Bivalve molluscs: barometers of climate change in Arctic marine systems.

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ABSTRACT

Bivalve molluscs store a complete history of their life in the growth lines in their valves. Through sclerochronology in combination with isotope signatures, it is possible to reconstruct both post-recruitment growth history at the individual level and commensurate environmental records of temperature and salinity. Growth patterns are integrators of local primary productivity: spatial and temporal changes in growth illustrate commensurate patterns of food availability. Mactrid clams are long lived benthic dominant species found on inner continental shelves throughout the northern hemisphere where they variously support major fisheries (Spisula solidissima in the Middle Atlantic Bight, Macomeria polymya in eastern Canada, Spisula sachalinensis in Japan), recreational fisheries (M. polymya in Alaska), and serve as dietary items for charismatic species such as bearded seals (Erignathus barbatus) and walrus (Odobenus rosmarus divergens). Ongoing studies, employing both sophisticated adult growth and larval dispersal models, of the response of Spisula solidissima to climate change in the Middle Atlantic Bight suggest that Mactrids may be generally used as barometers of climate change over broader geographic footprints. M. polymya is a candidate species for shallow Arctic marine systems, having a pan-Arctic distribution from the Gulf of Maine in the Atlantic to the Bering Sea and Gulf of Alaska in the northern Pacific. The longevity of extant individual (≥25y) provides opportunity for detailed reconstruction of the benthic environment and food regimes at the decadal level.

INTRODUCTION

The Arctic continental shelves are similar to those of northwest Europe, the middle Atlantic coast of North America, and much of the northwest rise of the Pacific in having wide and gentle slopes providing topography with the opportunity for seasonal, wind-induced vertical mixing of the water column. Surface-generated primary productivity is mixed to the benthos and available for grazing by infauna (Hofmann et al. 2008, Xu et al. 2011, Munroe et al. 2013). Shelf bathymetry does not preclude benthic production of diatom mats as additional food sources for benthic grazers and infauna (Munroe et al. 2013). Arctic benthos and associated fauna include a large component that is a continuum of boreal species from lower latitudes. We explore the application of individual based bioenergetic and growth models (IBBM's), originally developed for lower latitude species, to long-lived bivalve molluscs exposed to changing primary productivity and thermal regimes in high latitude systems.

AN IMPORTANT FEATURE OF THE IBBM IS THAT WEIGHT AND LENGTH CAN BE DECOUPLED ALLOWING CHANGES IN CONDITION TO DRIVE CHANGES IN LENGTH, AND FOR CONDITION TO REFLECT THE FOOD ENVIRONMENT EXPERIENCED BY THE ORGANISM.

INDIVIDUAL SURFLCNM BIOENERGETIC MODEL

Scope for growth (SGF) for S. solidissima

- Differences between assimilated energy and respiration (dotted lines) result in gradually increasing SGF to 130 mm length.
- Beyond 130 mm SGF decreases to zero at about 170 mm.
- Above 170 mm SGF is negative under these conditions.
- Equations for assimilation and respiration are given in Munroe et al. (2013).

Scope for growth (SGF) for S. solidissima varying temperature constant (1mg/L) food.

- Maximum SGF occurs between 15 - 23°C and 120 - 140 mm length.
- The contour of zero SGF, (thick line) tracks with increasing length as temperature increases to approximately 18°C, remains stable until 23°C, the decreases rapidly to ≤40mm at 25°C.

CONCLUSIONS

- Individual based bioenergetic models provide tools to elucidate those environmental parameters regulating bivalve growth in response to primary production and food availability over broad temporal and spatial scales.

LITERATURE


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