Quantifying the limits of paleontological resolution using a global compilation of individually-dated skeletal remains

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Objectives

Marine fossil assemblages typically include remains of non-contemporaneous organisms that accumulated over time or were subsequently mixed by bioturbation or reworking. The resulting **time averaging (temporal mixing) imposes the fundamental limit on the temporal resolution of paleontological samples** and thus restricts the range of processes that can be studied in the fossil record. Time averaging can be directly quantified in late Quaternary assemblages by numerical dating of individual skeletal remains, however previous case studies were limited in their spatiotemporal and taxonomic scope.

Here, we present a **global compilation of data from multiple projects focused on age-dating of marine invertebrate** remains sampled from present-day seabeds and Quaternary sediment cores. We use this dataset to quantify the scale and variability in time averaging and identify potential gaps in spatial, environmental and taxonomic coverageof the data to guide future sampling efforts.

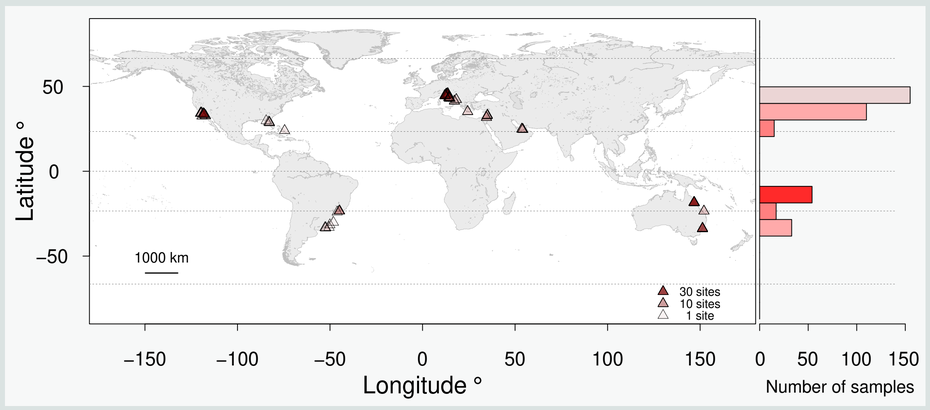
Data compliation

The **dataset aggregates radiocarbon and amino-acid racemization ages of skeletal elements** and links them to a broad range of standardized variables describing sampling methodology, intrinsic characteristics of skeletal producers, as well as stratigraphic, sedimentary and environmental context.

Currently, the data includes **age estimates for 7,593 specimens representing 384 monospecific samples** of 10 or more individually dated skeletal remains coming from 291 sampling units (core increments, grabs, dredges, hand collections or suction samples) sourced from 118 unique sites.

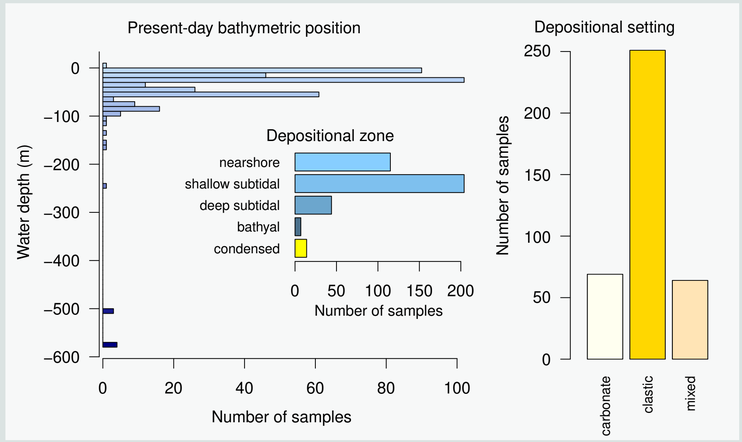
Geographic coverage

The sampling site are located across seven warm-temperate, subtropical, and tropical regions, with majority of samples coming from the Adriatic Sea (40%), southern California (25%) and western Australia (22%).



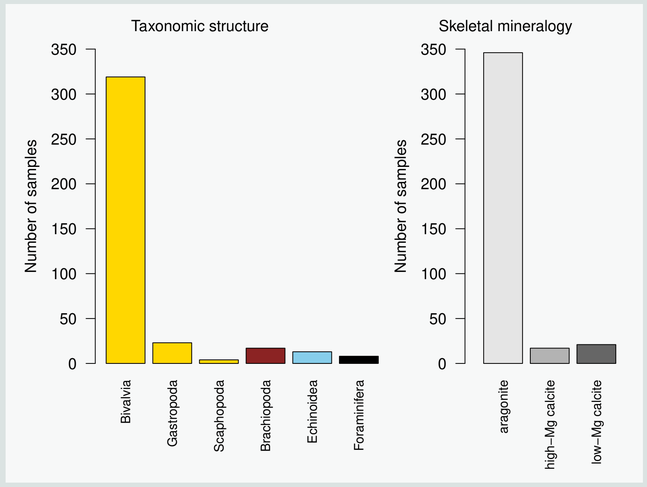
Environmental coverage

The dataset covers nearshore to continental slope environments, mostly from clastic depositional settings. Outer shelf and slope environments are poorly represented with only 7% of sampling sites and 3% of samples coming from water depths below 100 m.



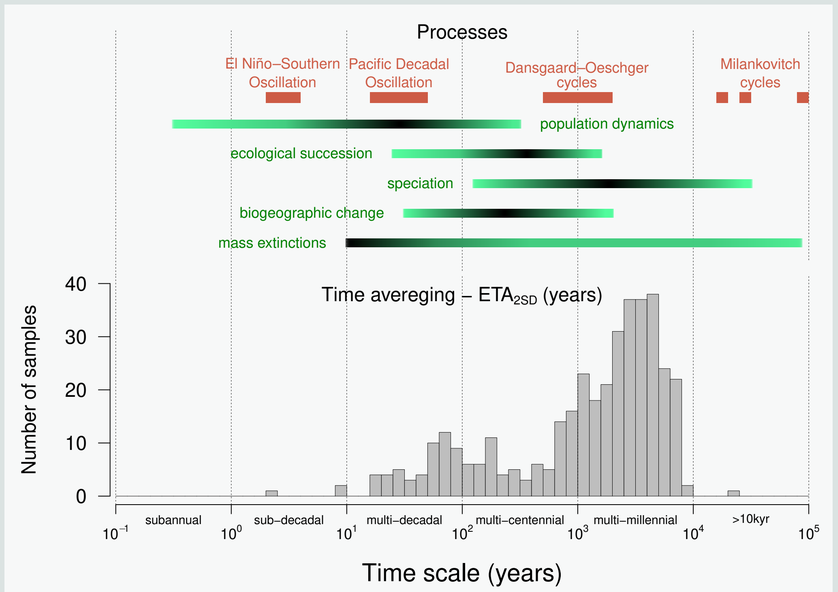
Taxonomic coverage

The dataset is strongly dominated by aragonitic bivalves (>80% of samples and dated specimens), with much more limited data available for other taxa. Except for 13 echinoid samples, time-averaging estimates are lacking for taxa with poorly biomineralized or easily disarticulating skeletons.



Scale of time averaging

Time averaging was measured as ETA_{2SD} – 2 standard deviations of specimen ages in a sample corrected for the geochronological imprecision associated with numerical dating. The majority of the analyzed samples (66%) underwent millennial time averaging (median ETA_{2SD} = 1990 years), but a significant portion (14%) was time-averaged to less than 100 years.



Conclusions

Our quantitative assessment of the temporal resolution of marine invertebrate fossil assemblages represents the **first global synthesis based on a large number of time averaging estimates**. We find that time averaging ranges across three orders of magnitude and that fossil assemblages are adequately resolved for studying a broad spectrum of processes including those operating on centennial or even decadal scales.

Our compilation also highlights the lack or relative **paucity of quantitative time averaging estimates from deep-water and high-latitude settings, as well as for taxa with low durability or multi-elemental skeletons** (such as echinoderms and arthropods). Increasing the taxonomic and environmental coverage of the data is thus crucial for improving our current understanding of the temporal resolution of the fossil record.

Acknowledgments

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