Essay

Integrating Paleobiology, Archeology, and History to Inform Biological Conservation

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Abstract: *The search for novel approaches to establishing ecological baselines (reference conditions) is constrained by the fact that most ecological studies span the past few decades, at most, and investigate ecosystems that have been substantially altered by human activities for decades, centuries, or more. Paleobiology, archeology, and history provide historical ecological context for biological conservation, remediation, and restoration. We argue that linking historical ecology explicitly with conservation can help unify related disciplines of conservation paleobiology, conservation archeobiology, and environmental history. Differences in the spatial and temporal resolution and extent (scale) of prehistoric, historic, and modern ecological data remain obstacles to integrating historical ecology and conservation biology, but the prolonged temporal extents of historical ecological data can help establish more complete baselines for restoration, document a historical range of ecological variability, and assist in determining desired future conditions. We used the eastern oyster (*Crassostrea virginica*) fishery of the Chesapeake Bay (U.S.A.) to demonstrate the utility of historical ecological data for elucidating oyster conservation and the need for an approach to conservation that transcends disciplinary boundaries. Historical ecological studies from the Chesapeake have documented dramatic declines (as much as 99%) in oyster abundance since the early to mid-1800s, changes in oyster size in response to different nutrient levels from the sixteenth to nineteenth centuries, and substantial reductions in oyster accretion rates (from 10 mm/year to effectively 0 mm/year) from the Late Holocene to modern times. Better integration of different historical ecological data sets and increased collaboration between paleobiologists, geologists, archeologists, environmental historians, and ecologists to create standardized research designs and methodologies will help unify prehistoric, historic, and modern time perspectives on biological conservation.*

Keywords: applied paleozoology, Chesapeake Bay, conservation paleobiology, environmental history, historical ecology, restoration, shifting baselines

Integración de Paleobiología, Arqueología e Historia para Informar a la Biología de la Conservación

Resumen: *La búsqueda de métodos nuevos para establecer líneas de base ecológicas (condiciones de referencia) está limitada por el hecho de que la mayoría de los estudios ecológicos abarcan las últimas décadas, cuando mucho, e investigan ecosistemas que han sido alterados sustancialmente por actividades humanas, por décadas, siglos o, posiblemente, más. La paleobiología, arqueología e historia proporcionan contexto ecológico hist*

*a la determinación de condiciones futuras deseadas. Utilizamos la pesquería del ostión oriental (*Crassostrea virginica*) de la Bah´*

use of historic and prehistoric data (e.g., paleobiological, archeological, historical) to understand ancient and modern ecosystems, often with the goal of providing con-

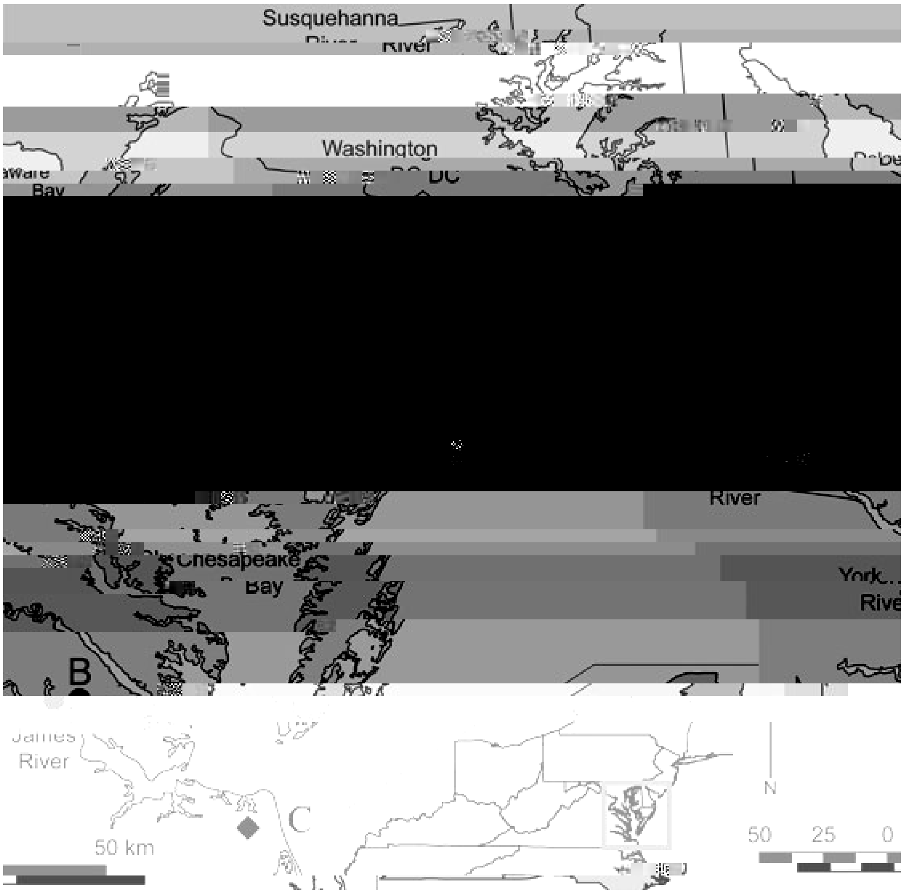
Susquehanna River
Washington DC
River
Chesapeake Bay
York River
B
James River
C
50 km
N
50
25
0

Figure 2. Ancient and modern assemblages used in studies of the historical ecology of the Chesapeake Bay (U.S.A.) oyster fishery: (a) Pleistocene oyster reef deposit along the Piankatank River near Dutton, Virginia, and close-up of the deposit, (b) Late Holocene prehistoric archeological deposit of oysters collected by Native Americans on the eastern shore of Maryland and close-up of the deposit, (c) living oyster reefs exposed at low tide on the eastern shore of Virginia and close-up of reef.

of covariates such as location, salinity, nutrients, and harvesting. Even though these growth rate data are useful, they are for a relatively short period of the bay's history (<1000 years) and from a fairly limited geographical extent that includes only portions of the James, Patuxent, and Potomac Rivers. These data leave unanswered questions that are important for understanding the resilience and historical range of variability of Chesapeake oysters over centuries and millennia. What were the average growth and accretion rates of Chesapeake oysters before the widespread establishment of major oyster diseases in 1949, before widespread dredging started in 1870, before massive clearance of native vegetation for agriculture by European settlers in the late 1800s, and before the several millennia of Native American harvest?

Researchers have provided the answers to some of these questions, at least for portions of the bay and particular time intervals. For example, Kirby and Miller (2005) sampled sixteenth century to modern oyster specimens preserved in archeological sites along the St. Mary's and Patuxent Rivers in Maryland. They divided specimens into 4 time intervals (<AD 1760, 1760–1860, 1861–1920, >1920) to measure the effect of anthropogenic eutrophication on growth rates. They found that oyster growth increased during the early stages of eutrophication in the 1700s to early 1800s before decreasing precipitously after 1860 (Fig. 3). Precolonial (before AD 1600s) growth rates (and by extension mean body sizes) were also somewhat higher than colonial growth rates (Mann et al. 2009*b*; Harding et al. 2010), and Pleistocene (400,000–250,000 years ago) rates may have been similar (Kirby et al. 1998). However, these data come from different geographic locations with different paleoclimates and were analyzed with different techniques, and evidence for the Pleistocene rates consists of just 2 specimens. Reef accretion also declined at estimated rates of 10 mm/year in the late

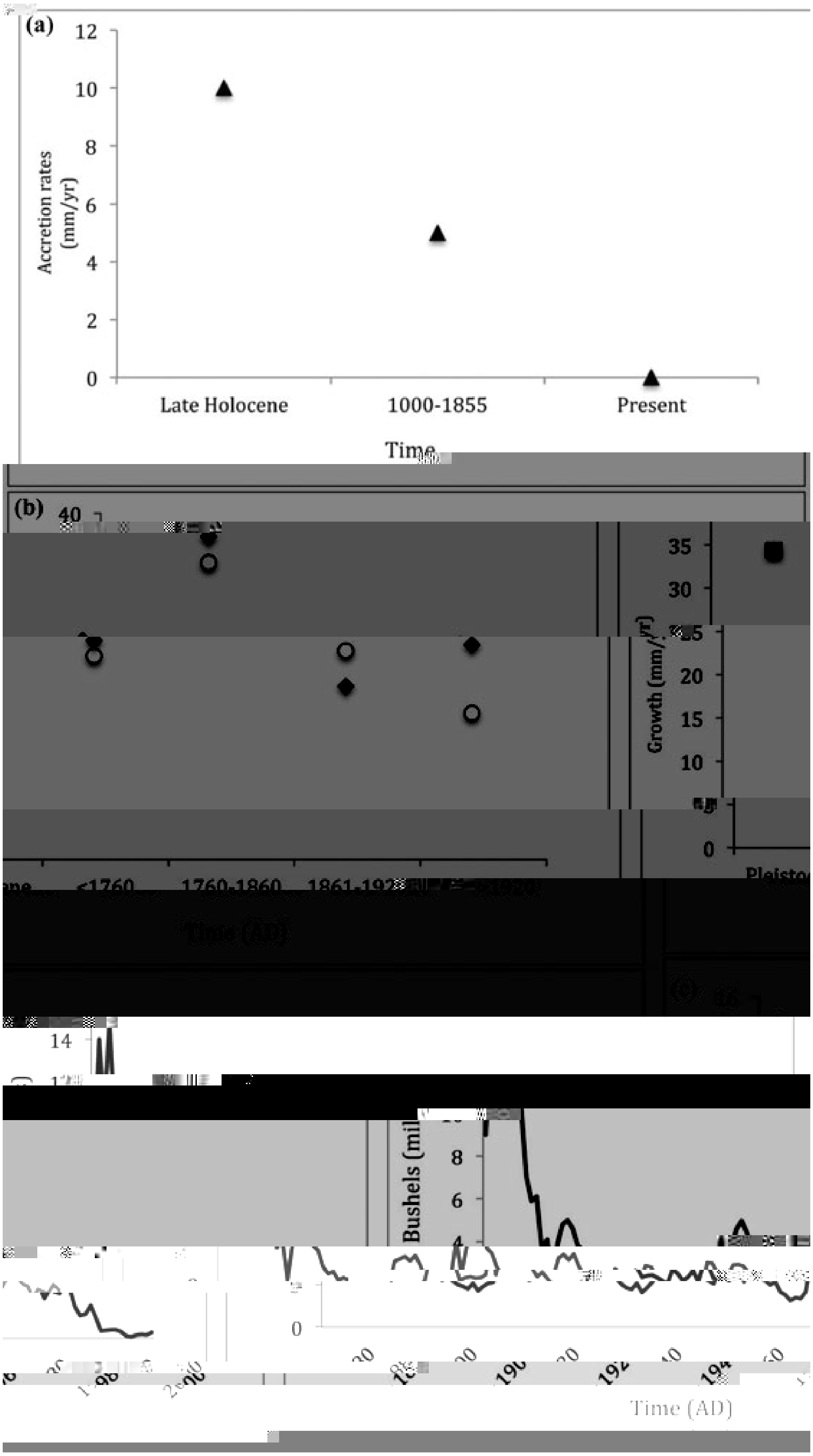

Figure 3. Oyster (a) reef accretion rates (Mann et al. 2009*b*), (b) shell growth-rate estimates (circles, Patuxent River; diamonds, St. Mary's River [Kirby & Miller 2005]; square, Gomez Pit, Virginia [Kirby 2001]), and (c) harvest levels (1 bushel is approximately 23 kg) over the last 2 centuries of catch records from commercial fisheries (Maryland Department of Natural Resources [Rothschild et al. 1994]).

Holocene (on the basis of extrapolation from estimates of sea level rise) (Mann et al. 2009*b*) and 5 mm/year from AD 1000 through 1855 (on the basis of sub-bottom profiling of the James River) (DeAlteris 1988), and effectively there is no growth in the same location today (Fig. 3) (Mann et al. 2009*b*). Five millimeters per year is approximately the equivalent of adding 975 bushels (approximately 22,400 kg) of oysters per hectare (390 bushels [approximately 9000 kg] of shell per acre) of river bottom per year as a repletion action—which current oyster restoration efforts do not come close to achieving (Mann et al. 2009*b*). These results highlight the potential utility