Spatial Variability and Drivers of Mysis Partial Diel Vertical Migration

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ABSTRACT:

The omnivorous macroinvertebrate *Mysis diluviana* plays important roles in Great Lakes food webs by consuming detritus, phytoplankton, and zooplankton, serving as a major prey for fish communities, and coupling these food web compartments in benthic and pelagic habitats through diel vertical migration (DVM). We have recognized in recent years that *Mysis* exhibit partial DVM (pDVM) where subsets of the population remain in benthic habitat during the night and in pelagic habitat during the day, contrary to long-held assumptions that DVM was a synchronized, population-level behavior. The consequences of pDVM behavior for assessments, and the drivers behind pDVM, remain unknown. We evaluated pDVM behavior in Lake Ontario to fill in these knowledge gaps by sampling day and night in both benthic and pelagic habitats to assess densities and demographics and to test several hypotheses on the drivers of pDVM. Due to field sampling constraints on Lake Ontario and COVID-19, we included additional systems (Lake Superior in particular, and seven other North American and European lakes) and approaches (experiments) to further and better address our hypotheses.We found that *Mysis* suspend in pelagic habitat during the day when light levels are sufficiently low (e.g., over deep bathymetric depths or over relatively shallow bathymetric depths in brown water lakes), pelagic habitat is occupied by smaller individuals during the day than at night, and larger individuals are found in benthic habitat versus pelagic habitat regardless of the time of day. Ninety-two percent of gravid females captured in Lake Ontario were from benthic night sampling, supporting the asset protection hypothesis. Consequently, pelagic night sampling misses at least some if not a major portion of an important demographic in *Mysis* populations - gravid females. Benthic density estimates at night were over an order of magnitude lower than pelagic density estimates at night in Lake Ontario, compared to 20% lower in Lake Champlain, when comparing vertical net hauls and benthic sled estimates. However, benthic density estimates using an underwater video system were similar to night pelagic estimates, similar to previous findings from Lake Champlain with the same equipment, suggesting benthic sleds do not represent benthic densities. The tradeoffs between density and demographic differences between pelagic and benthic habitats for *Mysis* production estimates are currently being evaluated in a Leftkovitch matrix model. The size-dependency of pDVM behavior in Lake Ontario was not related to sizeselective predation by deepwater sculpins (*Myoxocephalus thompsonii*), rainbow smelt (*Osmerus mordax*), and alewife (*Alosa pseudoharengus*) but appeared more related to ontogenetic shifts in foraging; δ15N values increased and isotopic niche spaces expanded with *Mysis* size in Lake Superior, and isotope mixing models indicate smaller individuals consume deep chlorophyll layer production more than larger individuals in Lake Ontario, consistent with expected diet shifts from more herbivory to more carnivory/detrivory with size. Evidence

from Lake Superior also suggests that smaller *Mysis* may exhibit trophic polymorphism as we saw consistent differences in isotopic values between pelagic- and benthic-caught individuals. However, such differences became less strong with size and disappeared for the largest size group, suggesting the potential for fixed resident and migrant behavior in juveniles but flexible DVM behavior as adults. Partial DVM behavior was unrelated to body condition in Lake Superior for all size groups. Preliminary results from experiments on predation risk in benthic habitats suggest *Mysis* may be more susceptible to slimy sculpin (*Cottus cognatus*) predation on smooth substrate (sediment) compared to rough (mussels) or a mix of smooth and rough habitat substrates. We are constructing a baseline, individual-based model to capture the impacts of *Mysis* behavior on their growth and reproduction as a function of daily and seasonal migration and seasonally varying food quantity and quality. The supported hypotheses from the current work will be incorporated into the model by an incoming PhD student and the model outputs will be evaluated against future field observations.