Supporting Information Appendix

Millennial Scale Sustainability of the Chesapeake Bay Native American Oyster Fishery
TC Rick et al.

SI Text
Figure S1
Tables S1-S19

SI Text: Oyster Samples and Statistical Analysis

Our research was designed to minimize the potential biases from sampling across the different datasets and time periods. The paleontological, archaeological, and modern samples are described in detail below. For the archaeological and paleontological samples, we were particularly cognizant of how the samples were collected and any potential effects from post-depositional processes (trampling, plowing, burrowing animals, etc.). As noted below, similar excavation procedures and bulk sampling were followed for these assemblages. Although there are broken shells in the archaeological samples, there are numerous small and large shells showing the full size spectrum is represented. The archaeological samples differ from the Pleistocene and modern samples in that they are all human-selected rather than natural accumulations.

Archaeological Samples. We excavated oysters from archaeological shell middens on the Rhode River and Fishing Bay, Maryland. To complement these data we reviewed published and unpublished accounts of oyster measurements reported by archaeologists and other researchers. We conducted a literature search for oyster measurements and also searched databases of unpublished reports at the Maryland Historical Trust, Crownsville, Maryland and the Department of Historic Resources, Virginia. We focused on Native American sites, but also include relevant contact period and historical sites that are from

Euro-American occupations. Only sites with large samples of measured oysters and clearly reported methods and size estimates were included in our study (Table S1-S2). Even if an average height was provided, data were excluded from our analysis if we could not discern the sample size, whether or not the sample was random, or the archaeological age of the sample. Many researchers reported height/length ratios, but did not present primary data on height or sample size and these were not included in our study. In virtually all cases, the only data provided were mean values and consequently those are entered as single data points on the Fig. 1 scatter plot and are described in Table S2.

We attempted to create a regression formula to estimate size from broken shells, but analysis of over 250 modern shells did not produce statistically reliable results. Potter (1) analyzed whole and fragmentary left valves from two sites on the Potomac River and in both cases fragmentary valves were less than 10% of the assemblage. Since our results provide a wide range of archaeological shell sizes from 10 to 189 mm, we are confident that the use of whole shell measurements provides a representative sample of oyster height. Tables S1-S2 provide the mean, sample size, and standard deviation for each site used in our study.

To build on this bay-wide synthesis, we conducted detailed diachronic analysis of oyster size in two watersheds, Fishing Bay and Rhode River. These are high resolution archaeological data representing between 3200 and 1500 years of human harvest of oysters. All measured oysters are whole left valves obtained from excavated contexts. No oysters from the surface of sites or outside of the units were measured or included in our analysis.

Fishing Bay is a small sub-estuary of the Transquaking River on the eastern shore of Maryland located in the mesohaline zone of Chesapeake Bay. About a dozen shell middens have been recorded in the Fishing Bay/Transquaking region dating between the Middle and Late Woodland from approximately 1500 to 400 cal BP (2-4). We excavated six of these shell middens, including excavation of 1 x 2 and 1 x 1 m units and smaller 25 x 25 cm column samples using a combination of 1/4-inch and 1/8-inch mesh screen. Radiocarbon dates for each of these sites are available in Table S18 and in Rick et al. (3).

The Rhode River estuary is located on the western shore of Chesapeake Bay south of Annapolis, Maryland and contains a number of smaller tributary creeks and streams. Some 50 shell middens have been documented in the Rhode and adjacent West Rivers and these sites date from the Early Woodland through the historic period (5). We focused our excavations at six sites following the same general procedures as the work at Fishing Bay. These sites date from ~3200 to 200 cal BP. All of the sites were deposited by Native Americans, except 18AN1323, which dates to the 19th century, has historical artifacts, and was deposited by EuroAmericans. Radiocarbon dates from Rhode River sites are available in Table S19 and in Rick et al. (5).

Because oyster size is just one measure of human predation effects, we also calculated an abundance index (6), which compares oysters to all other shellfish taxa by weight (grams). In the oyster index, values approaching 1 indicate a near exclusion of all other species. These data show that regardless of time period oysters provide over 90% of all shellfish and never decline in relative abundance (Figure S1). This is a common pattern in the Chesapeake Bay where, after about 2000 years ago, oysters dominate nearly all shellfish assemblages, with slightly greater taxonomic richness at some earlier sites (including *Tagelus plebius*, *Mercenaria mercenaria*, *Mya arenaria*; 7).

We cannot rule out that archaeological oysters were transported from other watersheds by Native Americans, and particularly Colonial and historic inhabitants; however, a study of the potential for human transport of archaeological freshwater mussel shell from the southeastern USA demonstrated that long-distance prehistoric shell transport was not significant (8).

Pleistocene Samples. We compiled data from three Pleistocene localities in Maryland (Wailes Bluff) and Virginia (Holland Point, Cherry Point). Oyster length was measured from museum collections (Virginia Museum of Natural History, Martinsville, Virginia) for Wailes Bluff and Cherry Point, and field collections for Holland Point. The Pleistocene samples were from natural reefs and all sites were sampled using a bulk sampling strategy and sieved using a 4 mm mesh size, in which all material (regardless of size and condition) is retained for analysis. Compaction was limited and 95% of the assemblage had oysters of all sizes still preserved intact and in life position. Paleotemperature estimates vary from a few degrees colder for Holland Point to a few degrees warmer for Wailes Bluff and Cherry Point than today. These data suggest that temperature was not likely a driving factor in larger Pleistocene oyster size in our sample.

The middle Pleistocene (0.781 – 0.126Ma) site is located at Cherry Point, Virginia, close to the mouth of the Rappahannock River (37°30’N, 76°24’W). This site exposes the Shirley Formation, which is a silty fine-grained sand and sandy silt containing *C. virginica, Mulinia, Noetia, Mercenaria*, and other mollusks (9).

Wailes Bluff in Maryland and Holland Point in Virginia are both late Pleistocene (0.126Ma – 13,000 years ago) sites. Wailes Bluff is located in St. Mary's County, Maryland, at the mouth of the Potomac River (38°04' N, 76°22' W) and oysters are exposed from the Lynnhaven Member of the Tabb Formation, which is composed of clayey and silty fine sand and sandy silt (9). Holland Point occurs on the south bank of the Piankatank River, near Dutton, Virginia (37°30'N and 76°26'W). Amino acid racemization of *Mercenaria* shells places it within the Tabb Formation (10), which is composed locally of clayey and sandy silt.

Modern Samples. The modern oyster size data for this study came from three general areas that vary in salinity, harvest level, disease, and management activities: upper and lower Chesapeake Bay, and the Virginia coastal bays. All of these measurements represent live oysters collected from extant reefs during biological surveys. Some of these samples exclude juvenile oysters/spat <35 mm.

Size distributions of oysters in the upper Chesapeake Bay sample (Maryland waters of the Chesapeake Bay and its subestuaries) were calculated from samples collected from 43 oyster bars sampled with oyster dredges as part of the Maryland Department of Natural Resources (MD-DNR) annual fall surveys (11; data provided by M. Tarnowski, MD-DNR). These low to moderate salinity sites were sampled during 2010 through 2014 throughout Maryland waters. At each bar, two 0.5-bushel subsamples were collected from replicate dredge tows, and for the purpose of the analysis presented here, can be considered to be random samples of oysters from each bar. All live oysters that were not young of year based on morphology were included in the MD-DNR sampling, and oyster height was measured to the nearest mm.

The lower Chesapeake Bay samples are from the James, Piankatank, and Wicomico Rivers in Virginia with salinity ranging from 5 to 20 ppt collected during Fall (2010-2014) stock assessments in stratified random samples (see 12-15 for data and additional discussion of survey methods and results). Finally, the Virginia coastal bay samples are from four sites with patches that were randomly selected (R1-9, R2-4, R4-2 and R5-1 as described in 16) in the Virginia coastal bays with salinity of 29 ± 4 SD (17).

Statistical Analysis. Statistical analyses were performed in R v3.2.3. The Shapiro-Wilk normality test (p-value cutoff of 0.05) and quantile-quantile plots for each time period showed that shell height measurements were non-normally distributed. To explore the effects of different sample sizes on our results, median oyster height was bootstrapped using the R library *boot* with 195 measurements and 1000 replicates. Resulting biases in median oyster height were less than ~0.2 mm except the Virginia coastal bays (-0.6 mm) and upper bay (0.4 mm) (Table S17), indicating that variability in sample sizes are not likely impacting analyses. To test whether samples from different time periods across the bay and within sub-estuaries (Fishing Bay and Rhode River) are derived from different populations, Kruskal-Wallis X^2 tests were performed in R followed by pairwise post hoc Mann-Whitney tests (Tables S3-S14). We also conducted pairwise Kolmogorov-Smirnov tests as implemented in R to compare the distributions of oyster size among modern, historic, prehistoric, and Pleistocene deposits and between modern upper Bay and Virginia coastal bays. We adjusted *p*-values for multiple comparisons using a Bonferroni correction, when necessary.

We tested for the magnitude and statistical significance of Pearson's correlation coefficient to compare oyster height with salinity and distance-to-mouth (Table S16). For the Pearson's r statistic, values approaching 1 show a strong positive correlation, values approaching 0 show no correlation, and -1 show a strong negative correlation. The r^2 statistic is only meaningful for samples with a statistically significant correlation. Values approaching 1 suggest that much of the variation in the y variable (oyster height) can be explained by the x variable (MAS or Distance).

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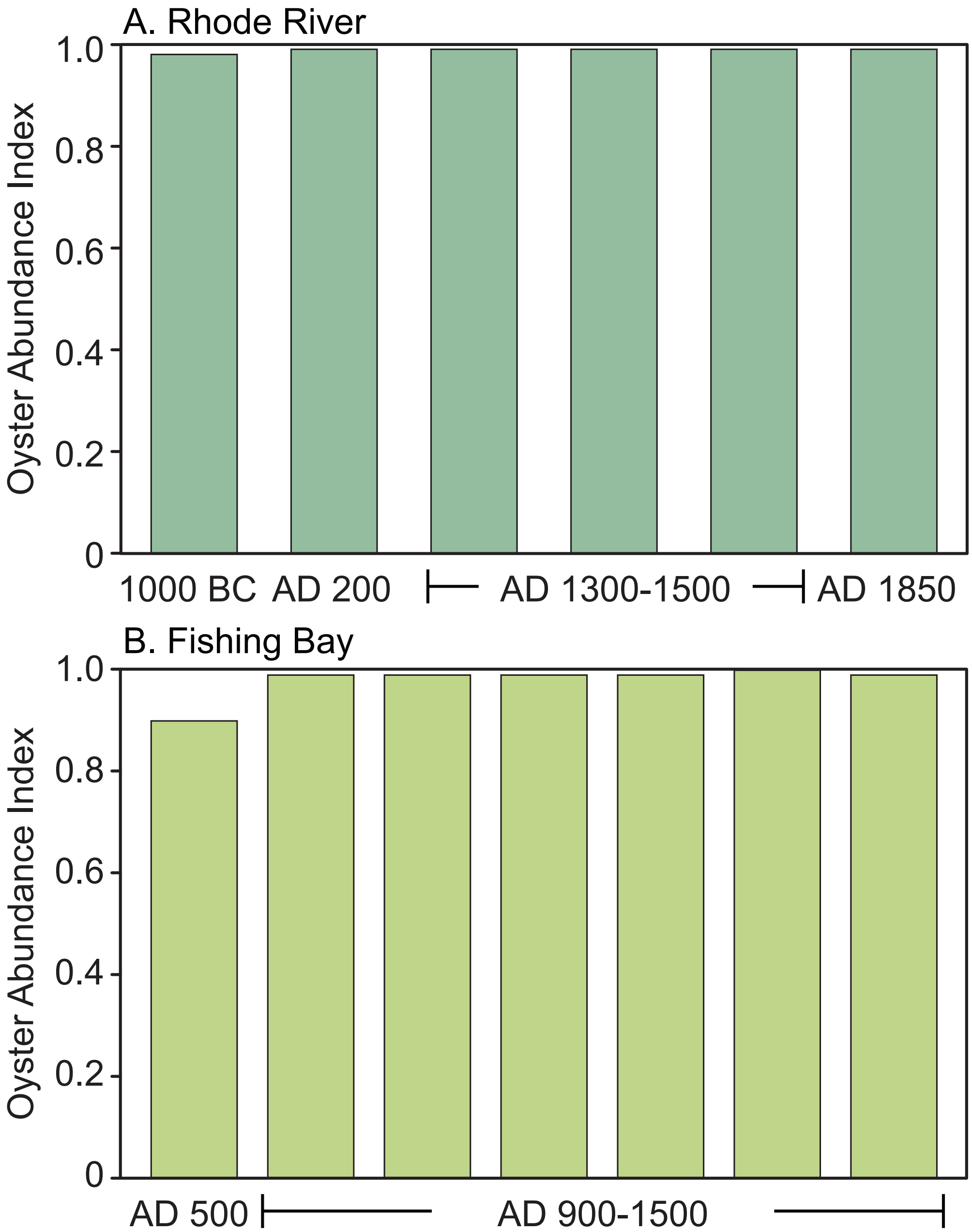

Fig. S1. Abundance index for oysters compared to all other shellfish in archaeological shell middens through time (measured by weight). A. Rhode River Sites in Figure 3 and B. Fishing Bay sites in Figure 3. Values approaching 1 indicate that oysters are present to the near exclusion of all other species. All site values are above 0.9 (90-99 percent) of the assemblage. These data demonstrate that oysters are the most abundant species to near exclusion at all sites regardless of time period and that there is no decline in oyster abundance at these middens through time. At the Fishing Bay site with 0.9 abundance, the next greatest taxon is *Tagelus plebius* (stout tagelus)

Table S1. Summary of oyster measurements for each site.[1]

	Sample Size	Mean (mm)	Maximum (mm)	Standard Dev. (mm)
Pleistocene	**621**	**87**	**259**	**38.7**
Middle Pleistocene	**36**	**92**	**138**	**28.0**
Cherry Point	36	92	138	28.0
Late Pleistocene	**585**	**86**	**259**	**39.3**
Holland Point	549	85	259	39.6
Wailes Bluff	36	100	197	31.5
Prehistoric	**6648**	**72**	**189**	**20.1**
Early Woodland	**469**	**61**	**112**	**14.8**
18AN308 (1090-850 BC)	469	61	112	14.8
Middle Woodland	**571**	**70**	**189**	**19.9**
18AN285 (AD 550-680)	390	63	189	15.9
18DO130MW (AD 340-990)	181	83	153	21.1
Late Woodland	**5608**	**74**	**176**	**20.2**
Fishing Bay	**2438**	**84**	**176**	**22.0**
18DO127 (AD 860-1320)	952	84	176	24.3
18DO130LW (AD 1050-1270)	117	81	138	21.1
18DO35 (AD 1010-1490)	307	79	137	17.5
18DO429 (AD 830-1160)	418	79	137	20.5
18DO436 (AD 900-1170)	81	77	116	20.7
18DO439 (AD 890-1130)	563	90	158	19.7
Rhode River	**3170**	**66**	**146**	**14.7**
18AN226 (AD 1300-1480)	180	56	112	14.9
18AN285 (AD 1430-1590)	750	66	115	14.3
18AN286 (AD 1340-1520)	1357	64	139	14.6
18AN287 (AD 1290-1510)	883	71	146	13.7
Historic	**198**	**81**	**156**	**20.1**
18AN1323 (AD 1770-modern)	198	81	156	20.1
Modern[2]	**23221**	**72**	**157**	**19.7**
Upper Bay (MD DNR Sites)	21486	73	157	19.3
VA Coastal Bays (VIMS Seaside Sites)	1735	55	130	15.3

[1] The minimum value for all oysters was set to 35 mm. Although this resulted in slightly larger average sizes (~1 mm or less), it had no effect on our interpretations and this made our data comparable across all datasets.

[2] As noted in the text, the modern Lower Chesapeake data were from size bins or groupings (e.g., 1-2 mm, 3-4, mm) rather than individual size classes. Consequently, these data were not incorporated into our detailed statistical analyses.

Table S2. List of additional archaeological components that are included in Fig. 1.

Site	Component/Age	Average Height (mm)	Sample Size	Reference
44WM119	Late Archaic	57	110	18
44WM119	Early Woodland	59	901	18
44WM119	Middle Woodland	58	394	18
44WM119	Late Woodland	58	2300	18
44WM119	Protohistoric/Early historic	59	528	18
44NB147	Protohistoric/Early historic	57	1151	18
18CV362	AD 1300-1635	76	85	19
18CV362	AD 1720-1750 (Feature 16)	99	96	19
44SK20	Middle Woodland (B2-B3)	71	208	20
44WM304	165 BC - AD 215	68	9956	21
44PM13	Middle Woodland	91	358	22
44YO2	Middle Woodland/Late Woodland I/Late Woodland II	61/67/55	1152	23

Table S3. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing time periods.

Kruskal-Wallis chi-squared = 1613.7, df = 4, p-value < 2.2e-16

Time Period	Pleistocene	Prehistoric	Historic	Modern Upper Bay
Prehistoric	1.14E-10			
Historic	1.00	1.20E-09		
Modern Upper Bay	5.46E-09	3.90E-08	2.35E-06	
Modern VA Coastal Bays	9.15E-75	4.61E-258	4.07E-58	< 4.61E-258

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S4. Effect size calculations from pairwise Mann-Whitney U comparing time periods.

	Effect Size			
Time Period	Pleistocene	Prehistoric	Historic	Modern Upper Bay
Prehistoric	0.58			
Historic	0.49	0.63		
Modern Upper Bay	0.43	0.52	0.61	
Modern VA Coastal Bays	0.25	0.23	0.85	0.78

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S5. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing time periods.

Kruskal-Wallis chi-squared = 1795.2, df = 7, p-value < 2.2e-16

Time Period	**Middle Pleistocene**	**Late Pleistocene**	**Early Woodland**	**Middle Woodland**	**Late Woodland**	**Historic**	**Modern Upper Bay**
Late Pleistocene	1.00						
Early Woodland	6.76E-09	1.61E-19					
Middle Woodland	1.31E-05	2.15E-07	3.80E-10				
Late Woodland	2.09E-04	1.48E-05	3.53E-38	3.19E-05			
Historic	0.058	1.00	1.07E-29	6.67E-12	5.26E-07		
Modern Upper Bay	1.85E-04	3.33E-06	3.42E-41	2.62E-06	1.00	6.57E-06	
Modern VA Coastal Bays	1.04E-11	1.66E-67	4.94E-19	8.89E-62	5.16E-275	1.14E-57	< 4.61E-258

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S6. Effect size calculations from pairwise Mann-Whitney U comparing time periods.

Effect Size

Time Period	**Middle Pleistocene**	**Late Pleistocene**	**Early Woodland**	**Middle Woodland**	**Late Woodland**	**Historic**	**Modern Upper Bay**
Late Pleistocene	0.43						
Early Woodland	0.18	0.33					
Middle Woodland	0.75	0.60	0.38				
Late Woodland	0.28	0.56	0.32	0.56			
Historic	0.34	0.50	0.22	0.67	0.62		
Modern Upper Bay	0.72	0.56	0.32	0.43	0.49	0.61	
Modern VA Coastal Bays	0.85	0.74	0.64	0.73	0.78	0.85	0.78

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S7. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing Rhode River sites.

Kruskal-Wallis chi-squared = 390.25, df = 6, p-value < 2.2e-16

Rhode River Sites	**18AN1323**	**18AN226**	**18AN285LW**	**18AN285MW**	**18AN286**	**18AN287**
18AN226	3.42E-29					
18AN285LW	1.32E-21	3.03E-17				
18AN285MW	8.74E-26	9.35E-08	1.75E-03			
18AN286	3.05E-30	4.10E-12	7.11E-04	1.00		
18AN287	1.13E-12	3.54E-31	2.55E-08	1.04E-17	7.35E-28	
18AN308	8.05E-30	2.19E-04	8.20E-09	0.82	3.92E-03	3.49E

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S8. Effect size calculations from pairwise Mann-Whitney U comparing Rhode River sites.

	Effect Size					
Rhode River Sites	**18AN1323**	**18AN226**	**18AN285LW**	**18AN285MW**	**18AN286**	**18AN287**
18AN226	0.84					
18AN285LW	0.73	0.29				
18AN285MW	0.77	0.35	0.57			
18AN286	0.76	0.33	0.55	0.48		
18AN287	0.67	0.22	0.41	0.34	0.36	
18AN308	0.78	0.39	0.61	0.54	0.56	0.69

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S9. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing Fishing Bay sites.

	Kruskal-Wallis chi-squared = 102.12, df = 6, p-value < 2.2E-16					
Fishing Bay Sites	**18DO35**	**18DO127**	**18DO130LW**	**18DO130MW**	**18DO429**	**18DO436**
18DO127	1.00					
18DO130LW	1.00	1.00				
18DO130MW	1.00	1.00	1.00			
18DO429	1.00	0.02	1.00	0.19		
18DO436	1.00	1.00	1.00	1.00	1.00	
18DO439	1.78E-13	2.75E-09	2.67E-04	9.44E-04	4.10E-18	2.37E-05

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S10. Effect size calculations from pairwise Mann-Whitney U comparing Fishing Bay sites.

	Effect Size					
Fishing Bay Sites	**18DO-35**	**18DO127**	**18DO130LW**	**18DO130MW**	**18DO429**	**18DO436**
18DO127	0.53					
18DO130LW	0.55	0.49				
18DO130MW	0.52	0.52	0.47			
18DO429	0.53	0.56	0.54	0.57		
18DO436	0.51	0.56	0.53	0.57	0.50	
18DO439	0.34	0.40	0.37	0.40	0.33	0.33

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S11. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing levels in 18AN285.

	Kruskal-Wallis chi-squared = 41.176, df = 6, p-value = 2.67E-07					
18AN285	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
Level 2	1.00					
Level 3	1.00	1.00				
Level 4	0.50	1.00	0.21			
Level 5	1.00	1.00	1.00	1.11E-03		
Level 6	1.00	0.90	0.38	1.89E-08	0.57	
Level 7	1.00	1.00	1.00	1.01E-03	1.00	1.00

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S12. Effect size calculations from pairwise Mann-Whitney U comparing levels in 18AN285.

	Effect Size					
18AN285	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
Level 2	0.43					
Level 3	0.42	0.52				
Level 4	0.35	0.43	0.41			
Level 5	0.45	0.53	0.52	0.60		
Level 6	0.49	0.58	0.57	0.66	0.55	
Level 7	0.51	0.59	0.58	0.66	0.56	0.51

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S13. Results of Kruskal-Wallis test and pairwise Mann-Whitney U comparing levels in 18AN1323.

	Kruskal-Wallis chi-squared = 11.79, df = 5, p-value = 0.04				
18AN1323	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 5/6**
Level 3	1.00				
Level 4	1.00	1.00			
Level 5	0.06	0.10	1.00		
Level 5/6	1.00	1.00	1.00	0.25	
Level 7	1.00	1.00	1.00	1.00	1.00

Adjusted P-value	1-0.5	0.5-0.1	0.09-0.051	0.050- 0.000

Table S14. Effect size calculations from pairwise Mann-Whitney U comparing levels in 18AN1323.

	Effect Size				
18AN1323	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 5/6**
Level 3	0.49				
Level 4	0.60	0.60			
Level 5	0.70	0.70	0.55		
Level 5/6	0.53	0.51	0.41	0.35	
Level 7	0.60	0.60	0.47	0.40	0.55

Effect Size	0.00-0.24	0.25-0.49	0.50-0.74	0.75-1

Table S15. Results of the Kolmogorov-Smirnov tests.

Time 1	**Time 2**	**N of Time 1**	**N of Time 2**	**D**	**p-value**	**p-value adjusted**
Historic	Prehistoric	198	6648	0.258	1.57 E-11	1.57 E-10
Historic	Pleistocene	198	621	0.204	7.76 E-06	7.76 E-05
Historic	Modern Upper Bay	198	21486	0.218	1.71E-08	1.71 E-07
Historic	Modern VA Coastal Bays	198	1734	0.594	<2.2 E-16	2.20 E-15
Prehistoric	Pleistocene	6648	621	0.266	<2.2 E-16	2.20 E-15
Prehistoric	Modern Upper Bay	6648	21486	0.120	<2.2 E-16	2.20 E-15
Prehistoric	Modern VA Coastal Bays	6648	1734	0.427	<2.2 E-16	2.20 E-15
Pleistocene	Modern Upper Bay	621	21486	0.287	<2.2 E-16	2.20 E-15
Pleistocene	Modern VA Coastal Bays	621	1734	0.451	<2.2 E-16	2.20 E-15
Modern Upper Bay	Modern VA Coastal Bays	21486	1734	0.451	<2.2 E-16	2.20 E-15

Table S16. Statistical comparison of mean oyster height to mean annual salinity (MAS) and distance to the mouth of the bay (distance), including Pearson's correlation coefficient values (Pearson's r and associated P value) and the r^2 values for a simple linear regression. Upper Bay archaeological sites refer to our watershed samples in Fishing Bay and the Rhode River.

Sample	Sample Size	Oyster Height vs. MAS			Oyster Height vs. Distance		
		Pearson's r	P value	r^2	Pearson's r	P value	r^2
All Sites	31	0.030	0.8727	0.001	-0.290	0.1135	0.073
Archaeological Sites	26	0.286	0.1567	0.082	-0.156	0.4467	0.024
Prehistoric Arch. Sites	22	0.403	0.0629	0.162	-0.283	0.2019	0.081
Early Woodland Sites	3	-0.986	0.1067	0.972	0.286	0.8153	0.082
Middle Woodland Sites	6	0.464	0.3539	0.21	-0.375	0.4639	0.140
Late Woodland Sites	13	0.368	0.2160	0.135	-0.251	0.4081	0.063
Upper Bay Arch. Sites	15	0.806	0.0003	0.647	-0.730	0.0020	0.534

Table S17. Results of bootstrap analysis to test for bias in sample sizes.

Time Period	**Sample Size**	**Median (mm)**	**Bootstrap median**	**Bias**	**Std. Error**
Historic	198	80.2	80.4	0.04	1.20
Prehistoric	6648	69.4	69.5	0.08	1.70
Pleistocene	621	81.7	81.7	0.09	4.50
Middle Pleistocene	36	93.5	NA	NA	NA
Late Pleistocene	585	80.2	80.3	0.19	4.53
Early Woodland	469	59.0	59.0	-0.02	1.18
Middle Woodland	571	66.5	66.5	0.05	1.81
Late Woodland	5608	70.5	70.5	0.00	1.68
Modern Upper Bay	21486	72.0	72.0	0.42	1.87
Modern VA Coastal Bays	1735	52.0	52.0	-0.60	1.31

Table S18. Radiocarbon dates from archaeological sites in Fishing Bay used for the oyster analysis (see 3 for discussion).

Site	Provenience	Material	Sample #	$\delta^{13}C$	^{14}C Age	Calibrated Age (2σ)
18DO35	Unit 1, Middle of Unit, 21cmbs	*C.v.*	OS-84255	-1.55	835 ± 40	AD 1320-1490
	Unit 1, Surface layer 5-7 cmbs	*C.v.*	OS-81504	-2.37	845 ± 25	AD 1330-1470
	26 cmbs base of Unit 2	*C.v.*	OS-81512	-2.15	1180± 25	AD 1040-1230
	25 cmbs base of midden	*C.v.*	OS-79757	-3.06	1220 ± 30	AD 1010-1200
18DO127	Column 1, Middle of Unit, 10-cmbs	*C.v.*	OS-84259	-3.67	1050 ± 25	AD 1190-1320
	Column 1, Top of Unit 5-10 cmbs	*C.v.*	OS-81501	-1.62	1110 ± 40	AD 1080-1300
	Unit 2, Level 2 (30-40 cm)	*C.v.* t.	OS-102056	-4.2	1320 ± 25	AD 900-1070
	Column 1, Base of Unit, 44-cmbs	*C.v.*	OS-81503	-2.63	1320 ± 35	AD 880-1100
	Unit 2, Level 2 (30-40 cm)	*C.v.* t.	OS-92436	-3.15	1350 ± 30	AD 860-1050
18DO130	Intertidal Pit Feature	*C.v.*	OS-81500	-5.46	1730 ± 25	AD 480-670
	Pit features, Sample 2	*C.v.* t.	OS-92434	-2.71	1800 ± 25	AD 420-610
	Pit features, Sample 2	*C.v.* t.	OS-92435	-2.45	1870 ± 30	AD 780-990
	Upper deposit, possible pit feature	*C.v.*	OS-79759	-2.04	1140 ± 25	AD 1070-1270
	Unit 2 base of midden, 13 cmbs	*C.v.*	OS-81509	-1.49	1170 ± 25	AD 1050-1240
	Base of Unit 2	Charcoal	OS-81228	-25.47	1120 ± 25	AD 780-990
	Pit feature, 10 cm	*C.v.*	OS-94972	-1.44	1860 ± 35	AD 340-580
	Pit feature, 10 cm	*C.v.*	OS-95091	-1.11	1860 ± 25	AD 350-560
	Pit feature, 10 cm	*C.v.*	OS-95092	-1.18	1800 ± 25	AD 420-610
	Pit feature, 10 cm	*C.v.*	OS-95093	-0.9	1770 ± 25	AD 440-640
18DO429	Unit 1, Top of unit, 3-6 cmbs	*C.v.*	OS-84260	-2.6	1280 ± 25	AD 950-1150
	Unit 1, 10-20 cm	*C.v.* t.	OS-92437	-3.63	1300 ± 25	AD 910-1100
	Unit 1, 10-20 cm	*C.v.* t.	OS-92447	-2.66	1310 ± 30	AD 900-1100
	Unit 1, Base of Unit, 20-25 cmbs	*C.v.*	OS-84257	-2.63	1390 ± 25	AD 820-1020
	Auger north of Unit, ~100cmbs	*C.v.*	OS-84256	-2.45	1750 ± 25	AD 460-660
	Unit 1, Stratum 1	*C.v.*	OS-95094	-3.68	1270 ± 25	AD 970-1160
	Unit 1, Stratum 1	*C.v.*	OS-95095	-1.96	1370 ± 30	AD 830-1040
	Unit 1, Stratum 1	*C.v.*	OS-95096	-2.88	1320 ± 25	AD 900-1070
	Unit 1, Stratum 1	*C.v.*	OS-95096	-3.29	1340 ± 25	AD 890-1050
	Unit 1, Stratum 1	*C.v.*	OS-101201	-2.82	1350 ± 25	AD 870-1050
18DO436	Surface	*C.v.* t.	OS-104719	-3.91	1260 ± 25	AD 980-1170
	unit 1 Bulk sample, lower deposit	*C.v.*	OS-81510	-2.49	1270 ± 25	AD 970-1160
	Surface	*C.v.* t.	OS-92579	-3.02	1290 ± 25	AD 930-1130
	Unit 2, lower level	*C.v.*	OS-81507	-2.18	1310 ± 25	AD 900-1080
18DO439	Unit 1, Top of Midden, 10-11 cmbs	*C.v.*	OS-81506	-1.51	1290 ± 25	AD 930-1130

Table S18 Continued.

	East locus, 20-23 cmbs, base of midden	*C.v.*	OS-81511	-0.48	1320 ± 25	AD 900-1070
	22 cmbs, base of midden	*C.v.*	OS-79758	-1.8	1330 ± 30	AD 890-1070

Notes: *C.v.= Crassostrea virginica*; *C.v.* t.= oyster shell temper from pottery; OS = National Ocean Sciences Accelerator Mass Spectrometry Lab, Woods Hole Oceanographic Institute. All dates were calibrated using OxCal v 4.2 (24,25). Dates from marine organisms were corrected for the marine radiocarbon reservoir using ΔR = -88 ± 23, from Rick et al. (26). Some shells from 18DO130 and 18DO429 were sampled multiple times to investigate intrashell variability in radiocarbon (27). *Note that sample OS-81228 from 18DO130 is from charcoal located just below the midden, and may not be associated with the human occupation.

Table S19. Radiocarbon dates from the archaeological sites on the Rhode River Estuary used for the oyster analysis (see 5 for a discussion).

Site	Provenience	Material[1]	Sample #	$\delta^{13}C$	^{14}C Age	Calibrated Age (2σ)[2]
18AN226	Bulk Sample 1, ~20cmbs	*C.v.*	OS-90147	-3.76	1030 ± 40	AD 1330-1480
	Bulk Sample 2, ~20cmbs	*C.v.*	OS-90143	-3.57	1100 ± 30	AD 1300-1430
	Probe, 32-34 cmbs base of midden	*C.v.*	OS-84252	-5.07	1180 ± 20	AD 1250-1390
18AN285	Unit 1c.s., 41-44cmbs	*C.v.*	OS-90323	-3.67	910 ± 30	AD 1440-1590
	Unit 1c.s., 5 cmbs	*C.v.*	OS-90153	-3.27	930 ± 25	AD 1430-1540
	Unit 1c.s., 70-71 cmbs	*C.v.*	OS-90145	-3.56	1890 ± 25	AD 550-680
	Aug 3, 43cmbs	*C.v.*	OS-90148	-3.66	2210 ± 25	AD 150-360
18AN286	Unit 1c.s., 30cmbs	*C.v.*	OS-90154	-3.91	950 ± 25	AD 1430-1520
	Unit 1, Level 4	*C.v. t.*	OS-92581	-5.03	950 ± 25	AD 1430-1520
	25 cm, base of deep exposure	*C.v.*	OS-90146	-3.54	1000 ± 35	AD 1350-1500
	Unit 1, Level 4	*C.v. t.*	OS-92433	-3.83	1040 ± 25	AD 1340-1470
	Creek exposure, 25cmbs	*C.v.*	OS-86708	-3.19	2020 ± 25	AD 400-570
18AN287	Unit 2, 66cmbs	*C.v.*	OS-90141	-3.4	985 ± 25	AD 1400-1500
	Unit 1, 55-58 cmbd	*C.v.*	OS-90144	-4.22	990 ± 30	AD 1360-1510
	20 cmbs in creek exposure	*C.v.*	OS-86704	-3.86	1110 ± 25	AD 1300-1420
	Unit 1, 65cmbd	C.v.	OS-90142	-4.1	1120 ± 30	AD 1290-1420
	Unit 1 South, Level 1	*C.v. t.*	OS-92432	-4.91	1390 ± 25	AD 1040-1200
	Unit 1 South, Level 1	*C.v. t.*	OS-92908	-4.54	1510 ± 45	AD 860-1110
18AN308	Unit 1, 35 cmbd, pair1	Charcoal	OS-98286	-25.65	2760 ± 20	970-840 BC
	Unit 2, 31 cmbd, pair2	Charcoal	OS-98285	-24.81	2900 ± 20	1190-1010 BC
	C.S. 1, 42-43 cmbd	*C.v.*	OS-98202	-2.81	3150 ± 20	950-800 BC
	Unit 1, 35 cmbd, pair1	*C.v.*	OS-98206	-3.17	3210 ± 20	1030-840 BC
	Unit 2, 31 cmbd, pair2	*C.v.*	OS-98207	-3.96	3230 ± 20	1060-870 BC
	20 cmbs in creek exposure	*C.v.*	OS-92427	-3.54	3240 ± 25	1090-880 BC
	STP2, 33cmbs	*C.v.*	OS-98204	-1.83	3250 ± 20	1090-890 BC
	C.S. 1, 16-18 cmbd	*C.v.*	OS-98203	-3.74	3250 ± 20	1090-890 BC
	Creek bed exposure, in situ	*C.v.*	OS-90320	-2.23	3360 ± 30	1250-1020 BC
18AN1323	Base of Unit 69-70 cmbs	*C.v.*	OS-84217	-3.98	465 ± 30	AD 1850-1950
	Top of Unit, 10-13 cmbs	*C.v.*	OS-84216	-4.97	550 ± 25	AD 1770-1950

Notes: C.v.= Crassostrea virginica; *C.v.*t.= *Crassostrea virginica* shell temper; Char=Charcoal. All dates calibrated using OxCal 4.2 (24,25) and applying a standard reservoir correction of 97 ± 18 years for all marine shells (5).