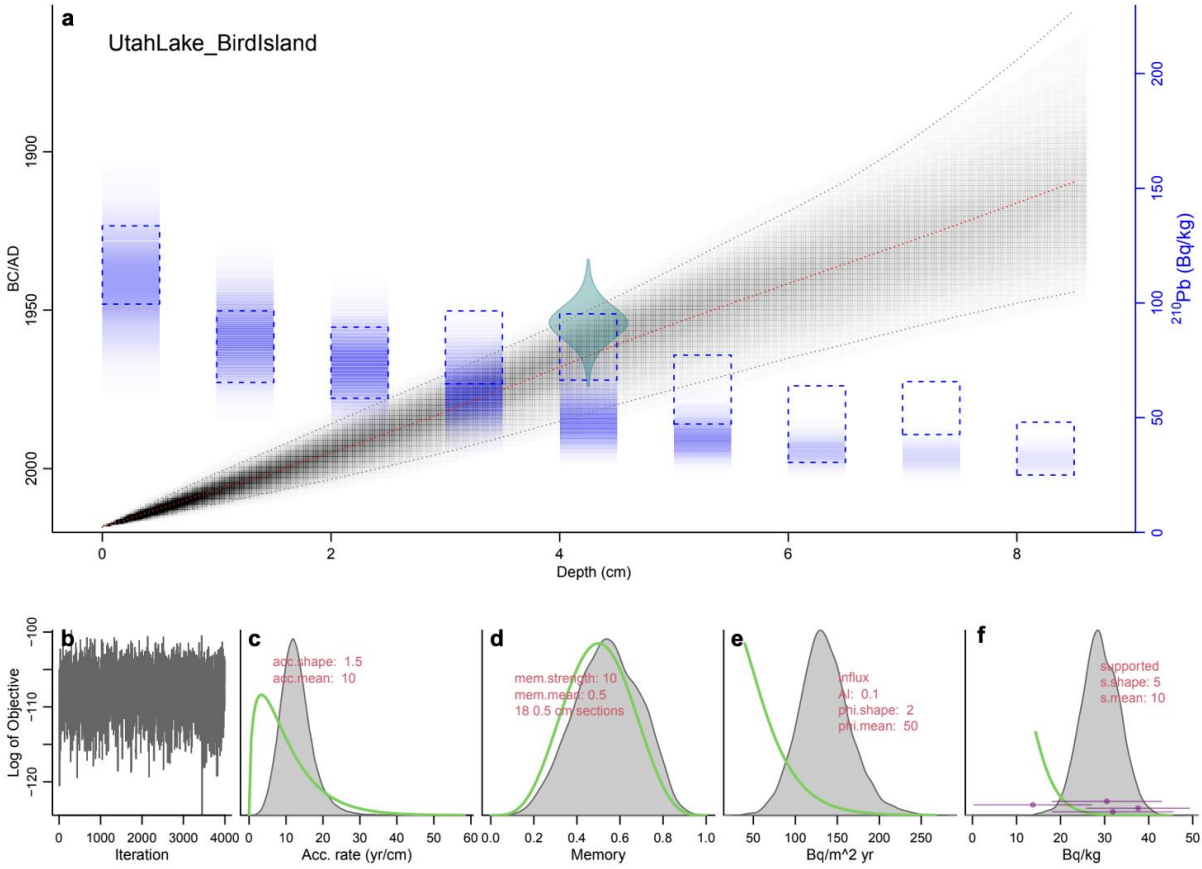
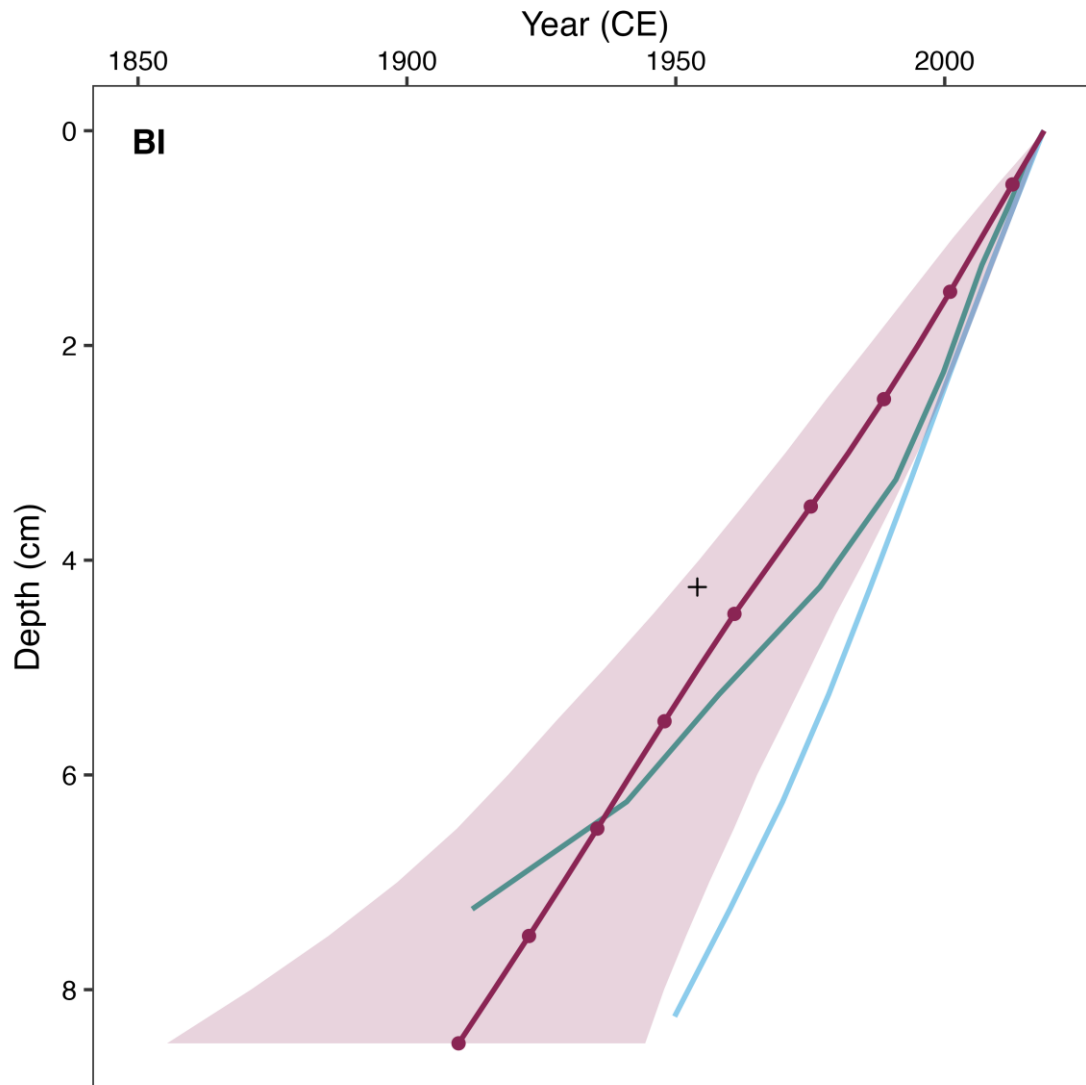


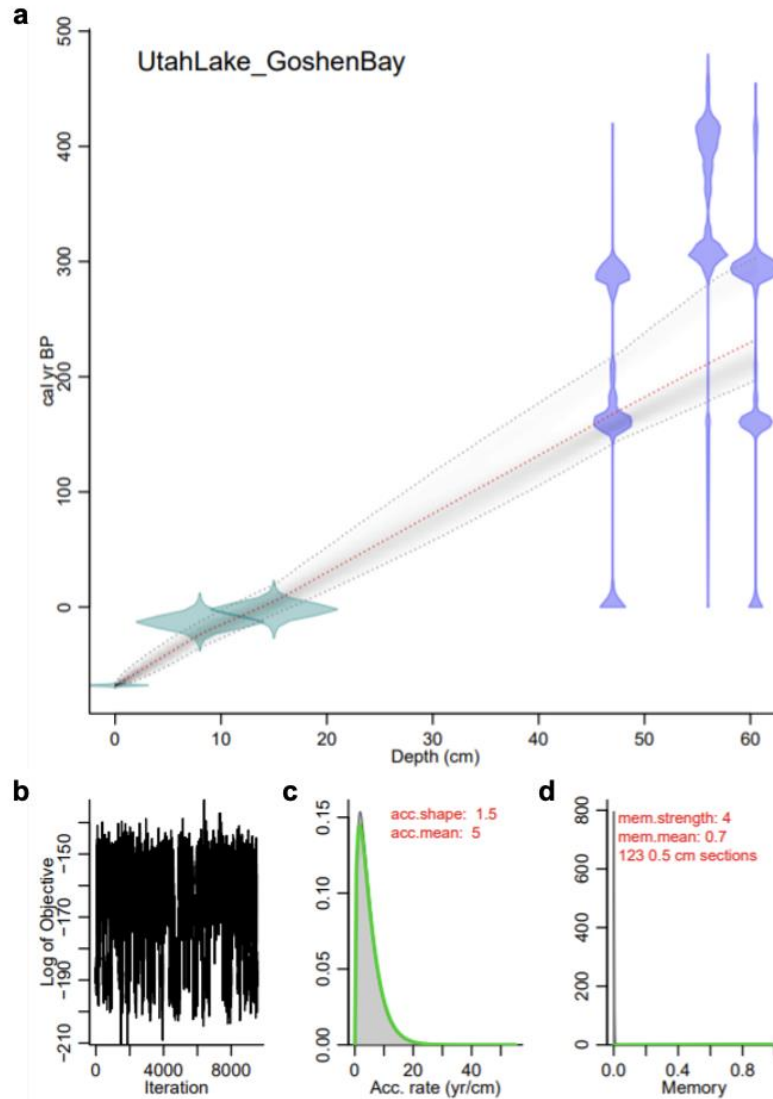
**Fig. S1** Tree-ring reconstruction of lake level change for nearby Great Salt Lake (a, adapted from deRose et al. 2014) used as an indicator of regional climatic fluctuations on observed lake-level changes of Utah Lake. Gray shaded area indicates the time period when data were available for Utah Lake. Inferred lake level change of Great Salt Lake (red) and measured Utah Lake (blue; shaded area represents the mean monthly minimum and maximum water levels; light blue lines indicate the estimated minimum and maximum water levels) water levels were significantly correlated over the period that data was available for both lakes (b; 1884-2020;  $r = 0.69$ ,  $p < 0.001$ ).



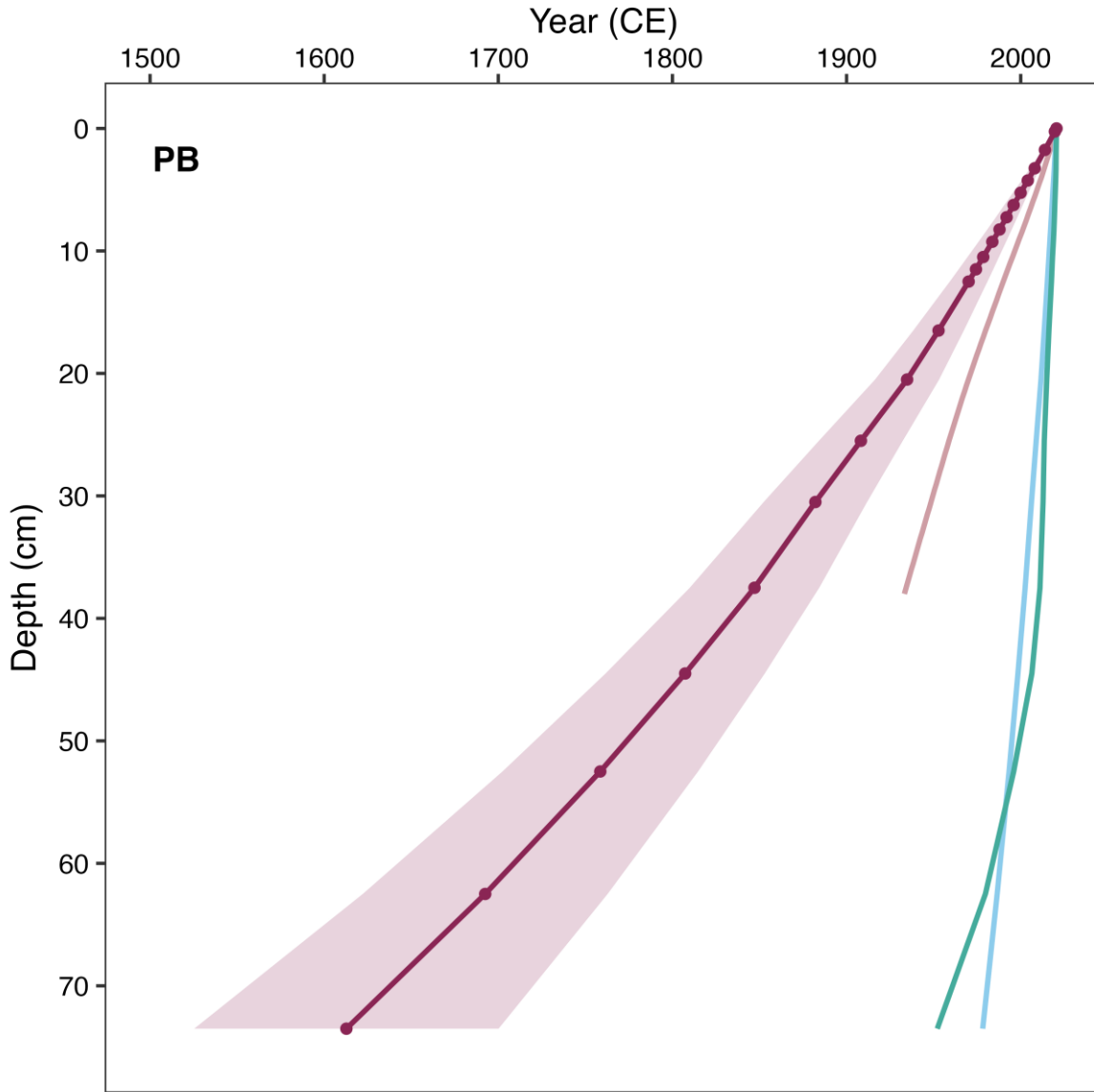
**Fig. S2** Output age-depth model of the Bird Island core (a) based on  $^{137}\text{Cs}$  (green) and excess  $^{210}\text{Pb}$  (blue) measurements using the package *rplum* (version 0.3.0; Aquino-López et al. 2018) in R. The red line indicates the best fit estimate from all MCMC iterations, the grey shaded area displays a summary of the iterative walks, and the grey dotted line represents the 95% confidence intervals. Markov Chain Monte Carlo random walk model iterations (b), and prior (green) and posterior (grey) distributions of accumulation rates (c), memory (d), influx (e), and supported  $^{210}\text{Pb}$  (f; purple dots indicate the measured concentrations used)



**Fig. S3** The <sup>210</sup>Pb-based Bayesian *rplum* age model (pink circles; shaded area represents the error), Constant Rate of Supply (green; Appleby & Oldfield, 1978), and Constant Flux:Constant Sedimentation age model (blue) for Bird Island. The supported <sup>210</sup>Pb activity (39.64 Bq kg<sup>-1</sup>) for the CRS and CF:CS models was calculated as the mean of the last five measurements plus one standard deviation. + indicates the <sup>137</sup>Cs peak at 4.25cm, representing 1954, used to constrain the Bayesian model.

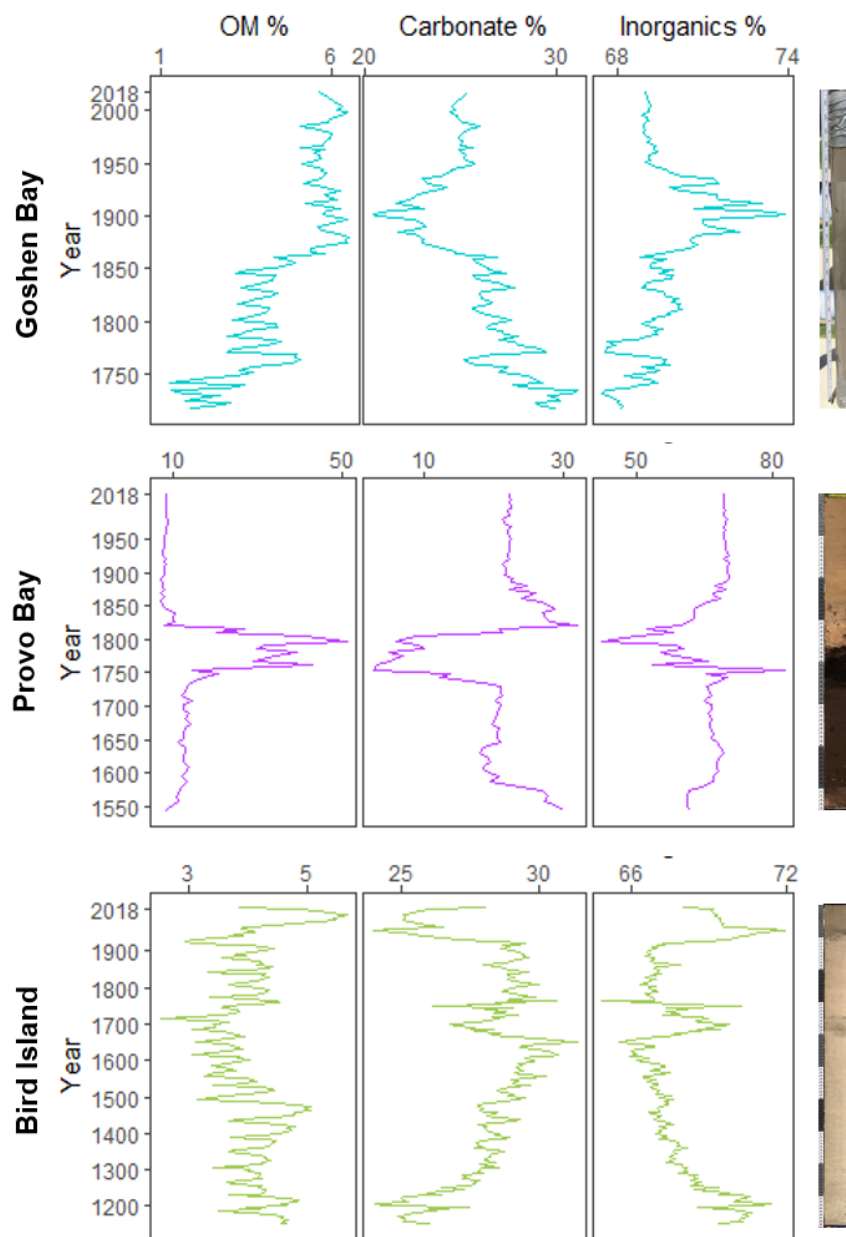


**Fig. S4** Output age-depth model of the Goshen Bay core (a) based on  $^{137}\text{Cs}$  (green) and  $^{14}\text{C}$  (purple) measurements using the package *rbacon* (version 2.5.7; Blaauw et al. 2021) in R. The red line indicates the best fit estimate from all MCMC iterations, the grey shaded area displays a summary of the iterative walks, and the grey dotted line represents the 95% confidence intervals. Markov Chain Monte Carlo random walk model iterations (b), and prior (green) and posterior (grey) distributions of accumulation rates (c), and memory (d; indicating coherence of sedimentation rates throughout the core).

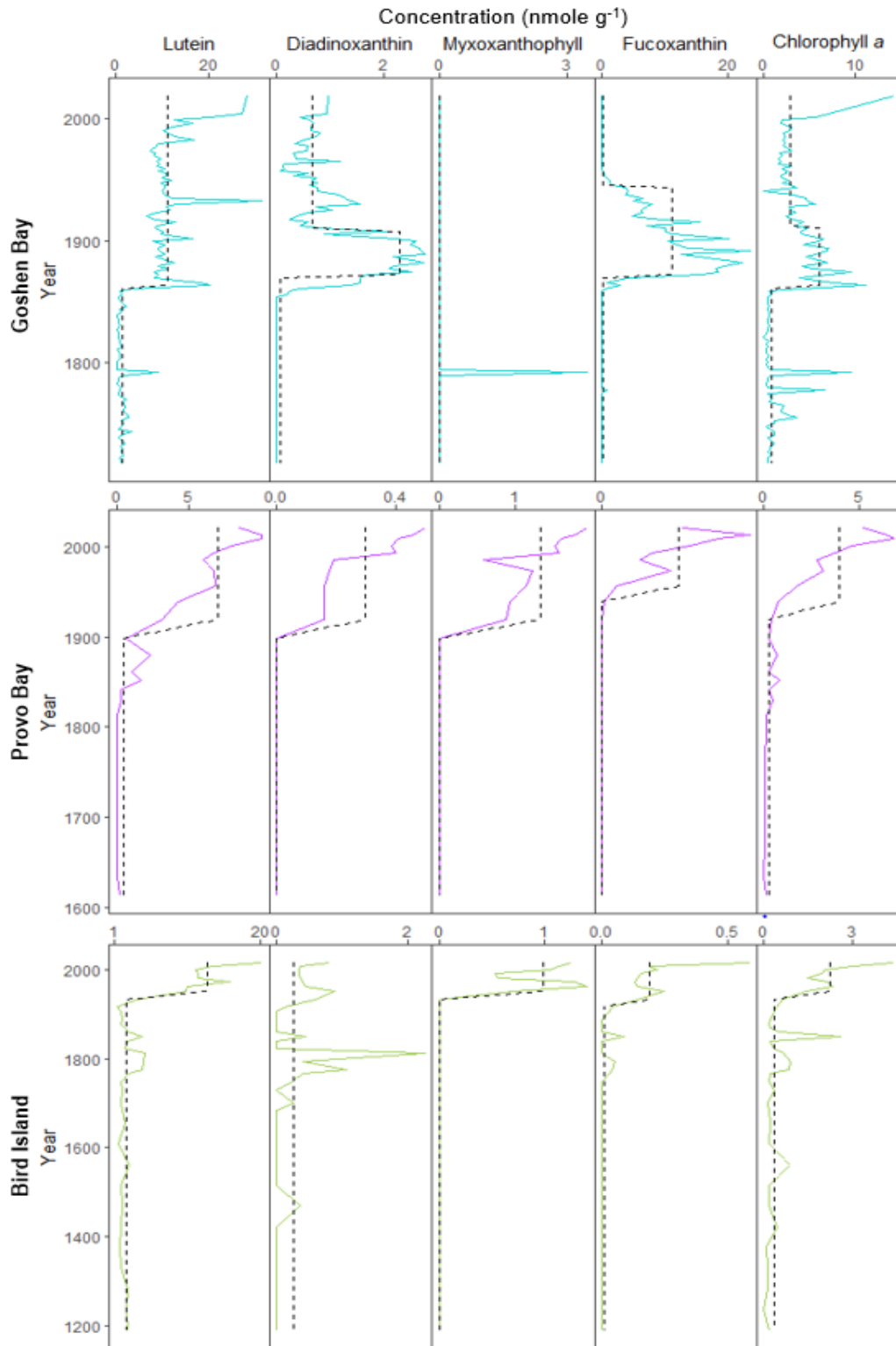


**Fig. S5** The  $^{210}\text{Pb}$ -based Bayesian age model (pink, constrained with  $^{137}\text{Cs}$ ), Constant Rate of Supply age model (green) and Constant Flux:Constant Sedimentation age model (blue) for the Provo Bay core compared with the  $^{137}\text{Cs}$  age-depth model (pink circles; shaded area represents the error). The  $^{137}\text{Cs}$  model (maroon) fit ( $R^2 = 0.599$ ) was calculated as:  $p_1 = 22.75 \pm 6.33$  (FWHM),  $p_2 = 8.67 \pm 1.76$  (Centroid),  $p_3 = 221.87 \pm 73.93$  (Area),  $p_4 = 1.80 \pm 1.53$  (Baseline),

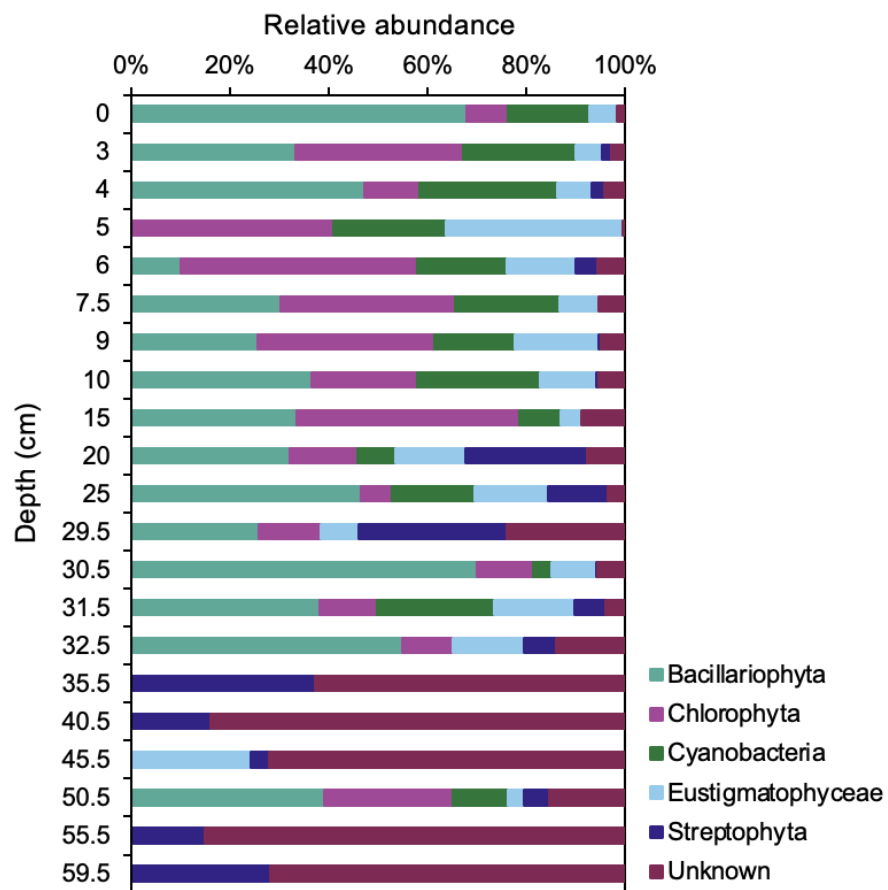
$$y = p_4 + p_3/p_1 \cdot \sqrt{4 \cdot \log(2)/\pi} \cdot \exp(-4 \cdot \log(2) \cdot ((x - p_2)/p_1)^2).$$



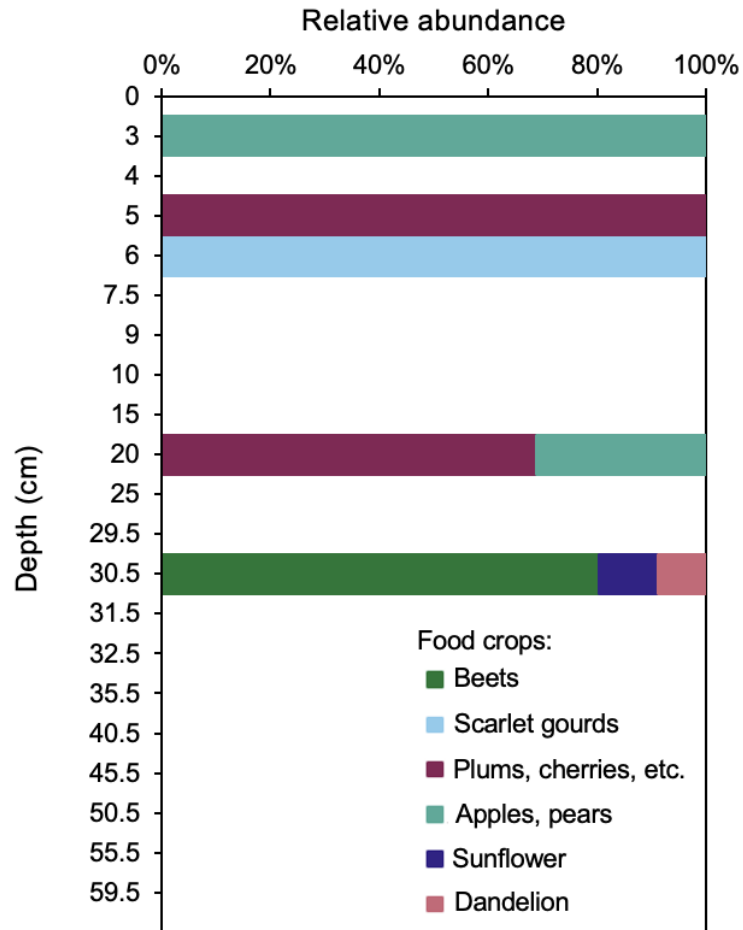
**Fig. S6** Percentages of organic matter, carbonates, and inorganics measured with loss-on-ignition (LOI) throughout the Goshen Bay, Provo Bay, and Bird Island cores. High-resolution photographs of the Goshen Bay and Provo Bay cores are included to show visual changes in stratigraphy. The Goshen Bay photograph is a low-quality photo from the field, no high-resolution photograph is available due to the extrusion method used.



**Fig. S7** Concentrations of additional algal pigments measured throughout the Goshen Bay, Provo Bay core, and Bird Island cores. Dashed lines indicate significant regime shifts.



**Fig. S8** Relative abundance of phytoplankton *sed*DNA sequences detected using the 23S primer in the Goshen Bay core.



57

58 **Fig. S9** Relative abundance of select plant taxa *sedDNA* sequences known to represent food

59 crops detected using the trnL primer in the Goshen Bay core.



65 **Table S1**  $^{210}\text{Pb}$  data from the Bird Island core that was used to create the Bayesian age-depth  
66 model using *rplum*, which was then further constrained with the peak of  $^{137}\text{Cs}$  at 4.25 cm used to  
67 represent 1954.

LabID	Depth	Density	$^{210}\text{Pb}$	sd	Thickness	Settings
	(cm)	(g cm <sup>-3</sup> )	(Bq kg <sup>-1</sup> )	( $^{210}\text{Pb}$ )	(cm)	
BI1	0.5	0.88	116.58	17.05	0.5	2018
BI2	1.5	0.8625	80.94	15.58	0.5	4
BI3	2.5	0.8253	73.95	15.49	0.5	0
BI4	3.5	0.8073	80.67	15.85	0.5	
BI5	4.5	0.8719	80.82	14.46	0.5	
BI6	5.5	0.8614	62.26	15.01	0.5	
BI7	6.5	1.0495	47.21	16.69	0.5	
BI8	7.5	1.1354	54.19	11.54	0.5	
BI9	8.5	1.1588	36.52	11.52	0.5	
BI10	11.5	1.1578	31.85	13.68	0.5	
BI11	22.5	0.9643	37.61	11.65	0.5	
BI12	29.5	1.1782	13.71	13.37	0.5	
BI13	33.5	1.2362	30.49	12.41	0.5	

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69 **Table S2** Input data for the Bayesian age-depth model for Goshen Bay using *rbacon*:  $^{137}\text{Cs}$  dates  
70 (GB-01-001, GB-01-012, and GB-01-026) and radiocarbon dates (GB-01-091, GB-01-109, and  
71 GB-01-118).

<b>LabID</b>	<b>Age</b>	<b>Error</b>	<b>Depth</b>	<b>cc</b>
	<b>(cal yr BP)</b>	<b>(cal yr BP)</b>	<b>(cm)</b>	
GB-01-001	-68	0.5	0	0
GB-01-012	-13	5	8	0
GB-01-026	-4	5	15	0
GB-01-091	220	20	47	1
GB-01-109	280	20	56	1
GB-01-118	240	20	60.5	1

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