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Unmixing the young fossil record using radiocarbon-calibrated amino-acid racemization (Gulf of Trieste, northern Adriatic Sea)

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Marine coastal habitats globally have been affected by eutrophication, hypoxia, habitat alteration, overfishing, and resource exploitation over recent decades. However, reconstruction of past natural ecosystem states is compromised by short-term archives and biotic surveys limited to the past decades and/or by low stratigraphic resolution of fossil assemblages in sedimentary cores due to slow sedimentation and bioturbation. In the northern Adriatic Sea, which was affected by eutrophication, algal blooms and mucilage blooms, and hypoxia during the second half of the 20th century, the composition of natural baseline states of benthic ecosystems and their responses to natural and anthropogenic disturbances over longer, centennial scales are poorly known. In this study, we evaluate the timing and forcing of past hypoxia events in the northern Adriatic Sea (Gulf of Trieste) based on the production history of the opportunistic, hypoxia-tolerant bivalve Corbula gibba, using 210Pb data, radiocarbon dating, amino acid racemization, and distribution of foraminifers in 1.5-m-thick sediment cores that capture the past 500 yr. Corbula gibba tolerates eutrophied and polluted conditions and survives seasonal hypoxic and mass mortality events affecting most of the benthic macrofauna in the northern Adriatic Sea. In the aftermath of such events, it can achieve density of thousands of individuals/1 m2 and can contribute with more than 80% of individuals to the bivalve assemblage. Unmixing the stratigraphic record of cores on the basis of 311 shells of C. gibba, we show that production of this species underwent major decadal-scale fluctuations since the 18th century, with outbreaks corresponding to density of more than 1000 individuals per square meter. A positive correlation between abundances of hypoxia-tolerant foraminifers and C. gibba, the temporal coincidence between the peak in abundance at ∼1980 and several hypoxic crises in the Gulf of Trieste in 1974, 1980, and 1983, and the temporal coincidence between the decline in C. gibba abundance and low frequency of hypoxia in the past two decades, suggest that outbreaks of C. gibba do correspond to past hypoxia events. We suggest that the outbreaks of C. gibba represent long-term phenomena in the northern Adriatic ecosystem rather than novel states characteristic of the 20th century eutrophication. These outbreaks correlate significantly positively with maxima in sea-surface temperature, indicating that the hypoxia events were connected with water-column stratification rather than with eutrophication events. The reconstructed fluctuations in production do not correlate with abundances of C. gibba in the raw stratigraphic record due to centennial-scale time averaging of bivalve assemblages.