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Title: Uncertainty in copepod mortality rates and fates: implications for ecological linkages

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Abstract (max 250 words)

Copepods are key zooplankton taxa in marine ecosystems. Uncertainty in their mortality is a major problem for reliably forecasting their role in the "to" linkages in end-to-end ecosystem models. Copepods have complex life histories with size class and ecological role varying by developmental stage. Later life stages exert top-down control on primary production and are prey for fish, whales and seabirds. Early stages are prey for mesozooplankton and the larvae of numerous fish species. Copepod physiological losses and non-predatory mortality contribute to nutrient export and regeneration. Accurate estimates of copepod mortality rates and fates are essential for understanding and predicting zooplankton dynamics and associated ecological fluxes. Modeling copepod mortality is problematic for several reasons. There are several different loss terms, including "closure", egestion and excretion, mortality is highly variable among stages, seasons and regions, and so are modelers' choices regarding how to parameterize this variability and partition associated losses. Here we examine the uncertainty associated with different sources of mortality, including ones that are largely unrecognized, and illustrate contrasting approaches from the literature. Field data and an individual-based model for *Calanus finmarchicus* in the Labrador Sea are used to demonstrate how neglecting egg viability and aggregating stages into a single variable biases estimates of survivorship and non-predatory losses. An NPZD model for Station India is used to illustrate how assignments of zooplankton mortality to predation vs. detritus vs. nutrients can be as ecologically significant as closure. New approaches that can improve ecosystem modelers' ability to cope with mortality-related uncertainty are discussed.

Key words copepods, mortality, estimation methods, trophic interactions, population dynamics models, closure schemes, detritus

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