Modeling the transition of death assemblages from surface to subsurface: predicting the effects of burial, mixing, and disintegration on time averaging

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Although the temporal resolution and incompleteness of the fossil record are strongly determined by the thickness of the taphonomic active zone and by the depth and rate of mixing, it is unclear whether changes in time-averaging associated with the burial of assemblages that form in the surface mixed layer (SML) can be generalized across environments. Here we extend our previous models, which estimated disintegration on the basis of shell-age distributions (AFDs) in the SML, to stochastic transition matrices, and then apply them to discrete stratigraphic layers in sediment cores. This permits us to: (1) predict downcore trends in the shape of shell AFDs, and (2) estimate burial, disintegration, and mixing rates on the basis of age distributions observed in sediment cores. We find that, first, if the time to burial of individual shells to a specific sediment depth is stochastic due to bioturbation, then the inter-quartile age range will increase and skewness and kurtosis will decrease downcore to the top of permanent, historical layers (because the deepest layers reached by bioturbators are affected by mixing for a longer time than are surface layers). Systematic dm- to meter-scale changes in AFDs downcore can thus arise without changes in rates of sedimentation or mixing. Second, in contrast to expectations that species with durable shells will exhibit greater time averaging (larger inter-quartile age ranges) than species with fragile shells (an effect typical of assemblages in the SML), this difference will be minimized below the taphonomically active zone. Third, the median and modes of the AFDs of species differing in durability will differ, however, in those subsurface assemblages, producing age offsets (geologic age discordance) among species. These three predictions are clearly relevant for Holocene-Anthropocene studies, but also inform our understanding of deeper time fossil records, where episodically rapid burial can move surface assemblage to historical layers. In such case, the downcore decline in time averaging associated predicted by the surface-subsurface transition will characterize some subsets of stratigraphic successions in the fossil record.