Growth rates and lifespans of *Glycymeris americana* from North Carolina, USA during the Pliocene and Pleistocene

Sam Houston State University

Stephen Casper and David K. Moss
Department of Geography and Geology, Sam Houston State University

College of Science & Engineering Tech

1. Lifespans of modern bivalves

- Like trees, lifespans and growth rates of bivalves can be determined using internal annual growth increments
- Bivalves are some of the longest lived non-colonial animals on the planet today; several species reach lifespans in excess of 50 years and one species, *Arctica islandica,* has a maximum reported lifespan of 507 years[1]
- Recently, a global database of bivalve lifespans and growth rates documented a pattern of increasing lifespan and decreasing growth rate with latitude,[2] suggesting a role for the environment in extreme longevity
- Here, to better understand the environmental controls on longevity, we investigate lifespans of *G. americana* from Pliocene (green house conditions) and Pleistocene (icehouse conditions) deposits in North Carolina

Hypothesis: If cool temperatures promote longer lifespans, then we predict that *G. americana* will be longer lived in the Pleistocene than in the Pliocene

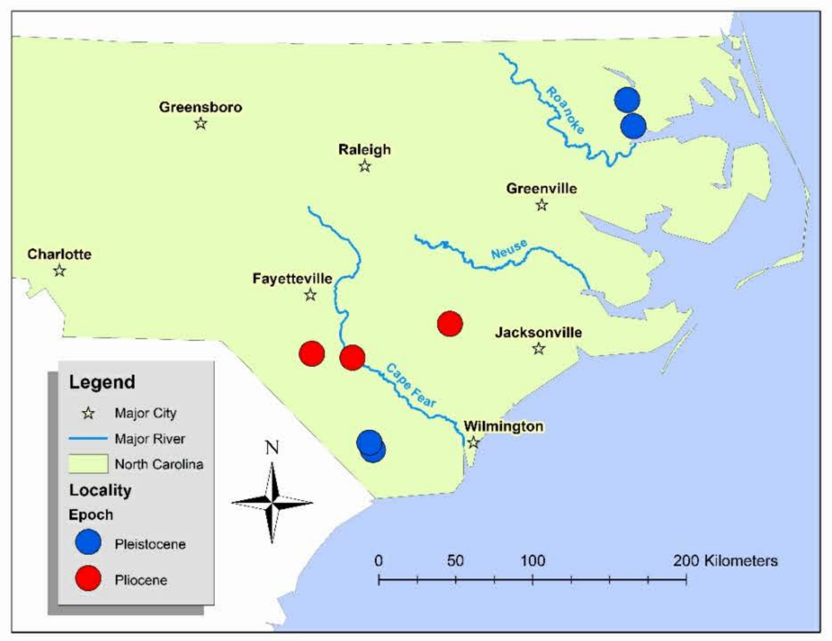

Figure 1. Map of North Carolina showing localities of our Pliocene and Pleistocene samples.

2. The von Bertalanffy growth equation

Growth in bivalves is well described by the von Bertalanffy growth equation (VBG)[3]. Here we apply VBG to size-at-age data to investigate both population and individual variation in growth parameters from the Pliocene and Pleistocene localities.

von Bertalanffy growth equation

$$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right)$$

where:

L_∞ = Asymptote of the curve

k = Rate at which L_∞ is approached

t_0 = Size at time 0 or the y-intercept

For the curve in Figure 2:

$L_\infty = 50$

k = 0.20

$t_0 = 1$

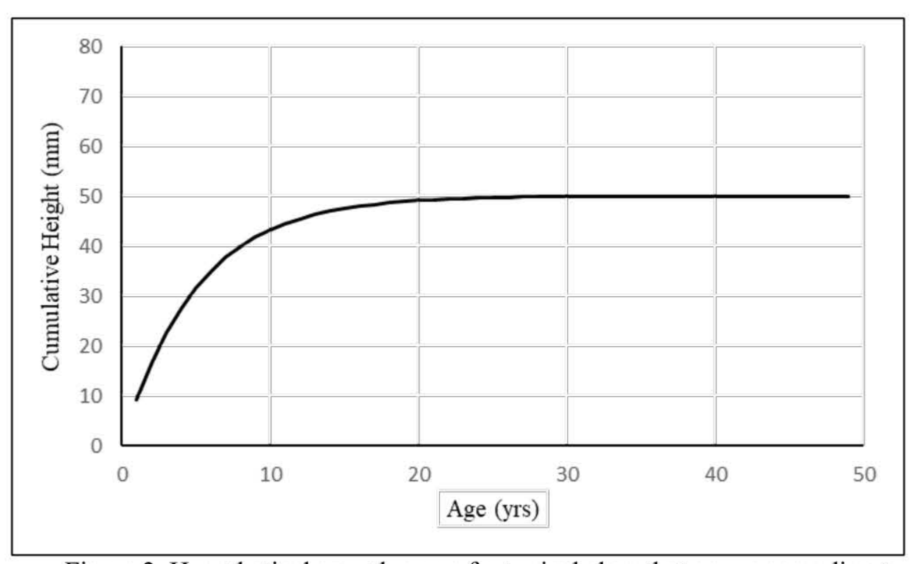

Figure 2. Hypothetical growth curve for typical clam that grows according to VBG.

3. What we did

- In total, 112 specimens, from 7 localities and three formations in North Carolina were used
  - Pliocene:
    - Duplin, 27
  - Pleistocene
    - Waccamaw, 59; Chowan River, 26
- To reveal internal growth increments:
  1. Shells were coated in an epoxy to prevent cracking during cutting
  2. Thick sections were made using a slow speed saw
  3. Sections were polished using 600 grit silica carbide paper and 1μm and 6 μm polycrystalline diamond suspension solution
  4. Polished sections were stained with Mutvei's solution[4] to enhance growth line visibility
  5. Specimens were photographed, growth lines counted, and increments measured using Zeiss Discovery v12 stereomicroscope
  6. von Bertalanffy growth curves were fit to size-at-age data using the nls procedure in Rstudio for each individual and for each population

4. Revealing growth increments

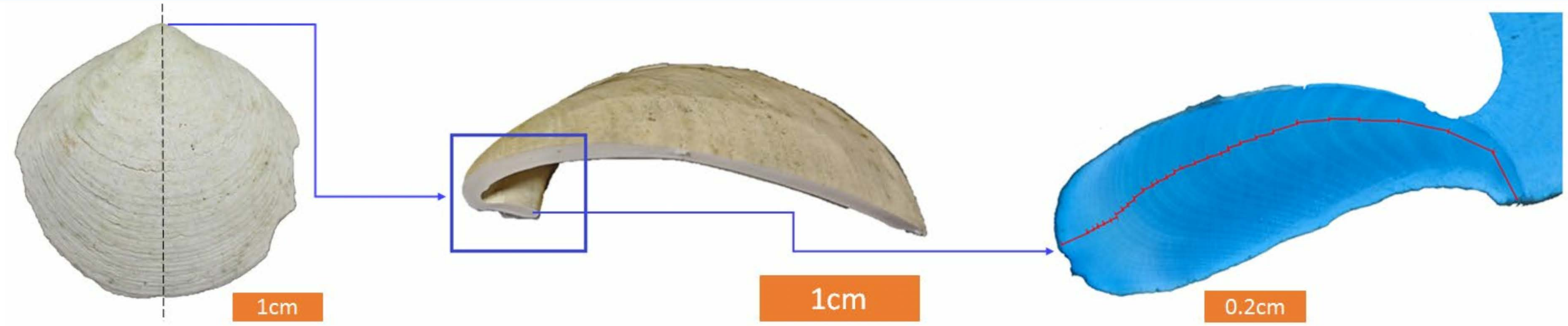

Figure 3. Pleistocene sample (RQ_1) from Register's Quarry, North Carolina, showing part of the process to prepare specimens for data collection. The whole shell specimen (far left) is measured for body size, coated in an epoxy and then cut along the line of maximum growth from dorsal to ventral. A thick section is made, and the hinge region is polished (middle). To increase contrast between growth increments, the polished section is stained using Mutvei's solution (far right).

5. What we found

- As we predicted, there were noticeable differences in the life histories of Pliocene and Pleistocene *G. americana* (Fig. 4)
- Compared to Pliocene *G. americana,* Pleistocene individuals tended to:
  1) be longer lived (Fig. 5),
  2) not attain as large of a size as evidenced by smaller L∞ values (Fig. 6)
  3) approach their asymptotic heights slower as evidenced by lower k values (Fig. 7)
- Our results support our hypothesis that individuals from cooler temperatures would tend to be longer-lived than those from warmer temperatures
- Long-life might be selected for through slower growth (lower VBG k values)

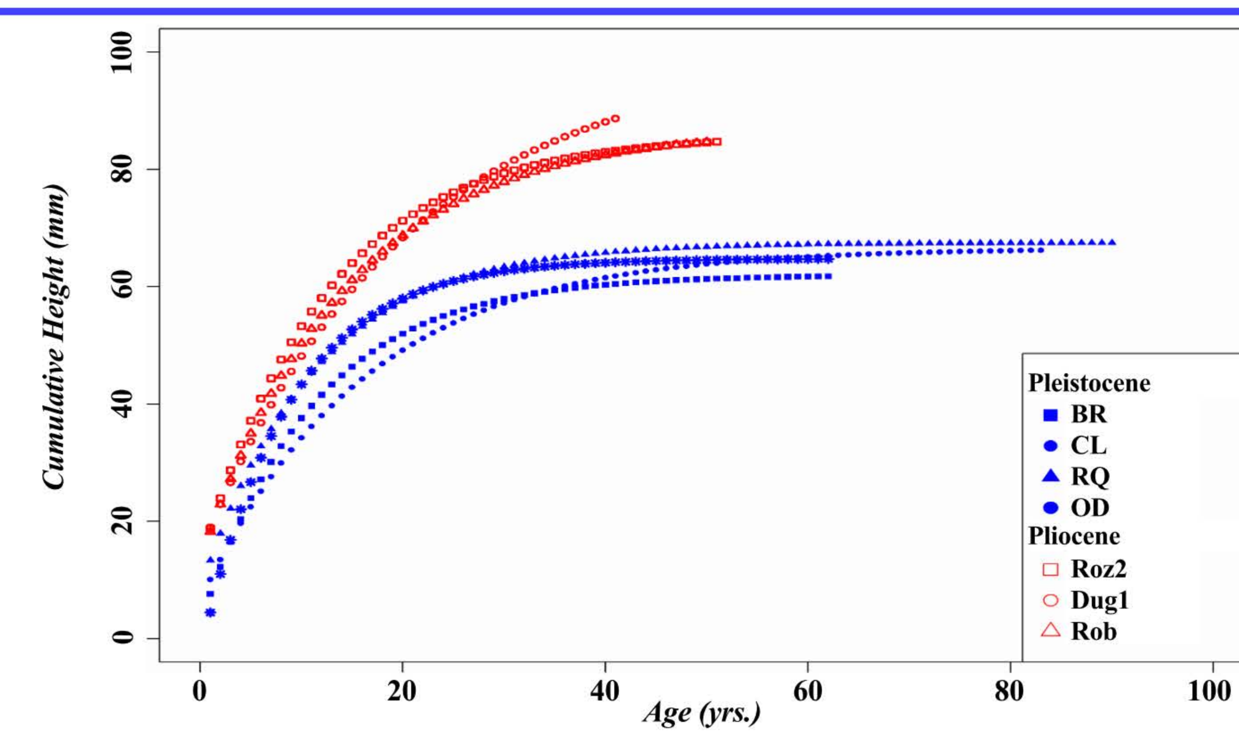

Figure 4. Best fit VBG curves for each of the five Pleistocene populations and three Pliocene populations.

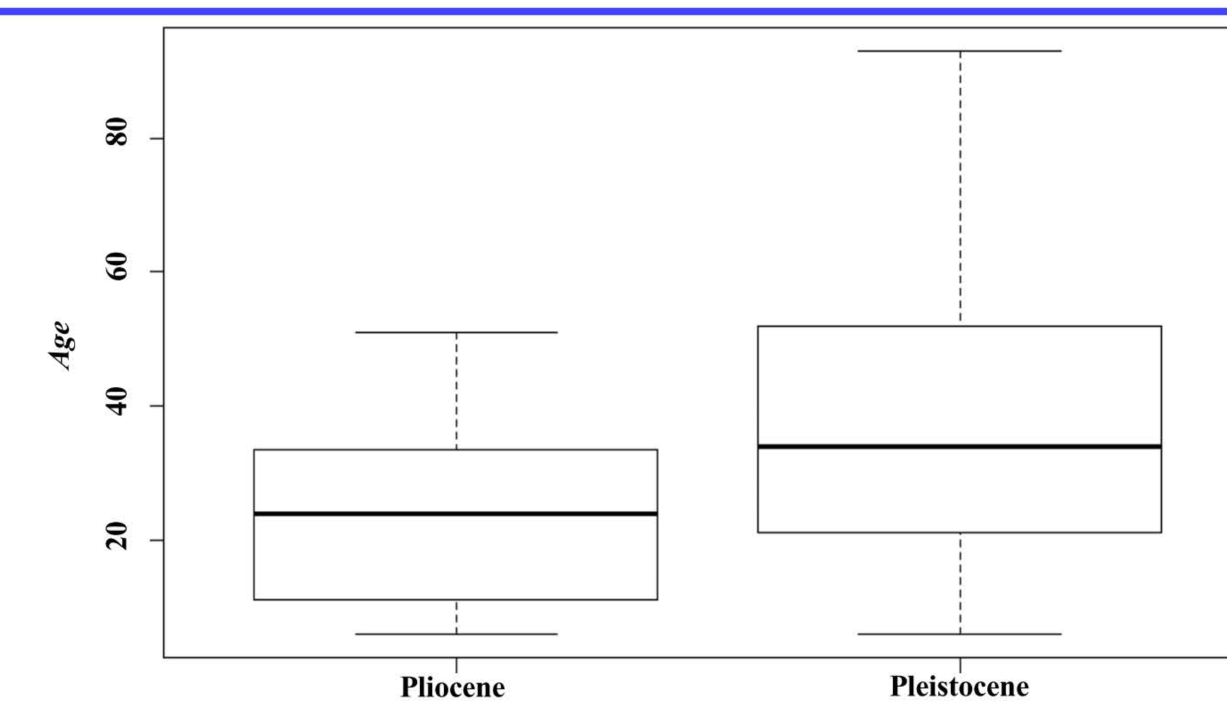

Figure 5. Box -plot showing the lifespans of all specimens for Pliocene and Pleistocene.

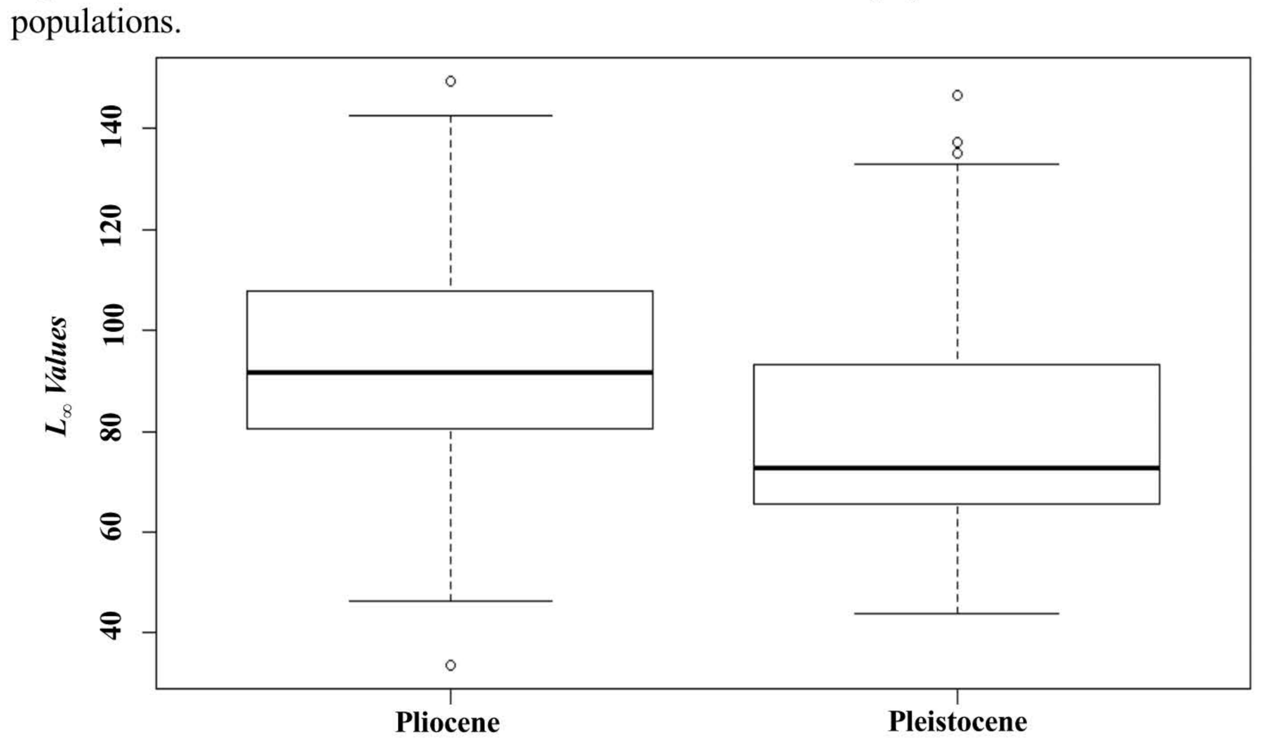

Figure 6. Box plot showing a comparison between Pliocene and Pleistocene L_∞ values.

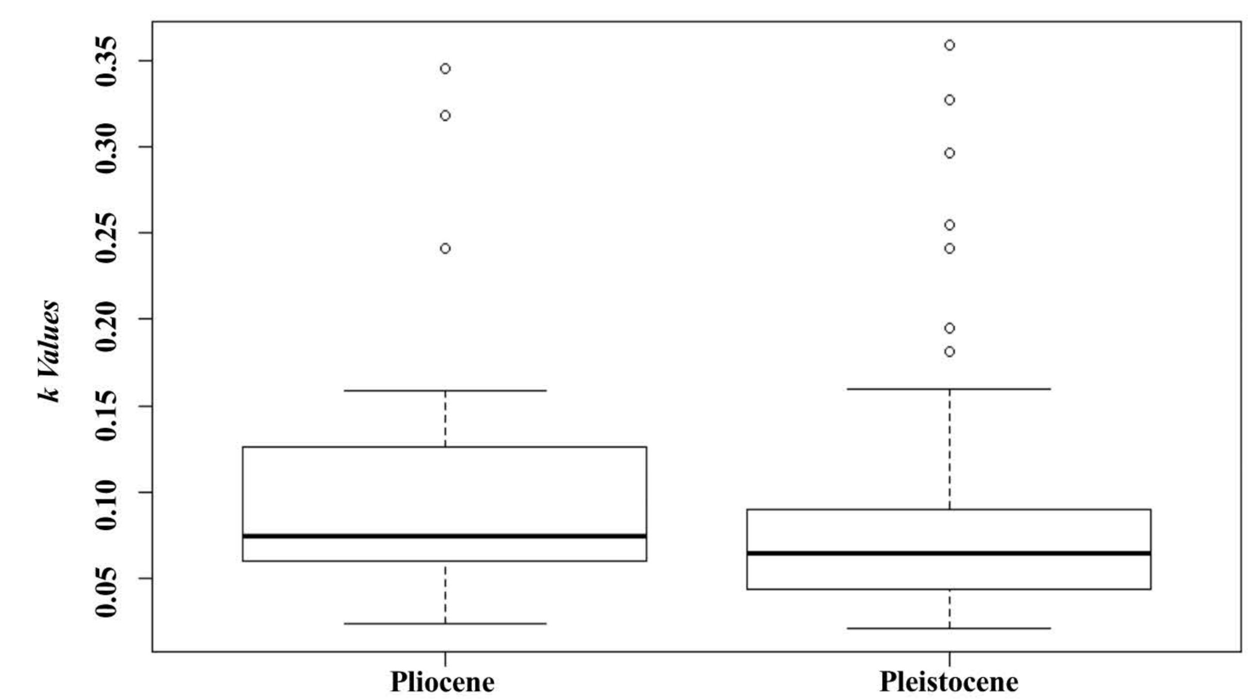

Figure 7. Box plot showing a comparison between Pliocene and Pleistocene k values.

6. Future directions

- *Do other bivalves show a similar trend in increasing lifespan across the Pliocene-Pleistocene boundary?* Deposits along the Atlantic Coastal Plain hold an abundance of species that could be used to further test our hypothesis that cooler temperatures promote longer lifespans in marine bivalves.
- *Does the trend of increasing lifespan and decreasing growth rate present in modern bivalves hold in the fossil record?* Preliminary data presented elsewhere[5] indicate mixed results for the Pliocene but that might be a side-effect of warmer global temperatures. We hope to use the data presented here to expand research into the latitudinal life history gradient of *Glycymeris* through time.

7. Acknowledgements

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8. References

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