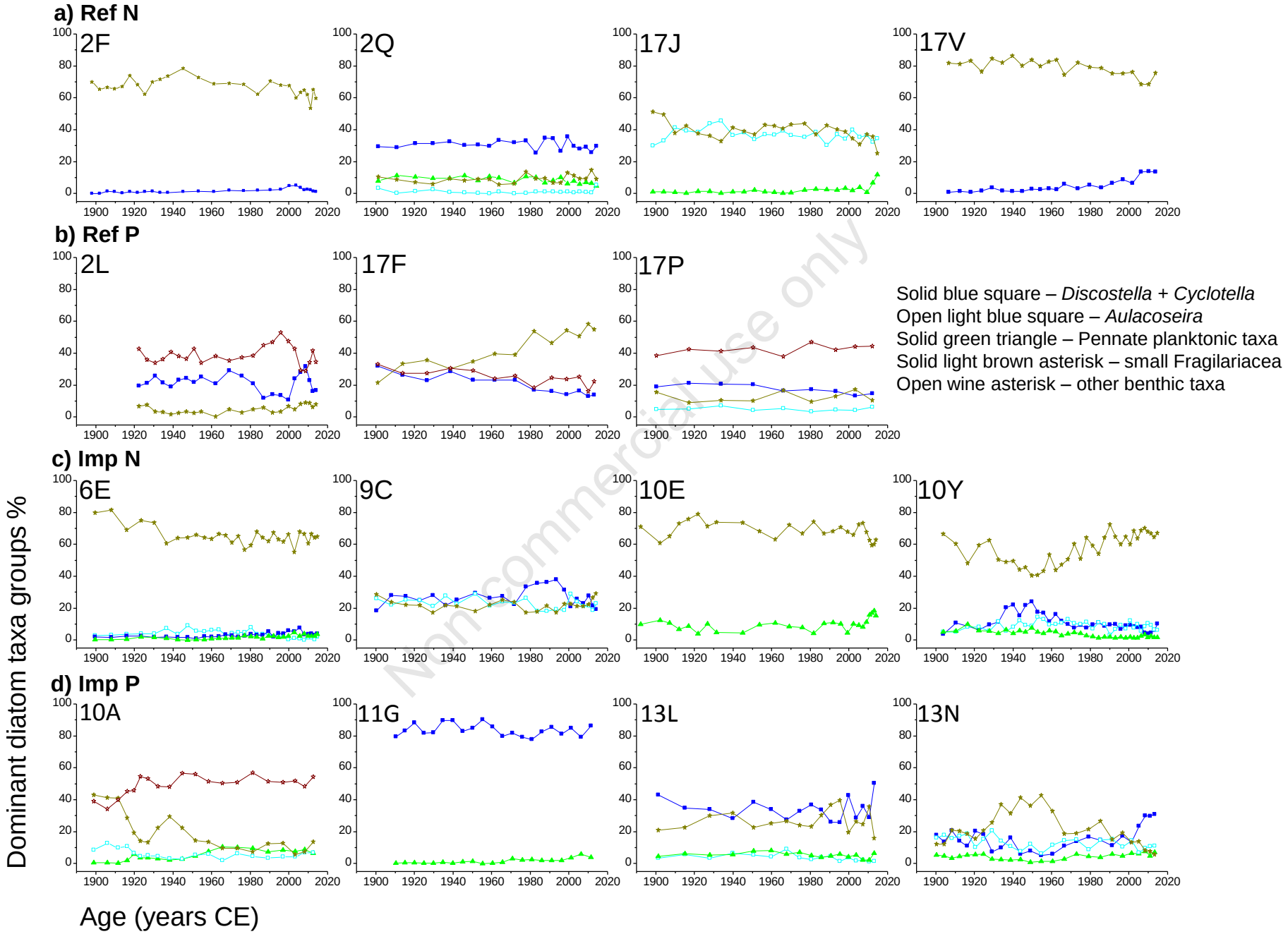
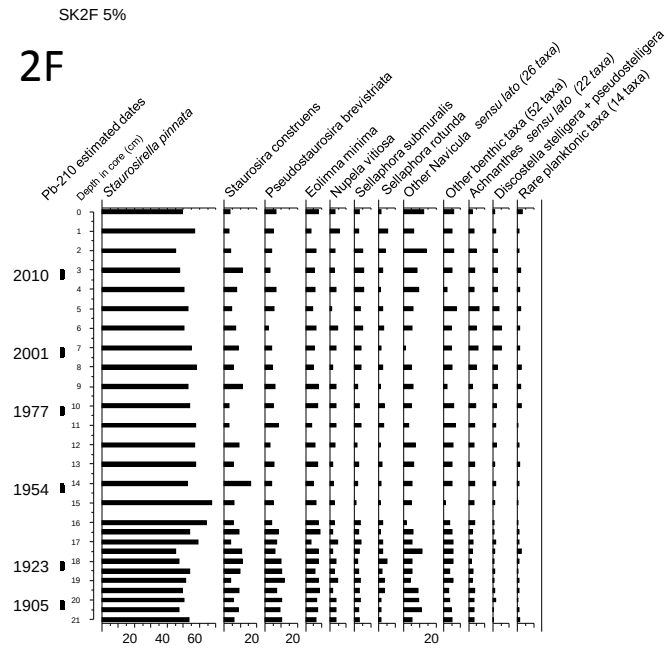
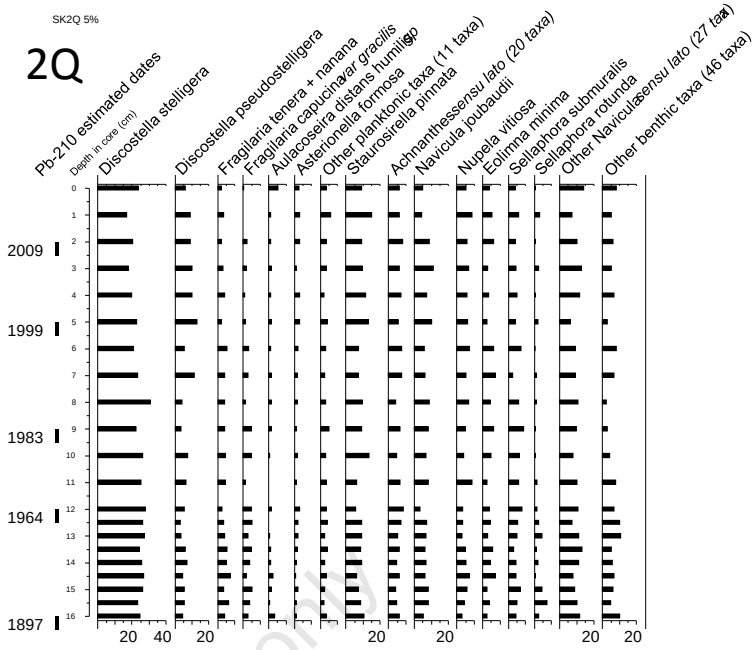
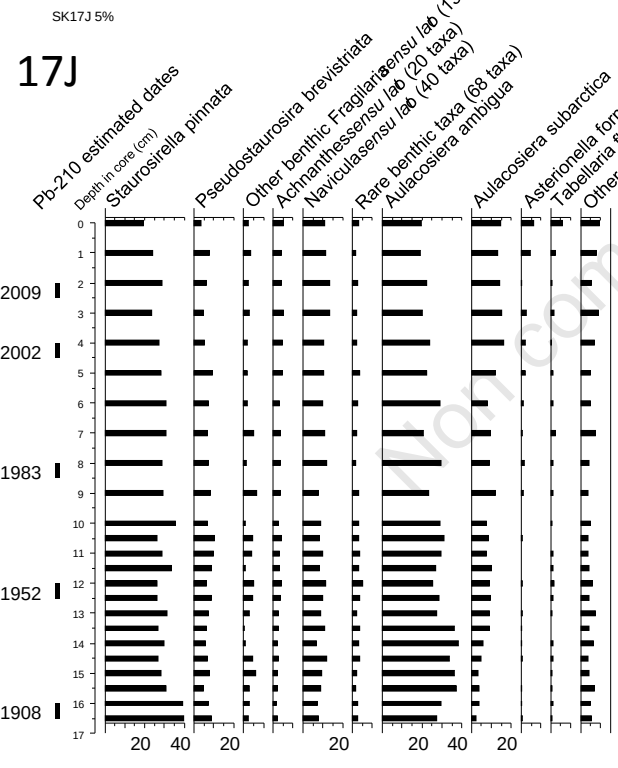


Fig. S5 (a) Reference N lakes (5% taxa)







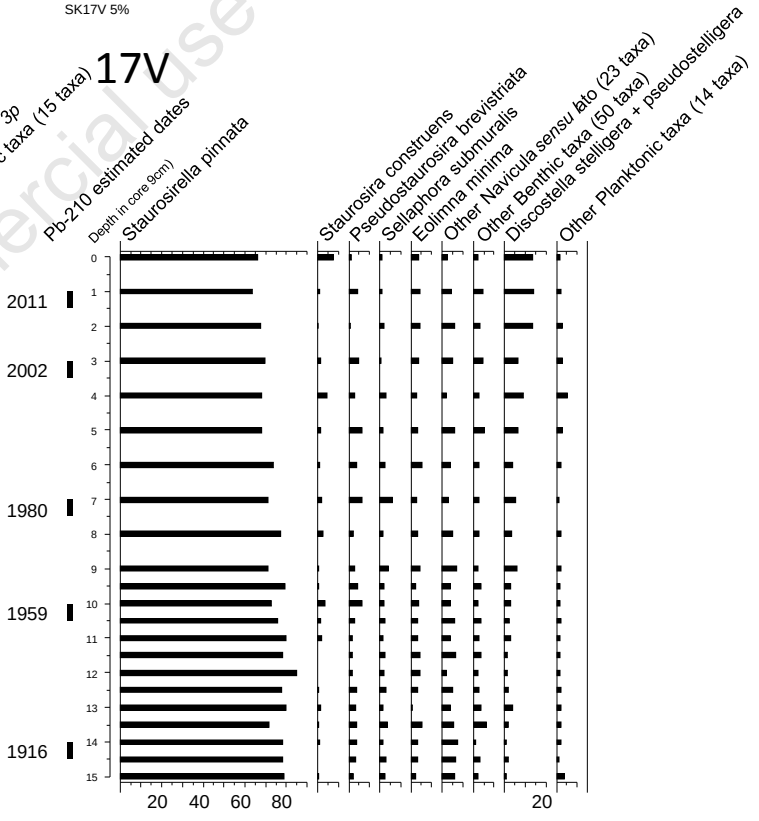
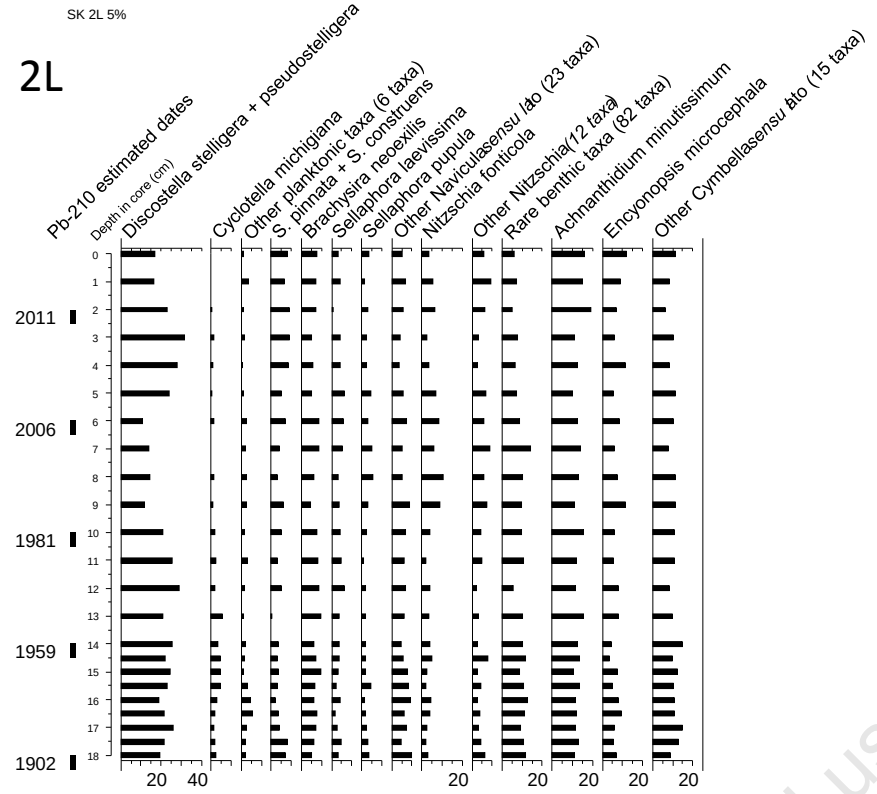
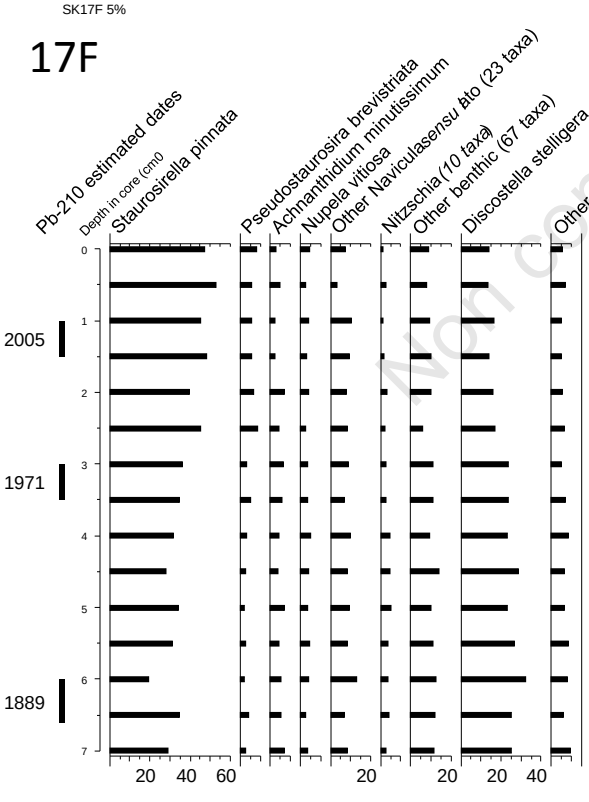


Fig. S5 (b) Reference P lakes (5% taxa)





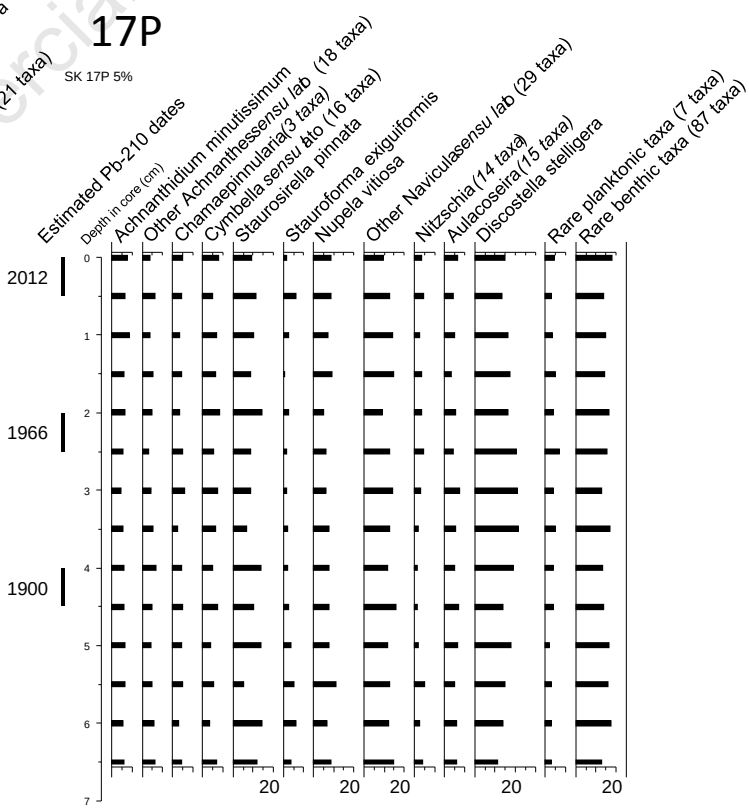


Fig. S5 (c) Impact N lakes (5% taxa)

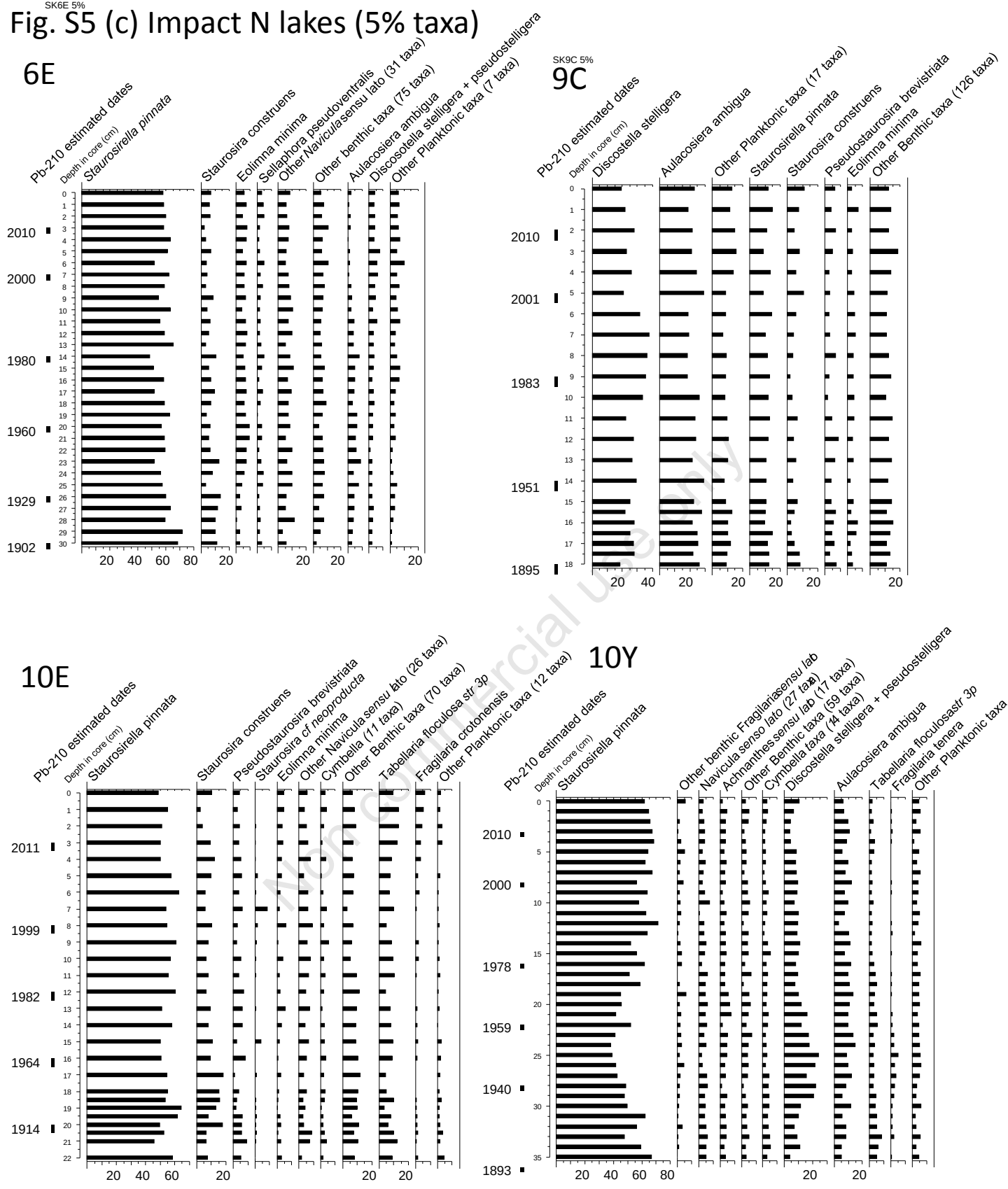
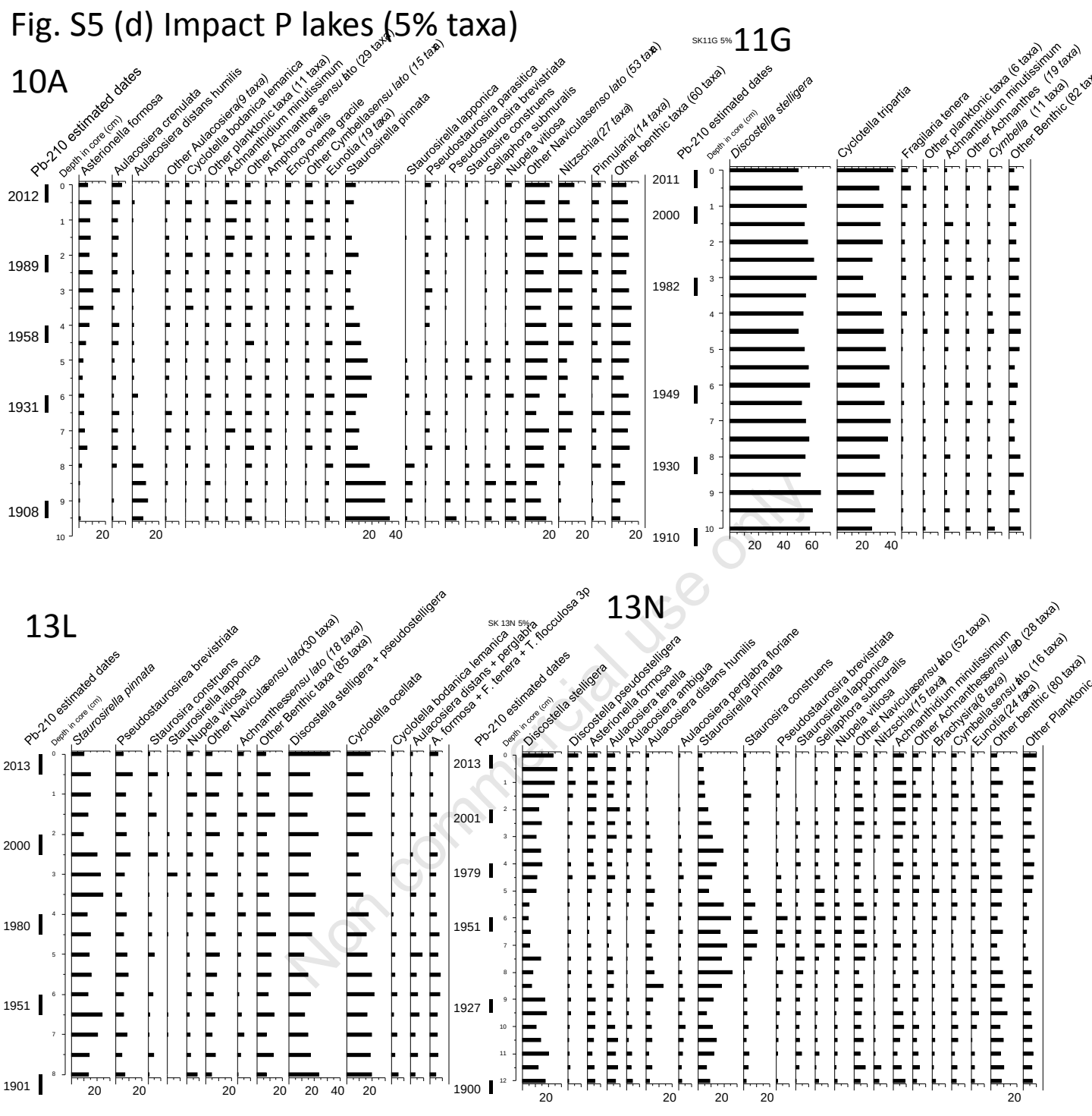


Fig. S5 (d) Impact P lakes (5% taxa)



Laird et al. Fig. S6

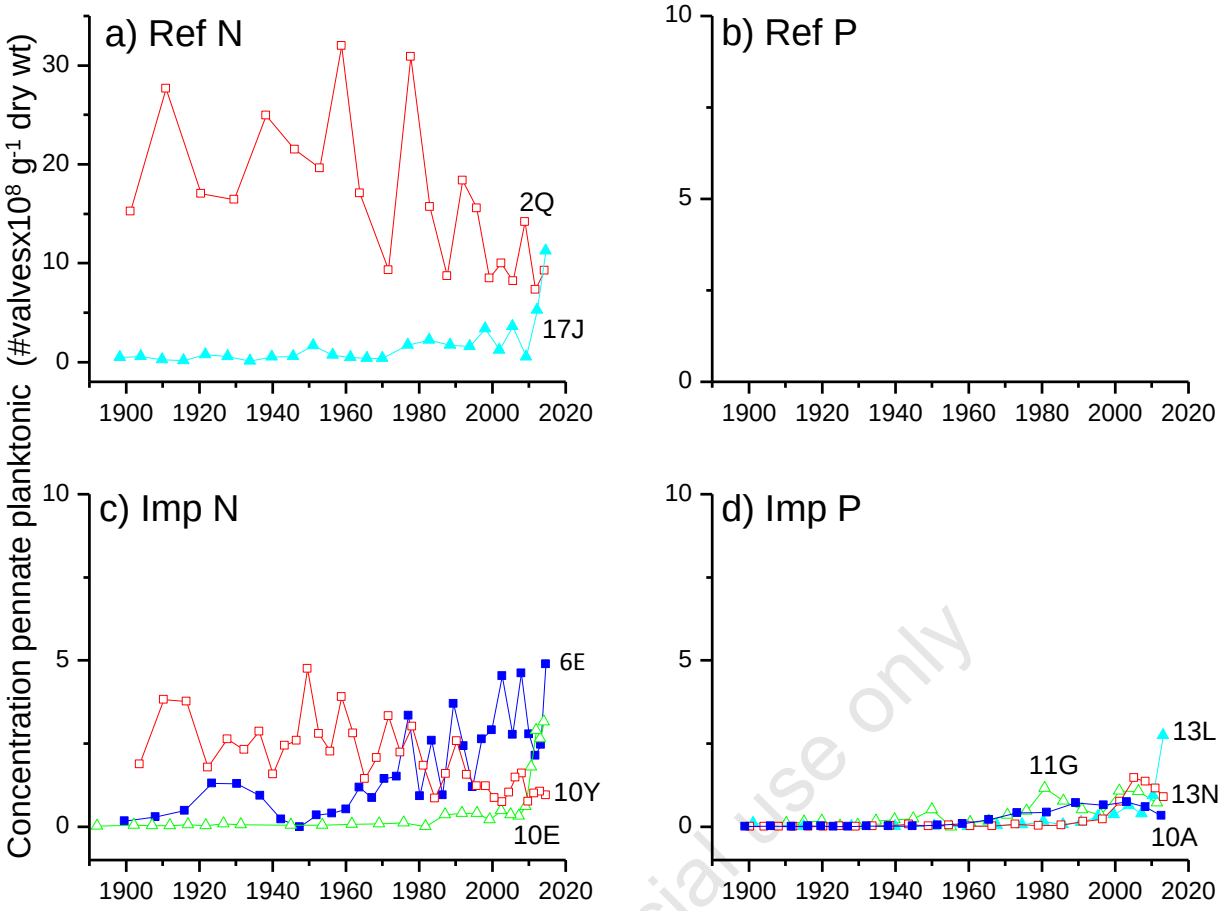


Fig. S7

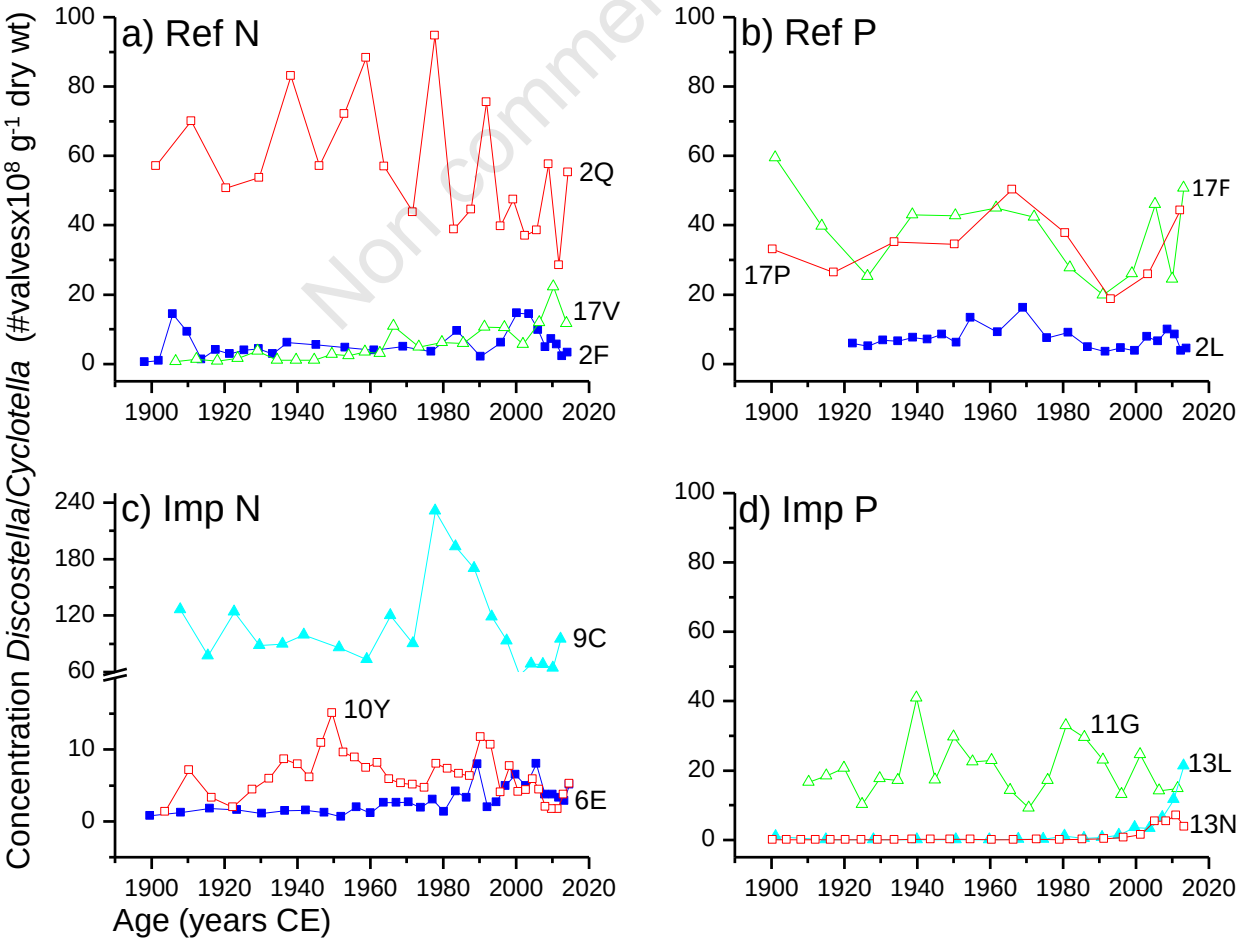


Fig. S8

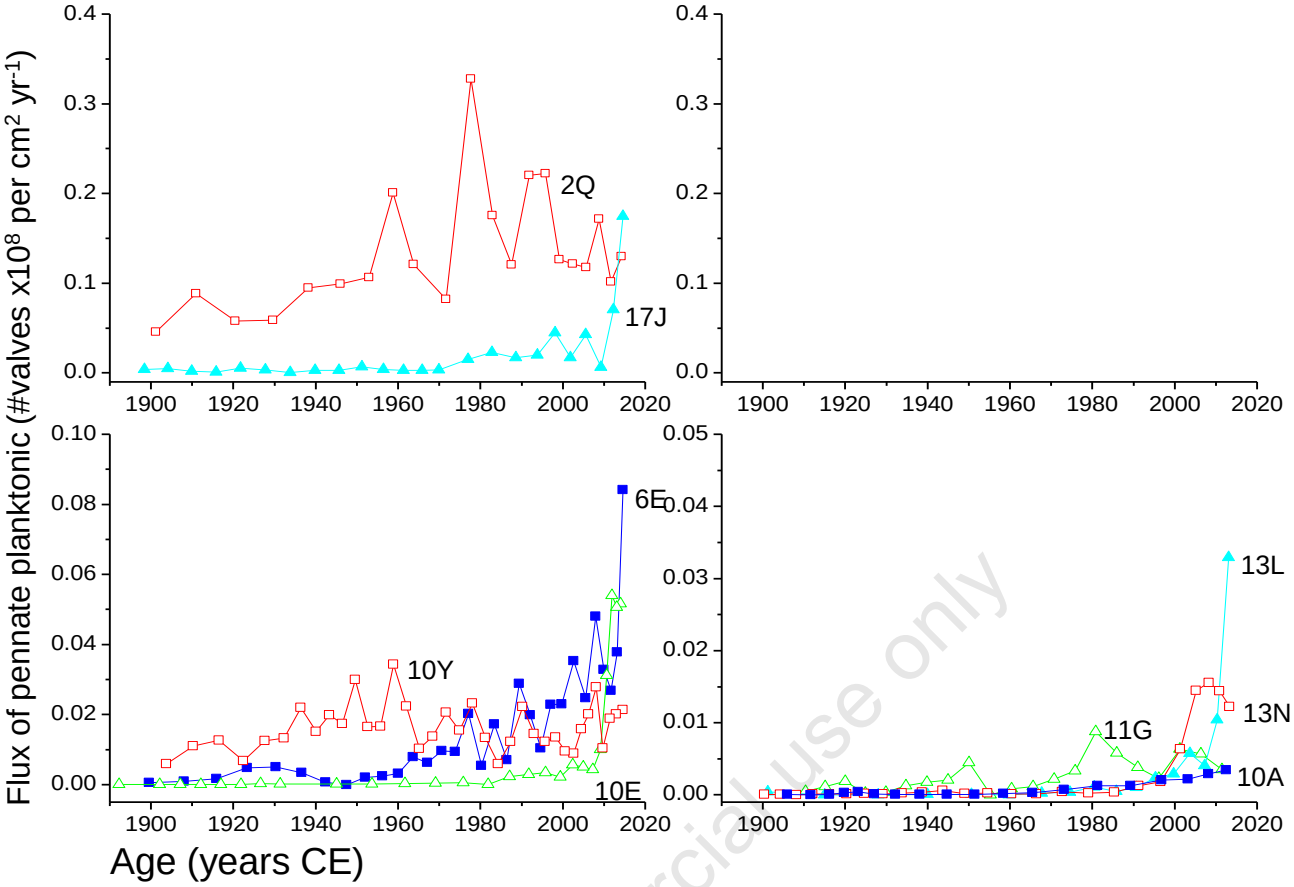


Fig. S9

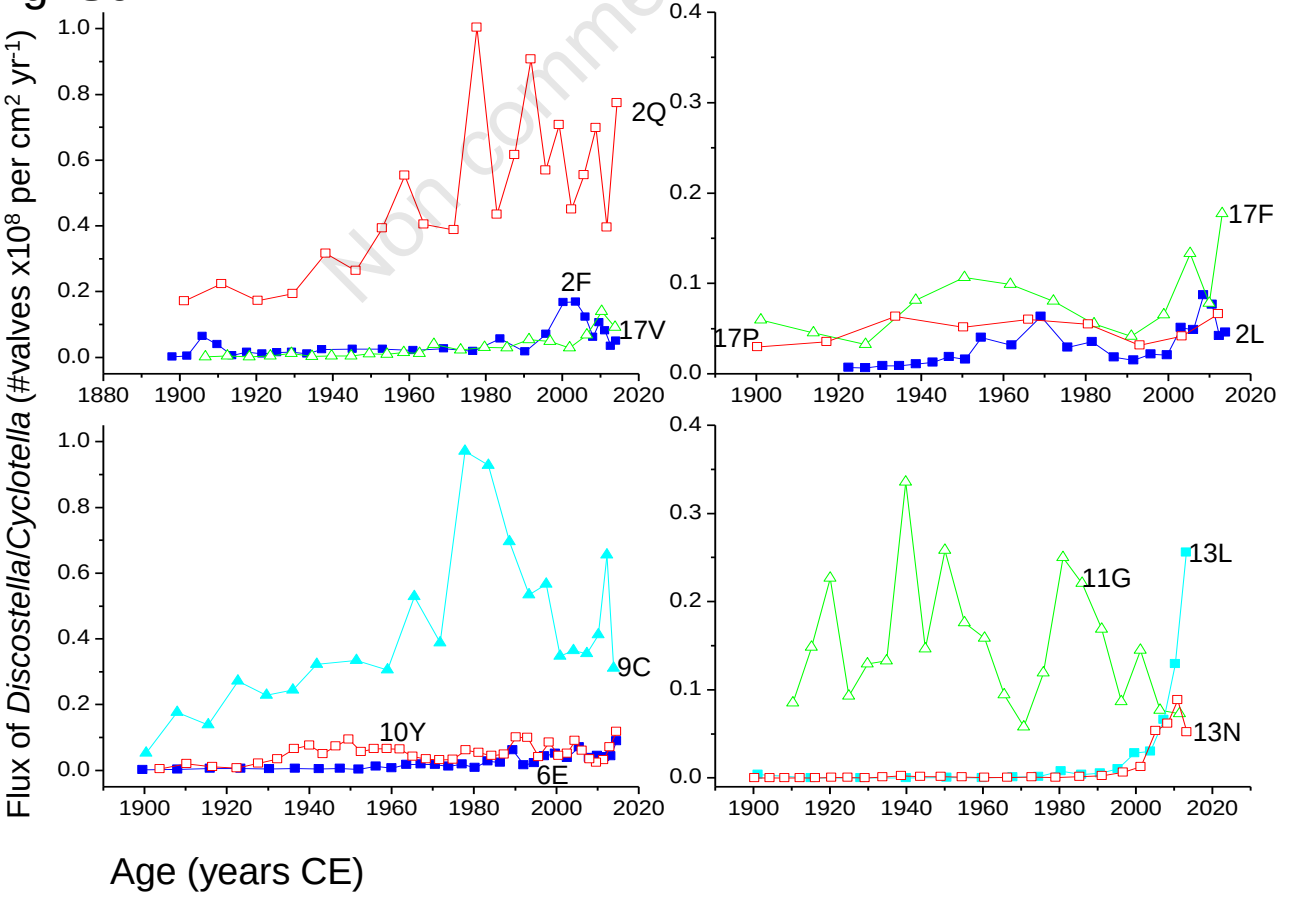


Table S1. Summary of major chemical variables for each of the sampling dates. Value of -999 represents no sampling.

Site	Date	DIN:TP	Chl *a*	NH4_N	NO3_N	TN	TP	DOC	DIC	PC	Cl	SO4	Si	Alk	SPCOND	pH
Reference N			mg m^{-3}	µg L^{-1}	µg L^{-1}	µg L^{-1}	µg L^{-1}	mg L^{-1}	mg L^{-1}	µg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	µS cm^{-1}	
2F	22-Sep-07	4.63	5.14	11	12	297	11	3.5	1.9	1316	0.17	0.99	1.89	8.4	17.72	6.78
2F	26-Sep-08	3.07	7.03	17	1	228	13	4	1.9	715	0.19	1.42	1.99	6.88	18.12	7.05
2F	5-Oct-09	3.76	3.76	15	2	316	10	4.1	1.6	874	0.16	1.21	1.95	6.32	17.4	6.93
2F	27-Sep-11	0.34	2.84	1	1	274	13	4.2	1.9	634	0.15	1.1	2.14	7.58	17.58	7
2Q	26-Sep-08	2.21	7.08	13	1	294	14	3.8	1.8	733	0.12	0.57	0.53	6.28	15.3	7.06
2Q	5-Oct-09	4.43	2.66	15	1	401	8	4.3	1.9	963	0.11	0.51	0.37	5.92	13.91	6.89
2Q	27-Sep-11	3.16	3.57	19	1	387	14	4.6	1.8	669	0.13	0.41	0.42	6.52	12.15	6.94
17J	27-Sep-07	2.61	7.11	19	1	250	17	2.8	2.1	456	0.22	0.59	4.59	7.4	17.63	6.78
17J	26-Sep-08	3.24	5.25	18	1	189	13	2.5	2	488	0.19	0.57	4.34	6.93	17.73	6.98
17J	5-Oct-09	3.24	-999.00	17	2	203	13	2.9	1.9	495	0.17	0.48	4.46	6.47	16.28	6.93
17J	2-Oct-11	5.38	6.34	25	9	198	14	2.4	2.1	389	0.22	0.56	4.5	7.27	16.22	7.04
17V	26-Sep-08	3.01	5.04	18	1	281	14	3.3	2	845	0.1	0.43	5.9	7.38	17.26	7.07
17V	5-Oct-09	2.21	-999.00	11	1	264	12	3.7	1.7	935	0.09	0.23	5.26	7.08	16.9	7.04
17V	2-Oct-11	3.18	5.72	22	1	325	16	3.3	2.4	965	0.12	0.29	5.54	8.09	16.64	7.12
Reference P																
2L	26-Sep-08	11.81	2.69	31	1	223	6	3.2	2.2	308	0.14	0.49	3.4	7.98	18.44	7.24
2L	5-Oct-09	19.49	2.02	43	1	323	5	3.9	1.9	634	0.13	0.3	3.21	7.22	15.87	7.07
2L	27-Sep-11	6.24	1.48	29	2	185	11	3.9	2.2	335	0.13	0.12	3.77	9.12	18.33	7.14
17F	27-Sep-07	8.86	2.83	14	2	284	4	4.1	2	539	0.13	0.33	1.9	7.9	18.53	6.94
17F	26-Sep-08	7.01	3.57	18	1	304	6	4.6	2.4	647	0.11	0.29	1.95	7.8	17.64	7.11
17F	5-Oct-09	11.07	-999.00	24	1	278	5	4.6	1.5	673	0.09	0.26	1.97	7.38	17.58	7.03
17F	2-Oct-11	4.23	3.09	20	1	330	11	4.2	1.8	660	0.1	0.2	1.75	8.03	16.64	7.09
17P	26-Sep-08	8.86	2.47	22	2	247	6	6.7	1.1	569	0.21	0.77	1.1	4.26	15.22	6.87
17P	5-Oct-09	9.81	-999.00	29	2	255	7	8.3	0.8	535	0.15	0.58	1.24	3.49	13.38	6.58
17P	2-Oct-11	4.87	1.47	21	1	257	10	6.4	1	410	0.21	0.74	0.91	4.78	13.7	6.85
Impact N																
6E	20-Sep-07	2.08	6.98	14	2	290	17	3.1	4	576	0.3	1.23	3.94	15.5	31.4	7.02
6E	26-Sep-08	0.74	5.87	4	1	310	15	3.5	4.5	628	0.09	1.2	4.32	15.61	34.8	7.4
6E	5-Oct-09	7.38	5.70	39	1	286	12	3	4.6	865	0.09	1.07	2.83	15.2	33.8	7.23
6E	28-Sep-11	3.12	6.03	30	1	372	22	4	4.9	743	0.09	0.66	4.06	19.75	33.7	7.41
9C	21-Sep-07	1.35	7.25	10	1	266	18	1.8	3.5	431	1.14	0.89	4.46	15	33	7.1
10E	24-Sep-07	2.77	3.90	14	1	329	12	3.5	4.4	470	0.19	0.89	2.98	18.1	35.5	7.26
10Y	24-Sep-07	3.32	6.81	17	1	532	12	4.7	4.3	685	0.18	0.53	2.08	17.2	33.7	7.15
Impact P																
10A	24-Sep-07	7.09	1.34	15	1	280	5	4.4	2.7	254	0.25	1.27	3.67	10.7	22.8	6.94
10A	26-Sep-08	8.58	2.83	26	5	307	8	4.5	2.7	365	0.1	1.02	3.7	9.59	23.8	7.13
10A	5-Oct-09	6.20	1.92	13	1	202	5	5.7	2.6	361	0.08	0.86	3.83	9.27	24.1	7.14
10A	29-Sep-11	11.07	4.15	19	1	194	4	3.9	2.4	205	0.12	0.93	3.7	10.33	23.6	7.22
11G	24-Sep-07	22.14	1.65	19	11	262	3	6.3	1.9	268	0.05	1.85	3.52	8.7	22.5	6.86
11G	5-Oct-09	29.34	1.98	52	1	213	4	7.4	1.5	550	0.11	1.36	3.52	6.62	21.3	6.98
11G	29-Sep-11	4.65	0.23	19	2	200	10	5.9	1.6	236	0.14	1.48	3.41	7.77	20.4	7.09
13L	26-Sep-08	8.30	2.27	14	1	120	4	1.3	2.3	281	0.41	0.9	3.71	6.6	17.3	6.98
13L	5-Oct-09	16.61	0.79	14	1	127	2	2	1.8	666	0.38	0.76	3.75	6.3	17.12	6.88
13L	29-Sep-11	8.30	1.57	14	1	88	4	1.5	1.6	194	0.35	0.82	3.51	6.78	17.07	7.04
13N	26-Sep-08	12.55	2.88	26	8	236	6	6.9	3	472	0.2	0.85	3.62	11.84	28.6	7.13
13N	5-Oct-09	16.61	3.54	26	4	301	4	7.9	2.5	527	0.17	0.6	3.38	10.5	26.8	7.02
13N	30-Sep-11	11.07	2.78	23	2	222	5	6.6	2.5	283	0.17	0.59	3.44	12.39	26.2	7.23

Table S2. Estimate of the degree of species turnover (DCA gradient length) in the diatom assemblages within each core.

Lake	Group	DCA gradient length
2F	Ref N	0.51
2Q	Ref N	0.59
17J	Ref N	0.95
17V	Ref N	0.55
2L	Ref P	0.56
17F	Ref P	0.76
17P	Ref P	0.71
6E	Imp N	0.63
9C	Imp N	0.5
10E	Imp N	0.63
10Y	Imp N	0.67
10A	Imp P	1.65
11G	Imp P	0.46
13L	Imp P	0.85
13N	Imp P	1.27