SOUTHERN DELMARVA BARRIER ISLAND BEACHES: LINKING OFFSHORE AND ONSHORE UNITS USING RACEMIZATION GEOCHRONOLOGY TO INFER SEDIMENT SOURCES DURING SHORELINE MIGRATION

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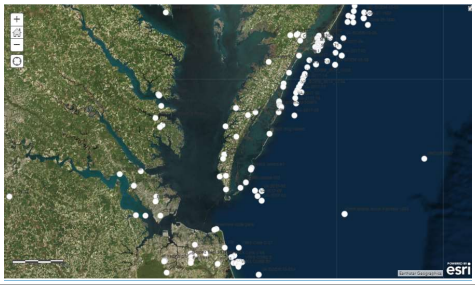
With **significant** input from Rob Thieler (USGS) and Linda York (Delaware and NPS)
And support from BOEM and USGS

THE ISLANDS: PARRAMORE, WRECK, AND SMITH & Kiptopeake Core (onshore)

Mid-Atlantic AAR collection sites with data

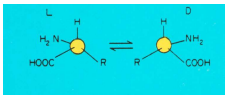


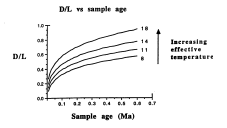
Example collection site: Wreck Island #1 MAY 2015

Age estimates: Amino acid racemization (AAR)

- Left-handed amino acids are common in most living proteins; fossilized amino acids are preserved in the hard skeletal remains of most organisms
- Racemization is the process by which left-handed forms convert to right handed forms – each form is the mirror image of the other
- Reaction can go both ways – left to right, right to left, so ratio of right to left grows from zero to 1.0
- Rate and limit of dating range affected by sample type and temperature
- What does AAR tell us? **Relative** and "semi-absolute" ages; **aminostratigraphy** and aminochronology

USEFUL SCREENING TOOL FOR 14C



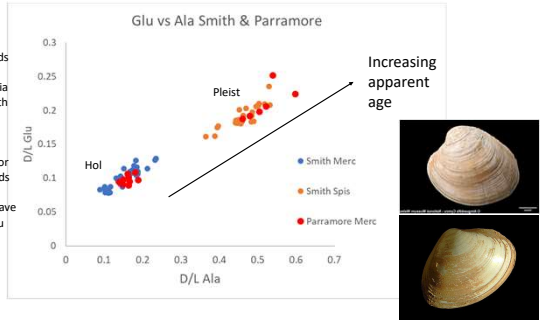


N = 47

Increasing D/L values = increasing apparent age

N = 84 shells for all 3 islands

Hol Mercenaria confirmed with 14C paired analysis;
No Holocene Spisula data for all three islands but offshore
6 ka Spisula have Ala = 0.21, Glu = 0.11



14C indicates that high D/L's not caused by heating

Different sources for Pleistocene and Holocene shells

Mercenaria Habitat

Found buried in muddy sediment on the lower shore and shallow sublittoral and in bays and estuaries. Prefers sandy environments to depths of 15 m.

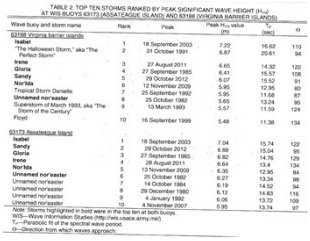
Spisula Habitat

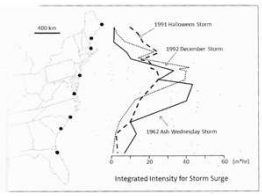
Adults tend to burrow in medium to coarse sand or gravel substrata but are also found in silty to fine sand. This species does not tend to burrow in mud. Found at depths ranging from 8 to 66 m.

WHERE WERE THE PLEISTOCENE SHELLS PRIOR TO TRANSPORT TO BEACH SITES? WERE THEY TRANSPORTED WHILE ARTICULATED?

January 1992 Atlantic City NJ
Articulated surf clams, storm deposit

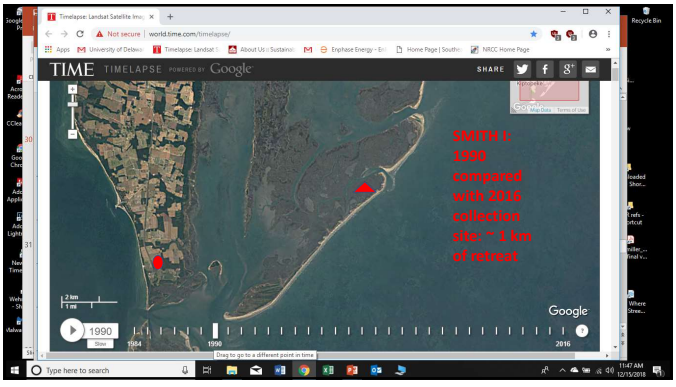
Storm history during the interval of sample collection: 1992-93, 2015 & 2016





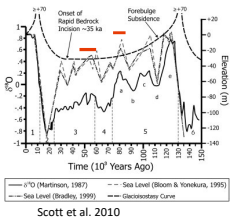
McBride et al. GSA Field Guide 2015 Annual Meeting

HOW FAST IS THIS PROCESS?: WRECK Island collection sites became emergent in 3 years prior to collection in May 2015



What is the true age of the Pleistocene DelMarVa beach shells? Problem statement or hypothesis: are MIS 3 units preserved at emergent or submerged sites in the mid-Atlantic?

- 30-40 ka: doubtful based on associated *Astarte* 14C data; 60 ka possible
- 75-80 ka: best estimate based on onshore data for both subsurface and emergent sites, and associated U-series data for onshore sites
- Implications of results from more southerly offshore Pleistocene units



Scott et al. 2010

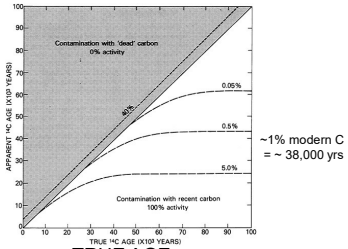
What is the true age of the DelMarVa Pleistocene beach shells?

- 14C potential contamination issues
- Could they be MIS 3 ~ 40-60 ka? "Best" offshore 14C control says >50 ka. AAR resolution of 60 and 80 ka is difficult.
- Inferred ages from offshore stratigraphic record of paleochannels
- Comparisons with onshore AAR results
- The proportional time approach – theoretical model for age estimation

EFFECT OF CONTAMINATION WITH OLD OR YOUNG CARBON

https://www.nap.edu/openbook/0309036380/xhtml/images/p2000a501g203001.jpg

APPARENT AGE



~1% modern C = ~ 38,000 yrs

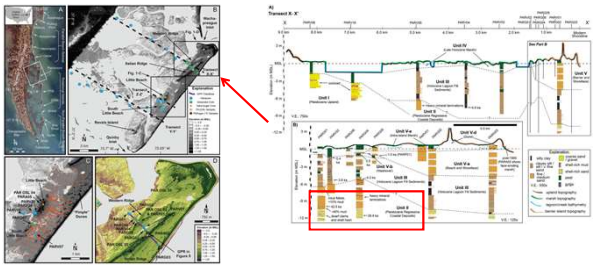
TRUE AGE

What is the true age of the DelMarVa Pleistocene beach shells: 14C results

Genus 14C (ka)	Parramore	Wreck	Smith
Spisula	>44.6	27.6 & 38.0	29.5, 29.6, 31.4, 35.0
Mercenaria	nd	nd	1.87, 4.40

All Spisula have virtually identical D/L values for multiple amino acids, hence no obvious relation between 14C and AAR D/L. Offshore (Maryland) samples with comparable D/L's are associated with >50 ka 14C results. Holocene Spisula are found offshore, calibrated with 14C, and have D/L values far below those seen in the Parramore, Wreck, and Smith Island Spisula samples.

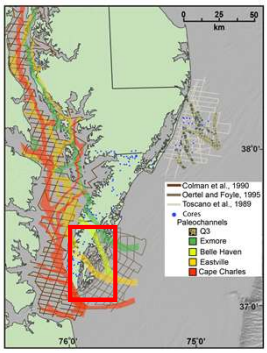
Raff et al. 2018 Marine Geology: Parramore Island sub-barrier unit with finite 14C ages on shell



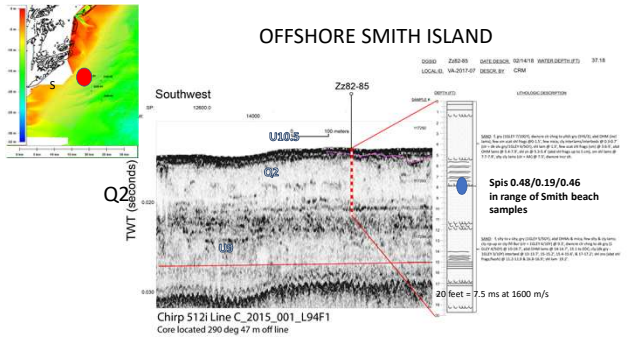
What is the true age of the DelMarVa Pleistocene beach shells?

- 14C issues – low level modern carbon contamination
- Could they be MIS 3 ~ 40-60 ka? "Best" offshore 14C control says >50 ka. AAR resolution of 60 and 80 ka is difficult.
- **Inferred ages from offshore stratigraphic record of paleochannels**
- **Comparisons with onshore AAR results**
- The proportional time approach – theoretical model for age estimation

THE REGIONAL STRATIGRAPHIC CONTEXT: Map shows seismic tracklines, published bore hole and vibracore locations, and interpreted paleochannels from previous studies



OFFSHORE SMITH ISLAND



Occurrence of Pleistocene shells – offshore and onshore:

Spisula **D/L values in beach samples are equal to those seen in samples onshore on the Peninsula, onshore VA Beach, and in several offshore cores**

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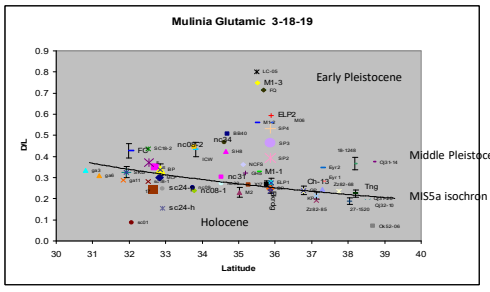
Regional isochron comparison: MIS5a and older aminozones



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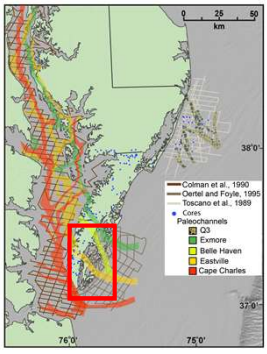
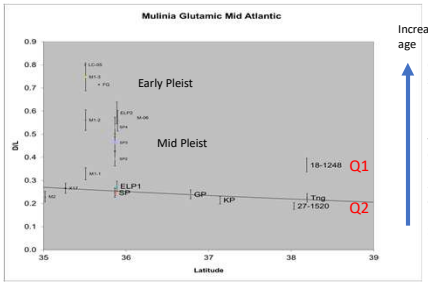


Regional isochron comparison: MIS5a and older aminozones compared with Q1 & Q2



MIS 5a

Increasing age

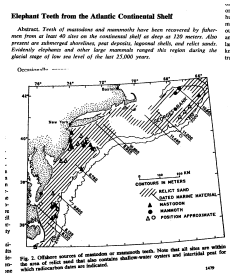
Q2 is inferred source for Delmarva Pleist beach shells and has MIS 5 D/L values.
Q1 (MIS 7?) is ~2-3x the age of Q2; all evidence indicates 14C should be >50ka.

Summary & Conclusions

- AAR results identify age mixing on the beaches of all three islands; preservation characteristics of shells are not diagnostic of age
- AAR is a simple economical tool for age mixing studies; numerous examples now exist at beach sites and in offshore cores from NJ to GA
- Different sources of Holocene and Pleistocene shells are sub-barrier or offshore within ~ 5km of island beaches and are being exhumed during coastal retreat; Oertel's (1989) "barrier platform"? **Shawler et al. this session**.
- 14C ages identify the "typical" issue of potential contamination with "young" carbon; true ages of the Pleistocene *Spisula* are ~60 ka (min) to ~130 ka (max); offshore stratigraphy is consistent with MIS 5 (MIS 5a?)
- Robust shells that are often "best" for geochemical analysis are more likely to survive age mixing in dynamic coastal environments – *biased record*
- A similar record of mixed ages of Mercenaria and Spisula is seen in a Pleistocene beach deposit in Virginia Beach, VA.
- **Questions answered: age and source**
- **Questions not answered: form and process during transport; GIA implications remain open**

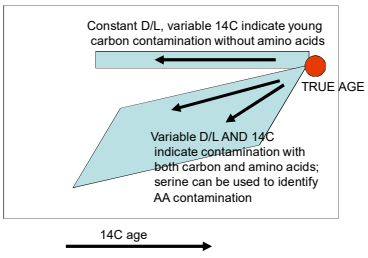
Pleistocene fossils in the mid-Atlantic nearshore

- Whitmore, June 1967 *Science*
- **Elephant teeth from the Atlantic shelf, INCLUDING back-barrier Parramore Island**



- **RADIOCARBON DATING OF LATE PLEISTOCENE MARINE SHELLS FROM THE SOUTHERN NORTH SEA**
- F S Busschers et al., Radiocarbon 2014
- This article presents a set of Late Pleistocene marine mollusk radiocarbon (AMS) age estimates of 30–50 14C kyr BP, whereas a MIS5 age (>75 ka) is indicated by quartz and feldspar OSL dating, biostratigraphy, U-Th dating, and age-depth relationships with sea level. **These results indicate that the 14C dates represent minimum ages. The age discrepancy suggests that the shells are contaminated by younger carbon following shell death.** The enigmatic 14C dates cannot be "solved" by removing part of the shell by stepwise dissolution. SEM analysis of the Late Pleistocene shells within a context of geologically younger (recent/modern, Holocene) and older (Pliocene) shells **shows the presence of considerable amounts of an intracrystalline secondary carbonate precipitate.** The presence of this precipitate is not visible using XRD since it is of the same (aragonitic) polymorph as the original shell carbonate. The combination of nanospheruilitic-shaped carbonate crystals, typical cavities, and the presence of **fatty acids** leads to the conclusion that the secondary carbonate, and hence the addition of younger carbon, **has a bacterial origin**. As shell material was studied, this study recommends an assessment of possible bacterial imprints in other materials like bone collagen as well.

Hypothesis: D/L trends vs 14C for "near infinite" ages



Contaminant 14C in "old" samples is the **only** 14C, hence it dominates the apparent age.

Contaminant AA are diluted in the pool of indigenous AA, hence less significant

Wreck Island 1, 2, and 3