Quaternary Newsletter
Report

UNDERSTANDING THE IMPACTS OF DESILTING AGENT ON AQUATIC ECOSYSTEM HEALTH AND SUSTAINABILITY

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Background and Rationale

Human activity has had profound impacts on the functionality and structure of freshwater systems. Manipulating water courses has significantly impacted flow regimes and sediment connectivity, altering sedimentation (Schleiss *et al*. 2016). In the UK, excessive accumulation of organic matter in reservoirs is now widely mitigated by desilting agents. Previously used to alleviate the effects of acidification (Clair and Hindar 2005), these calcium carbonate-based agents were adopted to protect aquatic ecosystems by controlling water chemistry parameters such as pH and the acid neutralization capacity (Clair and Hindar 2005). Despite the consensus that calcium carbonate agents help mitigate the effects of acidification and eutrophication, there is a severe lack of research on the long-term consequences of specific applications of desilting. Studies have reported their role in liming total organic carbon (TOC), but usually as a by-product. Results generally show no change in TOC following liming (Simmons and Doyle 1996, Persson and Appleberg 2001), highlighting a gap in our understanding of the processes triggered by these desilting products. Therefore, this work will examine the ecosystem response to a desilting agent at Riseholme Reservoir.

Riseholme Reservoir, Lincolnshire, UK was formed from a dammed spring-fed tributary (Nettleham Beck) in 1779 CE (Carrol Planning + Design 2016). The site is surrounded by arable and pasture grassland for agriculture and has been quickly filling with silt over recent years; therefore, estate managers have recently used (December 2021) desilting agent to improve the water quality. We thus had the unique opportunity to determine the efficacy of a desilting agent, through assessing the reservoir's status before and after the treatment of a desilting agent. Palaeoecological

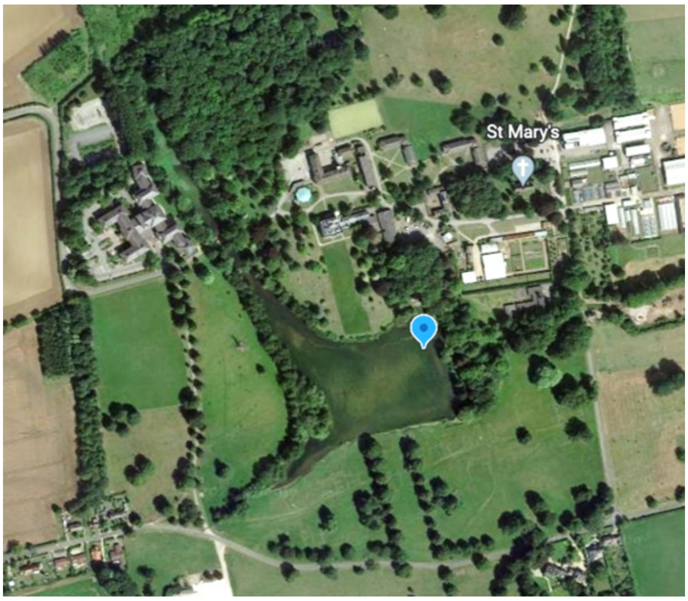

Figure 1. Riseholme Reservoir, Lincoln (53°15'59.9"N 0°31'44.8"W). Blue pin shows the location of core RSUN0420.

methods were used to determine baseline conditions and how sedimentation and environment has changed before desilting treatment was used. Sediment grab samples were used to investigate the reservoirs sediment and water conditions following the desilting treatment; however, this part of the project is not explored in this report.

A Universal core was collected from the deepest point in Riseholme Reservoir spanning 70 cm in length (RSUN0420) and analysed for aquatic pollen and algal pigments, to evaluate changes in primary producers and identify changes in aquatic community structure. Loss-on-ignition (LOI) and X-ray Fluorescence were used to investigate the organic matter and geochemical changes and ^{210}Pb was used to determine temporal changes in organic matter accumulation and the sedimentation rate.

Results and Interpretation

Lead-210 and pigment analysis were performed with the support of the QRA NWRA. The ^{210}Pb results reveal evidence of noisy total ^{210}Pb (Table 1), which could be due to low concentrations with high sedimentation load or mixing. However, results from other proxy data show no evidence of mixing (Figure 4). The age-depth model was produced using *Plum* (Aquino-López *et al*. 2018), an R package that uses Bayesian statistics to produce ages beyond the constant rate of supply model capabilities. The age-depth model results are in line with the expected age of the site (Figure 2). Lead-210 results can only date to 1800 CE, therefore, to retrieve basal dates the ages were extrapolated to the bottom of the core. This extrapolation suggests basal dates of 300 years ago consistent with the estimated date of damming, although these ages are to be interpreted with caution. The ^{137}Cs results do not show good alignment with the age-depth model. A ^{137}Cs peak from 36-38 cm suggests an age of c. 1945-1986 CE (Table 1) while the output from the age-depth model suggests ages from c. 1830-1900 CE (including confidence intervals). Therefore, more work needs to be done to improve the chronology.

Table 1. Lead-210 and Caesium-137 results for core RSUN0420 performed by gamma spectroscopy at Labor für Radioisotope, Georg-August-Universität Göttingen, Germany

Depth (cm)	Weight (g)	Ra 226 (Bq/kg)	+/- (Bq/kg)	Pb-210 (Bq/kg)	+/- (Bq/kg)	Cs-137 (Bq/kg)	+/- (Bq/kg)
0-2	14.87	13.46	3.08	36.00	12.92	4.25	1.50
2-4	14.61	17.46	5.56	44.99	15.01	3.67	1.50
4-6	14.73	8.78	2.94	35.64	13.36	3.77	1.44
6-8	14.42	18.58	4.31	52.66	8.57	4.44	8.57
8-10	17.4	15.19	4.75	32.11	12.13	2.63	0.93
10-12	17.19			43.77	13.87	5.19	1.42
12-14	17.94	14.29	3.18	42.48	7.94	3.71	1.11
14-16	16.37	18.74	5.09	29.34	10.71	3.93	1.25
18-20	19.61	9.24	5.88	37.70	12.04	3.31	1.84
20-22	19.64	12.99	4.30	34.21	11.77	5.46	1.28
24-26	19.37	18.77	4.73	31.95	12.45	5.17	1.38
28-30	16.99	15.51	4.68	27.07	11.10	5.63	1.49
30-32	18.08	15.48	4.71	27.13	11.86	8.93	2.01
32-34	18.07	21.30	27.63	21.95	10.66	8.82	1.37
34-36	18.47	22.35	5.05	30.02	11.33	12.70	2.04
36-38	18.75	21.68	5.06	25.63	11.07	16.30	2.06
38-40	22.1	21.91	4.48	22.01	9.89	16.17	1.83
42-44	22.27	15.22	4.14	<1,298E+01		<1,089E+00	
44-46	21.71	12.49	3.84	17.71	10.34		
46-48	22.78	14.82	2.64	11.48	4.68	<7,7877E-01	
48-50	23.24	14.22	3.85	14.82	9.73	<1,040E+00	
50-52	22.58	15.84	4.09	<1,342E+01		<1,077E+00	
52-54	23.29	12.12	2.58	10.43	4.62	<7,575E-01	
54-56	22.42	16.50	3.99	<1,431E+01		<1,061E+00	
56-58	22.13	13.53	2.743	12.61	5.76	<8,007E-01	
58-60	25.55	18.82	3.53	14.27	8.23	<9,992E-01	
60-62	25.41	21.17	2.53	14.00	4.91	<7,003E-01	
62-64	25.53	24.73	4.47	12.06	8.59	<9,649E-01	
64-66	25.23	23.43	2.87	20.94	5.48	<7,229E-01	
66-68	22.93	27.44	4.58	19.88	9.43	<1,223E+00	
68-70	25.06	27.03	2.94	18.85	5.391	<7,249E-01	

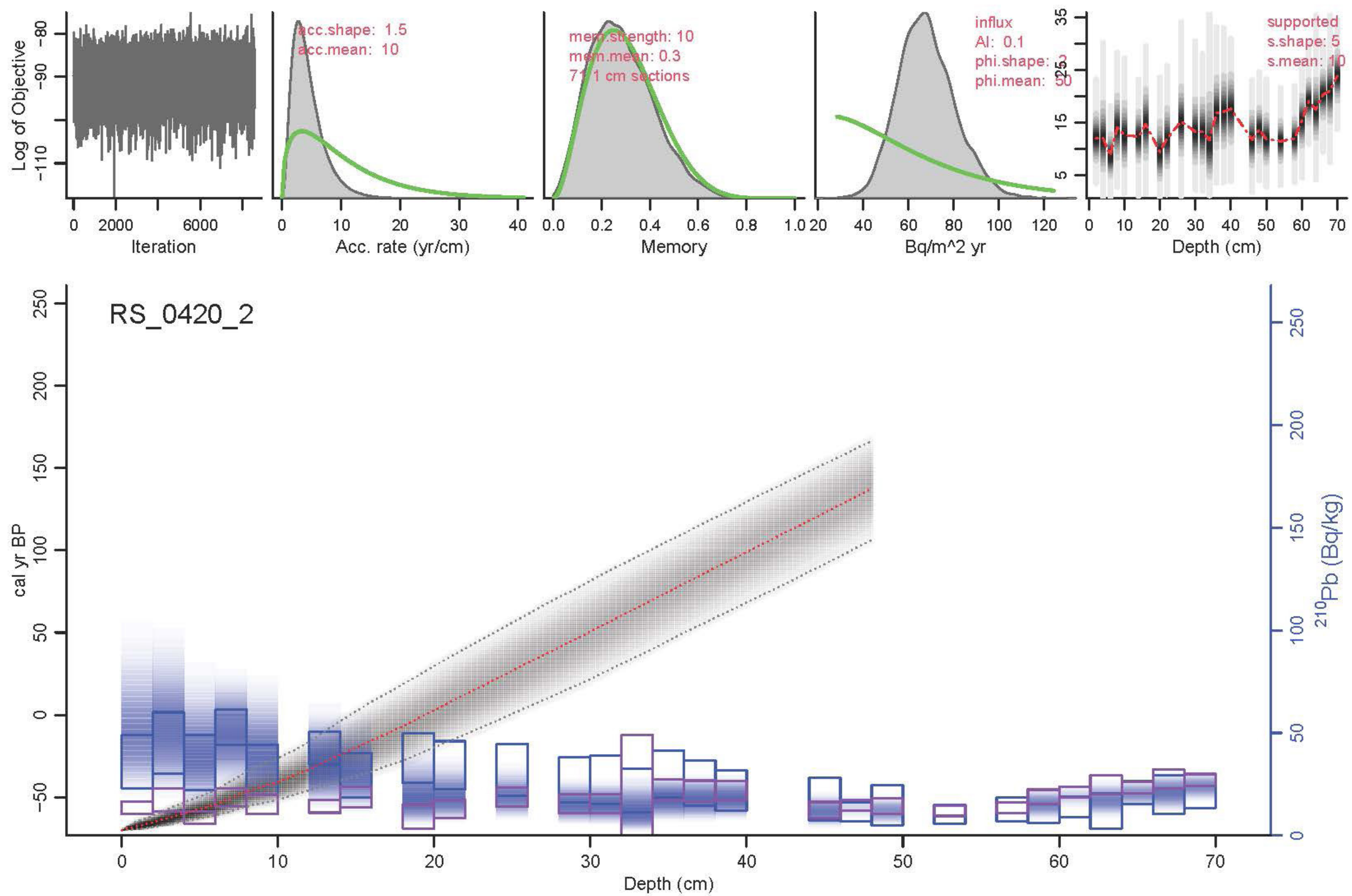

Figure 2. Age-depth model for Risholme Reservoir (core RS0420) performed using *plum* (Aquino-López 2018) in R. Top panel from left to right: self adjusting Markov Chain Monte Carlo iterations, accumulation rates, age model memory, supply of ^{210}Pb, and supported ^{210}Pb by depth (cm). The bottom panel shows the results of the age-depth model with the blue squares indicating the trends in unsupported ^{210}Pb and the purple showing supported ^{210}Pb the black dashed lines show the bayesian iterations and the red dashed line the final age-depth model, grey dashed lines represent upper and lower confidence interval of the age-depth model.

The calibrations for the pigments show good results for Lutein, Canthaxanthin, and Astaxanthin; however, there was a lack of data points for Diatoxanthin, Zeaxanthin, and Alloxanthin (Figure 3). Thus, concentrations cannot be determined at this point for the pigment data, and our interpretations will be based on the trends of the pigment results.

Preliminary results in the pigments show two transitions, at c. 1850 CE there is a drop in $\%LOI_{950}$ and Ca and an increase Lutein, Alloxanthin, and Zeaxanthin (Fig. 4), suggesting a decrease in calcium carbonate content and increased aquatic productivity. This transition coincides with the start of the Industrial Revolution, where increased land-use change, agricultural and human activity could have increased run-off, erosion and nutrient supply supporting more aquatic production (Anderson *et al.* 2013). At c. 1975 CE $\%LOI_{550}$, Ca and sedimentation increase, and all the pigments decrease (Figure 4). The decrease in aquatic productivity is likely due to increasing sedimentation at the site. High sediment loads can block out light in water bodies, important for primary producers causing unfavourable water conditions (Beck *et al.* 2020).

Significance

Our results show that the Industrial Revolution caused an increase in aquatic productivity at Riseholme Reservoir. Due to ongoing agricultural activity, the site began to experience an exponential increase in sediment loads causing a shift to low aquatic productivity (Figure 4). This site appears to be negatively impacted by high sedimentation and silt accumulation. However, it is still uncertain if desilting agents are a safe management strategy for freshwater environments. Next steps of this project are to uncover the efficacy of desilting agents on the aquatic system, improve the age-depth model and investigate the other proxy analysis.

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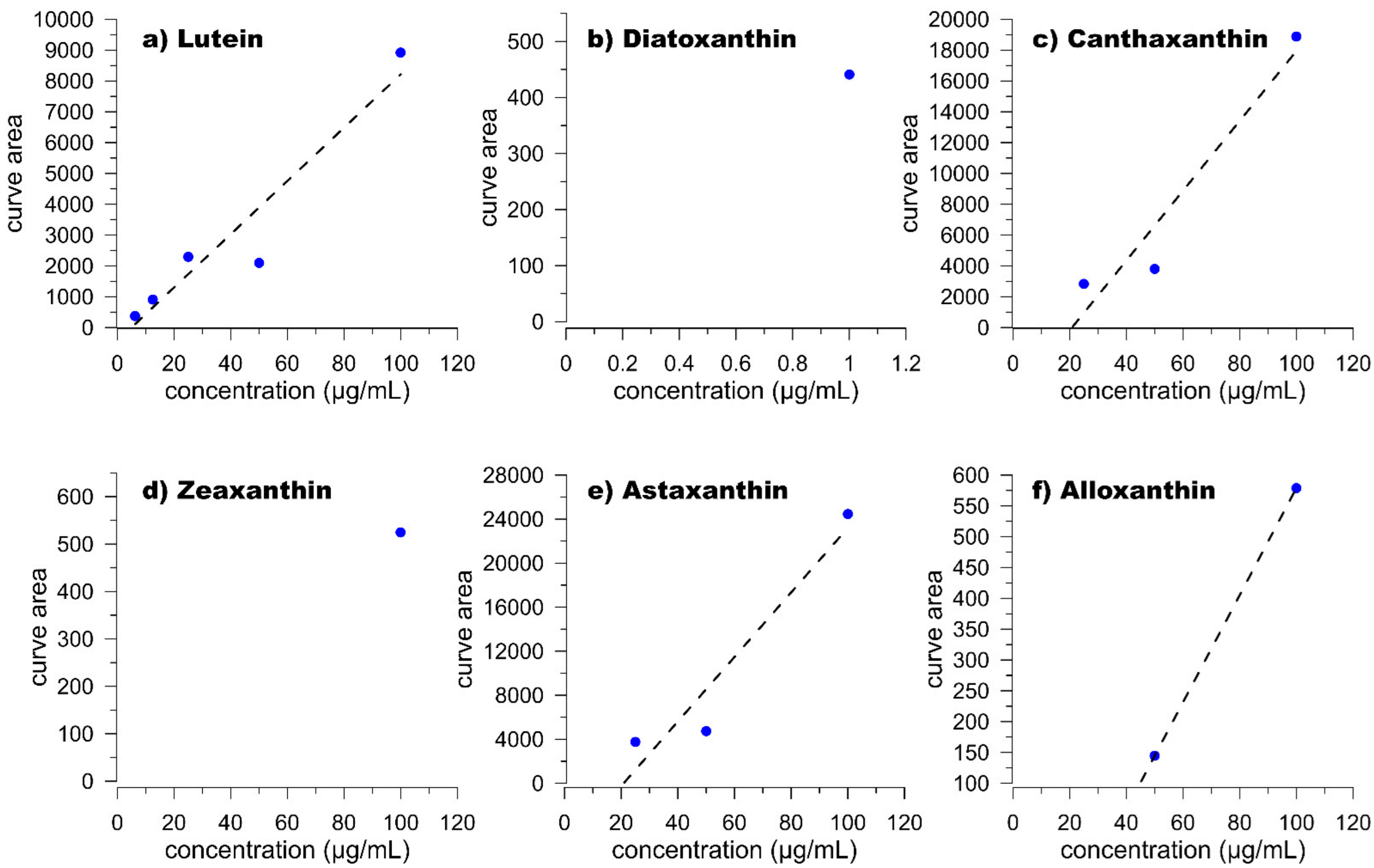

Figure 3. Calibration curves for the pigments: a) Lutein, b) Diatoxanthin, c) Canthaxanthin, d) Zeaxanthin, e) Astaxanthin, and f) Alloxanthin.

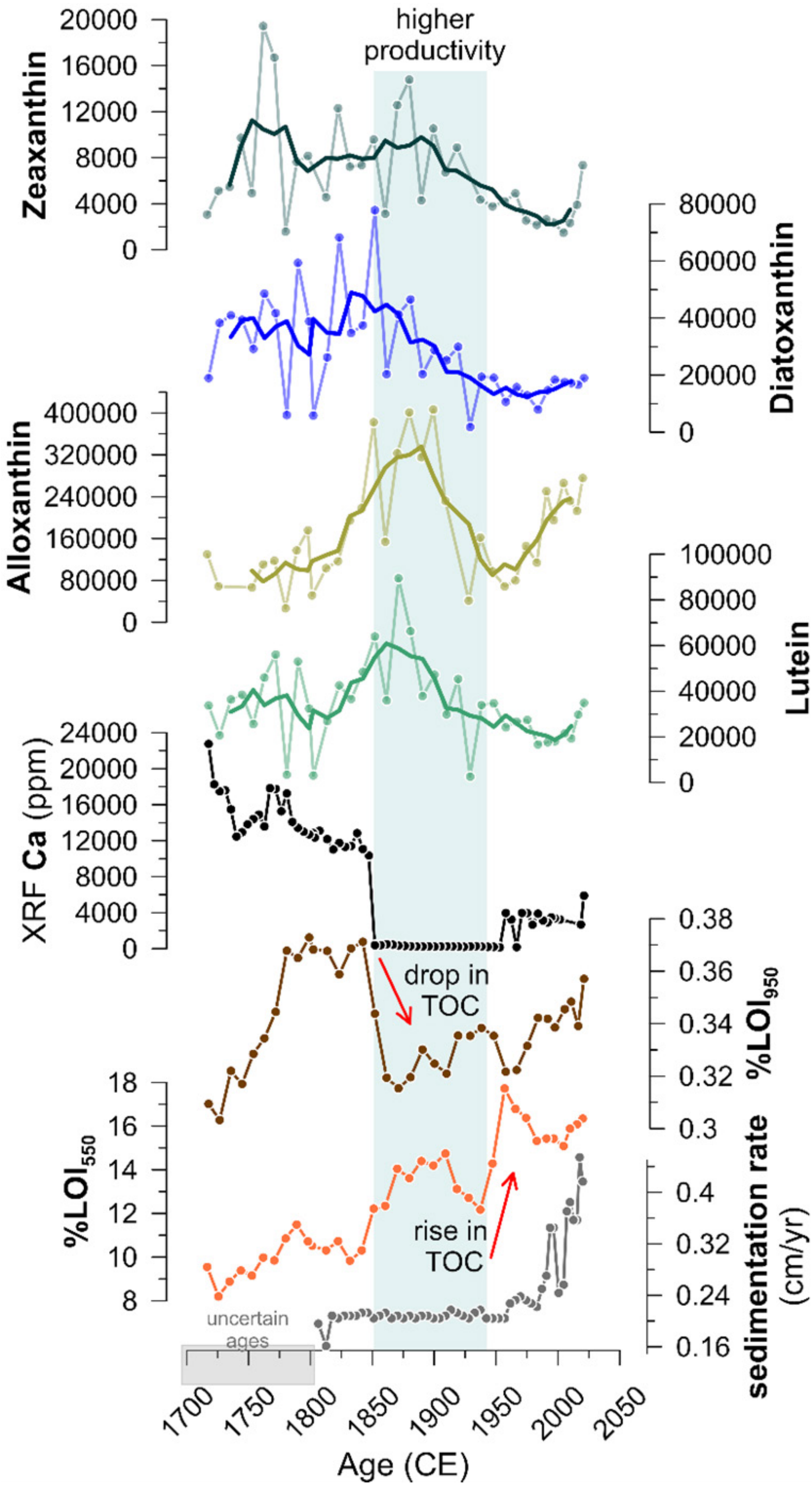

Figure 4. Proxy analysis of RSUN0420 by age (CE). Proxies from top to bottom: Zeaxanthin pigments, Diatoxanthin pigments, Alloxanthin pigments, Lutein pigments, XRF Ca (ppm), $\%LOI_{950}$, $\% \ LOI_{550}$ and sedimentation rate (cm/yr).

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