

advances.sciencemag.org/cgi/content/full/6/28/eaba9652/DC1

Supplementary Materials for

Ecosystem stability and Native American oyster harvesting along the Atlantic Coast of the United States

Victor D. Thompson*, Torben Rick, Carey J. Garland, David Hurst Thomas, Karen Y. Smith, Sarah Bergh,
Matt Sanger, Bryan Tucker, Isabelle Lulewicz, Anna M. Semon, John Schalles,
Christine Hladik, Clark Alexander, Brandon T. Ritchison

*Corresponding author. Email: vdthom@uga.edu

Published 10 July 2020, *Sci. Adv.* **6**, eaba9652 (2020)
DOI: 10.1126/sciadv.aba9652

This PDF file includes:

Supplementary Text
Fig. S1
Tables S1 to S8

Supplementary Materials

This supplementary information provides further detail in regard to descriptive statistics, as well as statistical analyses of oyster size differences between islands and between levels within sites. Tables 1 and 2 provide the results of pairwise Mann-Whitney U tests showing differences in mean LVL and LVH between the different sites. As discussed in the result section, many but not all sites are distinguishable in regard to mean oyster size (at the $p < 0.05$ level). Table 3 provides raw data on total oyster bed lengths in 5 km and 10 km foraging radii of sites included in the correlation test (supplemental to Fig. 5).

Figures S1 shows differences in oyster size and geographic clustering between sites on Edisto Island, Ossabaw Island, St. Catherines Island, and Sapelo Island. At the mean level, the islands are significantly different in regard to oyster size (Kruskal Wallis, LVH: $X^2 = 926.55$, $p < 0.05$; LVL, $X^2 = 2389.3$, $p < 0.05$, respectively). A pairwise Mann-Whitney U test shows that sites clustered by island are statistically different in regard to mean LVL and LVH, except for Ossabaw and Edisto islands, which have similar mean LVL values ($p < 0.05$). Descriptive statistics for each island are shown in Tables S4.

Tables 5-8 provide the results of pairwise Mann-Whitney U tests for intra-site differences in oyster shell size. These data demonstrate differences in oyster shell size between different levels at McQueen Shell Ring and St. Catherines Shell Ring. At both sites, there is a trend of decreasing shell size through time, with older levels generally having statistically larger shells than younger levels. A comparison of shell size from different levels at the St. Catherines Shell Ring shows a decrease in shell size across time. At the mean level, oyster size is significantly different between the different levels at St. Catherines Shell Ring (Kruskal Wallis, LVH: $X^2 = 30.4$, $p < 0.05$; LVL: $X^2 = 22.4$, $p < 0.006$). For example, Levels 7, 8, and 9 (the oldest levels) have mean LVH measurements of 84.13 mm, 75.85 mm, and 71.29 mm, respectively, whereas mean LVH is only 52.59 mm and 67.8 mm for Levels 1 and 2, respectively. However, a pairwise Mann-Whitney U test shows that only Level 7 is distinguishable from the other levels in regard to mean LVH, and only Levels 5 and 8 are distinguishable in regard to LVL (p -value < 0.05) (Tables S5 and S6). At the mean level, oyster size is significantly different between the different levels of the McQueen Shell Ring (Kruskal Wallis, LVH: $X^2 = 76.1$, $p < 0.05$; LVL: $X^2 = 58.1$, $p < 0.05$). A pairwise Mann-Whitney U test shows that shells from Levels 7-13 are generally larger than shells from Levels 1-6 in regard to both mean LVH and LVL (Tables S7 and S8). Interestingly, Levels 7 and 8 have the largest shell and are the oldest of the levels with associated AMS dates.

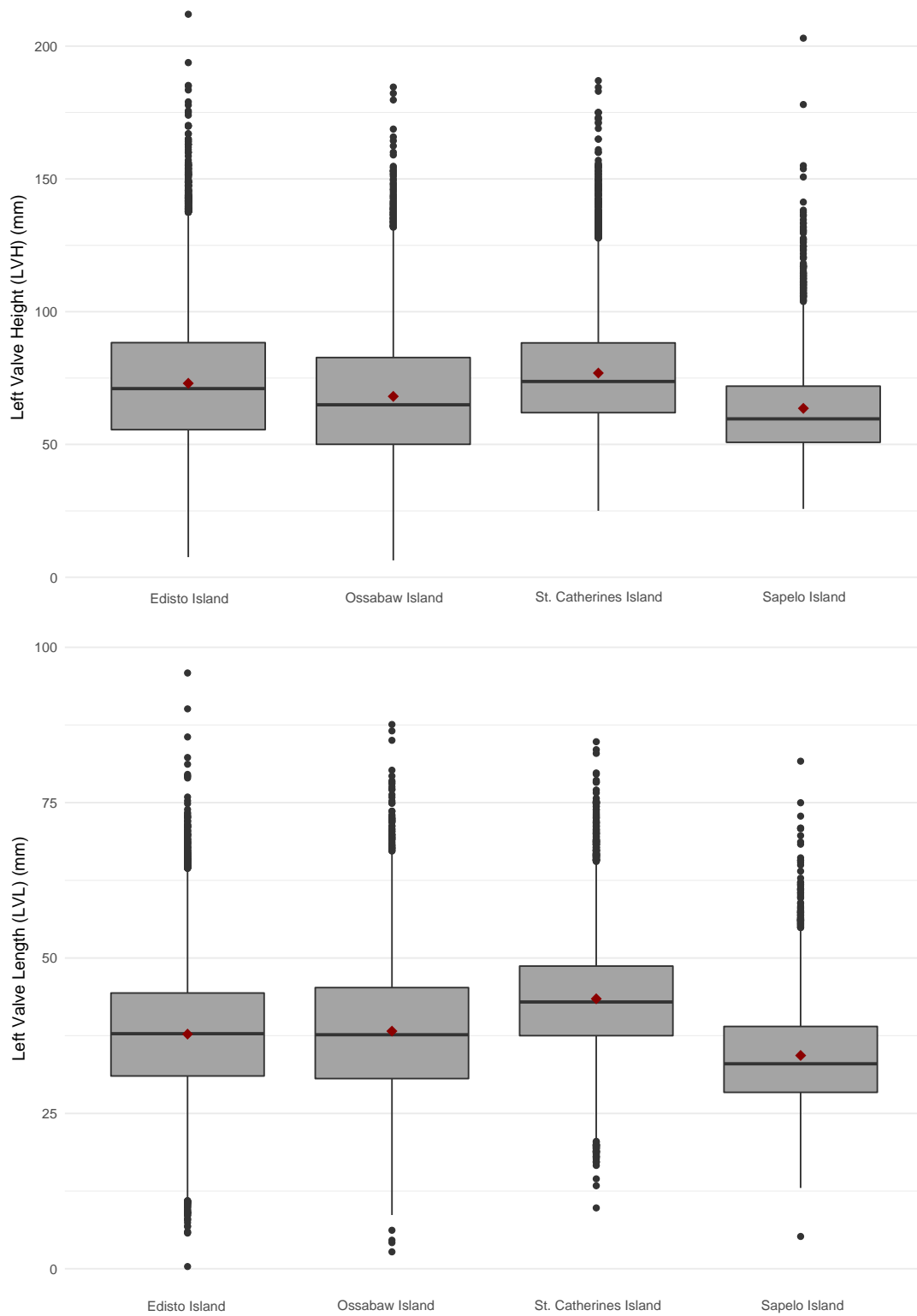


Fig. S1: Comparison of LVH (above) and LVL (below) between the different islands.

Table S1: Pairwise Mann-Whitney U results for LVL. *Denotes statistical significance at the $p < 0.05$ level.

| | Bluff Field | A Busch Krick | Cane Patch | Finley's Pond | Kenan Field | McQueen Shell Ring | Meeting House Field |
|----------------------------|--------------------|----------------------|-------------------|----------------------|--------------------|---------------------------|----------------------------|
| A Busch Krick | 1 | - | - | - | - | - | - |
| Cane Patch | 0.500 | 1 | - | - | - | - | - |
| Finley's pond | 0.000* | 0.000 | 0.000* | - | - | - | - |
| Kenan Field | 1.000 | 1.000* | 0.025* | 0.000* | - | - | - |
| McQueen Shell Ring | 0.001* | 1.000 | 0.000* | 0.000* | 1.000 | - | - |
| Meeting House Field | 0.001* | 1.000 | 0.000* | 0.000* | 1.000 | 1.000 | - |
| Ossabaw Shell Ring | 0.000* | 0.039* | 0.031* | 0.000* | 0.000* | 0.000* | 0.000* |
| Pockoy Ring 1 | 0.000* | 0.000* | 0.000* | 0.023* | 0.000* | 0.000* | 0.000* |
| Sapelo Ring 1 | 0.000* | 0.001* | 0.083 | 1.000 | 0.000* | 0.000* | 0.000* |
| Sapelo Ring 2 | 0.000* | 0.000* | 0.000* | 0.519 | 0.000* | 0.000* | 0.000* |
| Sapelo Ring 3 | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* |
| Sapelo South | 0.000* | 0.002* | 0.316 | 1.000 | 0.000* | 0.000* | 0.000* |
| Spanish Mount | 0.000* | 0.070 | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* |
| St Cath Shell Ring | 0.000* | 1.000 | 0.000* | 0.000* | 0.519 | 1.000 | 1.000 |

| | Ossabaw Shell Ring | Pockoy Ring 1 | Sapelo Shell Ring 1 | Sapelo Shell Ring 2 | Sapelo Shell Ring 3 | Sapelo South |
|----------------------------|---------------------------|----------------------|----------------------------|----------------------------|----------------------------|---------------------|
| Pockoy Ring 1 | 0.000* | - | - | - | - | - |
| Sapelo Ring 1 | 0.000* | - | - | - | - | - |
| Sapelo Ring 2 | 0.060 | 1.000 | - | - | - | - |
| Sapelo Ring 3 | 0.000* | 1.000 | 1.000 | - | - | - |
| Sapelo South | 0.000* | 0.263 | 0.161 | 0.003* | - | - |
| Spanish Mount | 0.255 | 1.000 | 1.000 | 1.000 | 0.012* | - |
| St. Cath Shell Ring | 1.000 | 0.000* | 0.163 | 0.000* | 0.000* | 0.519 |

Table S2: Pairwise Mann-Whitney U results for LVH. *Denotes statistical significance at the $p < 0.05$ level.

| | Bluff Field | A Busch Krick | Cane Patch | Finley's Pond | Kenan Field | McQueen Shell Ring | Meeting House Field |
|----------------------------|--------------------|----------------------|-------------------|----------------------|--------------------|---------------------------|----------------------------|
| A Busch Krick | 0.000* | - | - | - | - | - | - |
| Cane Patch | 0.000* | 0.000* | - | - | - | - | - |
| Finley's pond | 1.000 | 0.000* | 0.000* | - | - | - | - |
| Kenan Field | 0.008* | 0.005* | 0.000* | 0.021 | - | - | - |
| McQueen Shell Ring | 0.000* | 0.006* | 0.000* | 0.000* | 1.000 | - | - |
| Meeting House Field | 0.000* | 0.406 | 0.000* | 0.000* | 0.000* | 0.000* | - |
| Ossabaw Shell Ring | 0.000* | 1.000 | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* |
| Pockoy Ring 1 | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* |
| Sapelo Ring 1 | 1.000 | 0.000* | 1.000 | 1.000 | 0.160 | 0.016* | 0.000* |
| Sapelo Ring 2 | 0.249 | 0.000* | 1.000 | 0.179 | 0.000* | 0.000* | 0.000* |
| Sapelo Ring 3 | 0.000* | 0.000* | 0.517 | 0.000* | 0.000* | 0.000* | 0.000* |
| Sapelo South | 0.446 | 0.090 | 0.006* | 1.000 | 1.000 | 1.000 | 1.000 |
| Spanish Mount | 0.000* | 0.008* | 0.000* | 0.000* | 1.000 | 1.000 | 0.000* |
| St Cath Shell Ring | 0.001* | 0.003* | 0.000* | 0.000* | 1.000 | 1.000 | 0.000* |

| | Ossabaw Shell Ring | Pockoy Ring 1 | Sapelo Shell Ring 1 | Sapelo Shell Ring 2 | Sapelo Shell Ring 3 | Sapelo South |
|----------------------------|---------------------------|----------------------|----------------------------|----------------------------|----------------------------|---------------------|
| Pockoy Ring 1 | 0.000* | - | - | - | - | - |
| Sapelo Ring 1 | 0.000* | 0.011* | - | - | - | - |
| Sapelo Ring 2 | 0.000* | 0.000* | 1.000 | - | - | - |
| Sapelo Ring 3 | 0.000* | 0.090 | 0.016* | 0.001* | - | - |
| Sapelo South | 0.003* | 0.000* | 0.692 | 0.009* | 0.000* | - |
| Spanish Mount | 0.000* | 0.000* | 0.155 | 0.000* | 0.000* | 1.000 |
| St. Cath Shell Ring | 0.000* | 0.000* | 0.234 | 0.000* | 0.000* | 1.000 |

Table S3. Total oyster bed length (mm) in 5 km and 10 km foraging radii.

| Site | Total Oyster Bed Length (5 km) | Total Oyster Bed Length (10 km) | Mean LVH |
|---------------------------|---|--|---------------------|
| Ossabaw | 38759 | 125541 | 85.5 |
| Sapelo Shell Rings | 12389 | 26103 | 65.3 |
| Cane Patch | 34790 | 103781 | 62.6 |
| St. Catherines Shell Ring | 59788 | 121488 | 72.2 |
| McQueen Shell Ring | 35976 | 80123 | 73.9 |
| Ossabaw Shell Ring | 16159 | 73465 | 57.3 |
| Pockoy Ring 1 | 38759 | 125541 | 85.5 |
| Finley's Pond | 38759 | 125196 | 66.8 |
| Bluff Field | 24720 | 101519 | 65.8 |
| Meeting House Field | 59788 | 121488 | 78.6 |
| Kenan Field | 8198 | 29405 | 71.2 |

Table S4: Comparison of LVH and LVL measurements between islands.

| Site | Min LVH | Max LVH | Mean LVH | Min LVL | Max LVL | Mean LVL |
|-----------------------|----------------|----------------|-----------------|----------------|----------------|-----------------|
| Edisto Island | 7.58 | 212.0 | 73.0 | 5.74 | 95.9 | 37.6 |
| Ossabaw Island | 6.77 | 184.6 | 85.5 | 2.72 | 74.9 | 37.8 |
| St. Catherines Island | 25.02 | 178.0 | 73.9 | 18.37 | 84.8 | 43.6 |
| Sapelo Island | 28.78 | 150.7 | 59.7 | 5.2 | 81.7 | 32.6 |

Table S5. Pairwise Mann-Whitney U results for differences in LVH between levels at St. Catherines Shell Ring. *Denotes statistical significance at the $p < 0.05$ level.

| | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7 | Level 8 |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Level 2 | 1.000 | - | - | - | - | - | - | - |
| Level 3 | 1.000 | 1.000 | - | - | - | - | - | - |
| Level 4 | 1.000 | 1.000 | 1.000 | - | - | - | - | - |
| Level 5 | 1.000 | 1.000 | 1.000 | 1.000 | - | - | - | - |
| Level 6 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | - | - | - |
| Level 7 | 1.000 | 0.150 | 0.010* | 0.000* | 0.000* | 0.080 | - | - |
| Level 8 | 1.000 | 1.000 | 0.580 | 1.000 | 1.000 | 1.000 | 1.000 | - |
| Level 9 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.370 | 1.000 |

Table S6. Pairwise Mann-Whitney U results for differences in LVL between levels at St. Catherines Shell Ring. *Denotes statistical significance at the $p < 0.05$ level.

| | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7 | Level 8 |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Level 2 | 1.000 | - | - | - | - | - | - | - |
| Level 3 | 1.000 | 1.000 | - | - | - | - | - | - |
| Level 4 | 1.000 | 1.000 | 1.000 | - | - | - | - | - |
| Level 5 | 1.000 | 1.000 | 1.000 | 1.000 | - | - | - | - |
| Level 6 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | - | - | - |
| Level 7 | 1.000 | 1.000 | 0.610 | 1.000 | 0.870 | 1.000 | - | - |
| Level 8 | 1.000 | 0.790 | 0.030* | 0.050* | 0.040* | 1.000 | 1.000 | - |
| Level 9 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.640 | 0.050* |

Table S7. Pairwise Mann-Whitney U results for differences in LVH between levels at McQueen Shell Ring. *Denotes statistical significance at the $p < 0.05$ level.

| | Level 1 | Level 10 | Level 11 | Level 12 | Level 13 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7 | Level 8 |
|-----------------|---------|----------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|
| Level 10 | 1.000 | - | - | - | - | - | - | - | - | - | - | - |
| Level 11 | 1.000 | 1.000 | - | - | - | - | - | - | - | - | - | - |
| Level 12 | 0.000* | 1.000 | 1.000 | - | - | - | - | - | - | - | - | - |
| Level 13 | 0.000* | 0.950 | 1.000 | 1.000 | - | - | - | - | - | - | - | - |
| Level 2 | 1.000 | 1.000 | 1.000 | 0.390 | 0.050* | - | - | - | - | - | - | - |
| Level 3 | 1.000 | 1.000 | 1.000 | 0.020* | 0.000* | 1.000 | - | - | - | - | - | - |
| Level 4 | 1.000 | 0.820 | 0.820 | 0.000* | 0.000* | 1.000 | 0.790 | - | - | - | - | - |
| Level 5 | 1.000 | 1.000 | 1.000 | 0.010* | 0.000* | 1.000 | 1.000 | 1.000 | - | - | - | - |
| Level 6 | 1.000 | 0.540 | 0.640 | 0.000* | 0.000* | 1.000 | 0.950 | 1.000 | 1.000 | - | - | - |
| Level 7 | 0.360 | 1.000 | 1.000 | 1.000 | 0.230 | 1.000 | 1.000 | 0.240 | 1.000 | 0.340 | - | - |
| Level 8 | 0.260 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.120 | 0.000* | 0.020* | 0.000* | 1.000 | - |
| Level 9 | 0.790 | 1.000 | 1.000 | 1.000 | 0.210 | 1.000 | 1.000 | 0.060 | 0.400 | 0.060 | 1.000 | 1.000 |

Table S8. Pairwise Mann-Whitney U results for differences in LVL between levels at McQueen Shell Ring. *Denotes statistical significance at the $p < 0.05$ level.

| | Level 1 | Level 10 | Level 11 | Level 12 | Level 13 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7 | Level 8 |
|-----------------|---------|----------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|
| Level 10 | 0.530 | - | - | - | - | - | - | - | - | - | - | - |
| Level 11 | 1.000 | 1.000 | - | - | - | - | - | - | - | - | - | - |
| Level 12 | 0.410 | 1.000 | 1.000 | - | - | - | - | - | - | - | - | - |
| Level 13 | 0.120 | 1.000 | 0.120 | 1.000 | - | - | - | - | - | - | - | - |
| Level 2 | 1.000 | 0.380 | 1.000 | 0.820 | 0.090 | - | - | - | - | - | - | - |
| Level 3 | 1.000 | 0.380 | 1.000 | 0.910 | 0.070 | 1.000 | - | - | - | - | - | - |
| Level 4 | 1.000 | 0.010* | 1.000 | 0.090 | 0.000* | 1.000 | 1.000 | - | - | - | - | - |
| Level 5 | 1.000 | 0.040* | 1.000 | 0.170 | 0.000* | 1.000 | 1.000 | 1.000 | - | - | - | - |
| Level 6 | 1.000 | 0.010* | 1.000 | 0.070 | 0.000* | 1.000 | 1.000 | 1.000 | 1.000 | - | - | - |
| Level 7 | 0.490 | 1.000 | 0.810 | 1.000 | 1.000 | 0.230 | 0.210 | 0.010* | 0.020* | 0.010* | - | - |
| Level 8 | 1.000 | 1.000 | 1.000 | 1.000 | 0.370 | 1.000 | 1.000 | 0.950 | 1.000 | 1.000 | 1.000 | - |
| Level 9 | 1.000 | 0.170 | 1.000 | 0.170 | 0.000* | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.090 | 1.000 |