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Assessing the magnitude of recent compositional changes in marine ecosystems: a conservation paleobiology case study from the Persian Gulf

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Nearly every modern marine ecosystem has experienced major changes due to anthropogenic stressors such as habitat modification, pollution, overexploitation and climate change. However, our knowledge of ecosystem dynamics in a historical time-frame (decades to few centuries) is restricted by the lack of direct, recorded human observations: properly designed ecological surveys have been conducted for comparatively short durations in the last few decades only, and in merely a few localities, poorly representative of large-scale phenomena.
A unique but under-exploited source of information is hidden in death assemblages (DAs), the taxonomically identifiable, dead or discarded organic remains in a seabed. Due to the slow degradation of hard skeletal parts such as shells in the sea, DAs represent archives that accumulate information on species composition and community states over time and are inert to recent changes. Assessing the degree in compositional and ecological similarity between living (LAs) and death assemblages can be used to reconstruct the degree of recent community disturbances. Previous studies have shown that live-dead (LD) agreement tends to be poorer in anthropogenically disturbed settings, because LAs respond faster than DAs to pressures, thus increasing the LD disagreement in composition. As a complementary approach, age dating of shells (using radiocarbon calibrated amino acid racemization) allows identifying the timing of ecosystem change. These approaches help recognize community shifts in time, overcoming the lack of direct observation.
As a case study, we present the results of applying these techniques to the impacts of oil platforms on the benthic assemblages in the Persian (Arabian) Gulf. This semi-enclosed basin originated 12,500 years ago and currently hosts the highest concentration of infrastructures for oil and gas extraction in the world. Moreover, it has been affected by major oil spills.
Contaminants show a weak gradient within each of two oilfields, which does not explain the variation in taxonomic composition and abundance of the LA. Therefore, we would expect the LD agreement to be mainly determined by time-averaging, inducing an increase in species richness and in evenness in the DA. In contrast to this expectation, rarefied species richness and evenness were not higher in the DA. However, this finding was largely determined by the dominance in the DA of a single bivalve species, Ervilia purpurea, which represented 40% of the whole DA, but was totally absent from the LA. The removal of E. purpurea from the dataset led to results in accordance with expectations. The reasons for the absence in the LA of E. purpurea are currently being investigated with dating techniques to determine the age of the youngest specimens and its relation to the history of the basin and the age of the major pollution events.