# Monitors with Memories: Death Assemblages Record a Century of Wastewater Pollution and Remediation

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Long-term sediment monitoring programs are invaluable for detecting biological responses to changing environmental conditions under anthropogenic stressors. However, monitoring is rarely launched before the onset of human stressors, even where watershed industrialization and urbanization are quire recent. Integrating recent fossil records – e.g., time-averaged dead-shell assemblages – with ecological time series is a promising method to (1) characterize conditions prior to the onset of monitoring, and (2) detect otherwise unappreciated decline in condition. Here, I use the durable skeletal remains of bivalves to assess live-dead discordance in three types of ecological metrics: traditional univariate measures (e.g., richness, evenness, dominance), multivariate measures (e.g., dispersion), and abundance-weighted indices of ecological condition (e.g., Benthic Response Index; Infaunal Trophic Index; ATZI's Marine Benthic Index).

My test material includes (a) a 50-year-long dataset of living bivalve assemblages from the Palos Verdes shelf in Southern California, sampled annually at 44 sites to monitor the effects of treated wastewater effluent, and (b) dead bivalve shells sampled from the post-processed residue of the 2008 survey. The time series was parsed into temporal bins based on phases of wastewater treatment.

All metrics demonstrated that benthic conditions improved with remediation, and the greatest changes were close to the outfall source. Bivalve death assemblages – which include shells >100s years old on this shelf – indicated better conditions than was observed in early communities (1970s-80s) and either agreed with or underestimated the strain in more recent communities (2000s-10s). This live-dead discordance suggests that time-averaging causes death assemblages to retain a signal from pre-pollution benthic conditions that the shelf benthos is now re-attaining. Recent fossil assemblages, combined with long-term biological time series data, can reveal both the existence and direction of changing environmental conditions. Because skeletal remains are often sampled alongside living communities, live-dead discordance is an inexpensive procedure to add to biomonitoring protocols.

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