nature portfolio

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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☐	☒	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	no software was used
Data analysis	no software was used

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All data generated within this study are available as Supporting Information and are stored in the SeaDataNet repository (https://doi.org/10.17882/102344).

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	n/a
Reporting on race, ethnicity, or other socially relevant groupings	n/a
Population characteristics	n/a
Recruitment	n/a
Ethics oversight	n/a

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Geochemical and palynological analysis of sediment cores from the Aegean Sea region to investigate the anthropogenic impact on terrestrial and marine environments connected to the socioeconomic evolution of early cultures.
Research sample	Sediment samples from Tenaghi Philippon peatland (NE Greece) and marine cores from the Aegean Sea.
Sampling strategy	1. Continuous down-core (step-size 0.5 cm) semi-quantitative elemental measurements of sediment cores using X-ray fluorescence (XRF) core scanning. 2. Lead concentrations on 35 samples from core M51/3 SL152 and 34 samples from Tenaghi Philippon were determined by inductively coupled mass spectrometry (ICP-MS) in clean labs to confirm the down-core Pb variability in the XRF datasets. 3. Decadal-scale palynological analysis (pollen and spores) for the Tenaghi Philippon record (138 samples), marine core SL152 (73 samples) and core EF-AR2 (32 samples).
Data collection	The data were generated by multiple co-authors (please see the 'Author Contributions' section of the article).
Timing and spatial scale	Palynological and Pb concentrations from core M51/3 SL152 were generated in 2010 at Goethe University Frankfurt (Germany). The rest of the palynological and sediment geochemical data were generated between 2022 and 2024 at Heidelberg University (Germany).
Data exclusions	No data were excluded.
Reproducibility	XRF core scanning data were generated using an AVAATECH (GEN-4) core scanner. Pb and Zr concentrations on samples from core M51/3 SL152 were determined by a double-focusing Thermo Scientific Neptune MC-ICP-MS. Pb and Zr concentrations on samples from Tenaghi Philippon were determined with a Thermo Scientific iCAP TQe.
Randomization	Sampling of the sediment cores was designed to generate continuous paleoenvironmental records spanning from the Neolithic period to the Common Era at timescales that do justice to the tempo of sociocultural transformations.
Blinding	Blinding is not relevant in the analysis of sediment samples.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☐	☒ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Palaeontology and Archaeology

Specimen provenance	The study is based on sediment cores retrieved from Tenaghi Philippon basin (NE Greece) in 2005, and the Aegean Sea retrieved by R/V METEOR (cruise M51/3 in 2001 and cruise M144 in 2017/2018) and R/V AEGAEO (EUROFLEETS+ cruise 'MYRTOON' in 2021). Field work was carried out with permissions from the Greek authorities.
Specimen deposition	All studied sediment cores are stored at Heidelberg University (Germany), except from cores M51/3 SL151 and SL152 that are stored at the University of Tübingen (Germany).
Dating methods	The age models of the marine cores are based on a total of 60 new and seven previously published 14C accelerator mass spectrometry (AMS) dates. The dating was carried out on mixed planktic foraminifera, predominantly Globigerinoides ruber and, in case not enough G. ruber specimens were available, Globigerina bulloides, Globigerinoides sacculifer, and Orbulina universa from the >250 µm fraction as well as pteropods. The chronology of the uppermost 5 m of the core from Tenaghi Philippon is based on two new AMS radiocarbon ages from bulk peat samples, and three previously published AMS ages from snails (i.e., Oxyloma elegans and Viviparus contectus). All 14C dates and their uncertainties (1σ) are reported in the Supplementary Information of the article and in the SeaDataNet repository (https://doi.org/10.17882/102344).

☒ Tick this box to confirm that the raw and calibrated dates are available in the paper or in Supplementary Information.

Ethics oversight	n/a

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Plants

Seed stocks	n/a
Novel plant genotypes	n/a
Authentication	n/a