The following supplement accompanies the article

Role of habitat and predators in maintaining functional diversity of estuarine bivalves

Cassandra N. Glaspie*, Rochelle D. Seitz

*Corresponding author: glaspiec@oregonstate.edu

Marine Ecology Progress Series 570: 113–125 (2017)

Table S1. Results of multiple comparisons for bivalve diversity in different habitats. Bonferroni-adjusted p values from bootstrap hypothesis tests are given for Gini-Simpson diversity index and functional diversity (Gini-Simpson index of functional groups) in different habitats in lower Chesapeake Bay. Only contrasts significant at $\alpha = 0.05$ are shown.

Contrast	*Diversity*		*Functional Diversity*	
	Cohen's d	p	Cohen's d	p
Seagrass v. Detrital Mud	0.11	0.01	0.16	0.0005
Seagrass v. Shell Hash	0.10	0.001	0.11	0.0005
Seagrass v. Oyster Shell	0.07	0.04	0.10	0.006

Table S2. Gini-Simpson diversity index generalized linear model results. Model was fit with family = Gaussian, link = identity. Model based on 180 observations. McFadden's pseudo $R^2 = 0.28$. Null deviance 12.52 on 179 df. Residual deviance 8.99 on 157 df. Significant variables at $\alpha = 0.05$ are bolded.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	0.163	0.107	1.515	0.132
Year 2013	-0.079	0.042	-1.860	0.065
Season Spring	0.076	0.058	1.321	0.188
Season Summer	-0.016	0.061	-0.257	0.797
Subestuary Mobjack	-0.046	0.107	-0.430	0.668
Subestuary York	-0.117	0.111	-1.056	0.292
Coarse sand	0.046	0.098	0.471	0.638
Oyster shell	0.094	0.084	1.115	0.267
Seagrass	**0.372**	**0.091**	**4.073**	**< 0.001**
Shell hash	0.079	0.076	1.040	0.300
Habitat volume (L)	0.033	0.024	1.349	0.180
Fish density (m^{-2})	0.090	0.068	1.326	0.187
Crab density (m^{-2})	-0.005	0.082	-0.065	0.948
Ray pit density (m^{-2})	**0.768**	**0.294**	**2.615**	**0.010**
Lynnhaven Site 1	0.037	0.101	0.369	0.712
Lynnhaven Site 2	0.105	0.098	1.070	0.286
Lynnhaven Site 3	-0.065	0.093	-0.695	0.488
Mobjack Site 1	-0.006	0.091	-0.067	0.946
Mobjack Site 2	-0.061	0.091	-0.669	0.504
Mobjack Site 3	-0.076	0.088	-0.867	0.387
York Site 1	-0.104	0.116	-0.897	0.371
York Site 2	0.186	0.107	1.737	0.084
York Site 3	**0.294**	**0.111**	**2.660**	**0.009**

Table S3. Functional diversity generalized linear model results. Model was fit with family = Gaussian, link = identity. Model based on 180 observations. McFadden's pseudo R^2 = 0.27. Null deviance 10.31 on 179 df. Residual deviance 7.55 on 157 df. Significant variables at α = 0.05 are bolded.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	0.154	0.098	1.559	0.121
Year 2013	-0.018	0.039	-0.469	0.640
Season Spring	0.014	0.053	0.258	0.797
Season Summer	-0.086	0.056	-1.537	0.126
Subestuary Mobjack	-0.029	0.098	-0.296	0.768
Subestuary York	-0.096	0.102	-0.942	0.347
Coarse sand	0.046	0.090	0.515	0.608
Oyster shell	0.019	0.077	0.246	0.806
Seagrass	**0.341**	**0.084**	**4.071**	**< 0.001**
Shell hash	0.055	0.070	0.785	0.434
Habitat volume (L)	0.017	0.022	0.744	0.458
Fish density (m^{-2})	0.085	0.062	1.373	0.172
Crab density (m^{-2})	0.015	0.075	0.194	0.847
Ray pit density (m^{-2})	**0.842**	**0.269**	**3.130**	**0.002**
Lynnhaven Site 1	0.089	0.092	0.965	0.336
Lynnhaven Site 2	0.108	0.090	1.210	0.228
Lynnhaven Site 3	-0.032	0.085	-0.377	0.707
Mobjack Site 1	-0.013	0.083	-0.150	0.881
Mobjack Site 2	-0.081	0.083	-0.971	0.333
Mobjack Site 3	-0.081	0.081	-1.000	0.319
York Site 1	-0.038	0.106	-0.353	0.725
York Site 2	0.095	0.098	0.970	0.334
York Site 3	0.165	0.101	1.628	0.106

Table S4. Rarefied species richness generalized linear model results. Model was fit with family = Gaussian, link = identity. Model based on 180 observations. McFadden's pseudo R^2 = 0.24. Null deviance 2847.7 on 179 df. Residual deviance 2151.4 on 157 df. Significant variables at α = 0.05 are bolded.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	**3.315**	**1.662**	**1.995**	**0.048**
Year 2013	0.404	0.655	0.617	0.538
Season Spring	1.522	0.889	1.711	0.089
Season Summer	0.586	0.940	0.623	0.534
Subestuary Mobjack	-2.213	1.647	-1.343	0.181
Subestuary York	-2.137	1.713	-1.247	0.214
Coarse sand	2.921	1.512	1.932	0.055
Oyster shell	**4.288**	**1.306**	**3.283**	**0.001**
Seagrass	**6.883**	**1.413**	**4.870**	**< 0.001**
Shell hash	**3.570**	**1.180**	**3.026**	**0.003**
Habitat volume (L)	**0.765**	**0.375**	**2.042**	**0.043**
Fish density (m^{-2})	0.962	1.047	0.919	0.359
Crab density (m^{-2})	-1.870	1.265	-1.479	0.141
Ray pit density (m^{-2})	-3.944	4.543	-0.868	0.387
Lynnhaven Site 1	-0.436	1.555	-0.280	0.780
Lynnhaven Site 2	-1.725	1.512	-1.141	0.256
Lynnhaven Site 3	0.529	1.442	0.367	0.715
Mobjack Site 1	0.362	1.405	0.257	0.797
Mobjack Site 2	-0.116	1.404	-0.082	0.935
Mobjack Site 3	0.313	1.361	0.230	0.818
York Site 1	1.695	1.794	0.945	0.346
York Site 2	**6.148**	**1.657**	**3.710**	**< 0.001**
York Site 3	**5.426**	**1.712**	**3.169**	**0.002**

Table S5. Functional richness generalized linear model results. Model was fit with family = Gaussian, link = identity. Model based on 180 observations. McFadden's pseudo R^2 = 0.21. Null deviance 190.20 on 179 df. Residual deviance 149.58 on 157 df. Significant variables at α = 0.05 are bolded.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	**1.165**	**0.438**	**2.658**	**0.009**
Year 2013	0.083	0.173	0.482	0.631
Season Spring	0.397	0.234	1.695	0.092
Season Summer	0.059	0.248	0.241	0.810
Subestuary Mobjack	-0.368	0.434	-0.846	0.399
Subestuary York	-0.540	0.452	-1.194	0.234
Coarse sand	0.285	0.399	0.715	0.476
Oyster shell	0.228	0.344	0.661	0.510
Seagrass	**1.469**	**0.373**	**3.943**	**< 0.001**
Shell hash	0.387	0.311	1.242	0.216
Habitat volume (L)	**0.213**	**0.099**	**2.151**	**0.033**
Fish density (m^{-2})	0.105	0.276	0.382	0.703
Crab density (m^{-2})	-0.199	0.333	-0.598	0.551
Ray pit density (m^{-2})	1.455	1.198	1.215	0.227
Lynnhaven Site 1	0.238	0.410	0.580	0.562
Lynnhaven Site 2	0.096	0.399	0.240	0.810
Lynnhaven Site 3	0.014	0.380	0.037	0.971
Mobjack Site 1	-0.016	0.371	-0.044	0.965
Mobjack Site 2	-0.289	0.370	-0.781	0.436
Mobjack Site 3	-0.187	0.359	-0.520	0.604
York Site 1	-0.076	0.473	-0.160	0.873
York Site 2	0.790	0.437	1.809	0.072
York Site 3	**1.238**	**0.451**	**2.742**	**0.007**

Table S6. Deposit-feeding (DF) bivalve abundance generalized linear model results. Model was fit with family = Quasi-Poisson, link = log. Model based on 180 observations. McFadden's pseudo R^2 = 0.79. Null deviance 5093.3 on 179 df. Residual deviance 1068.3 on 157 df. Significant variables at α = 0.05 are bolded. Samples were collected in a 0.11 m^2 area.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	-0.513	1.107	-0.464	0.644
Year 2013	**0.741**	**0.241**	**3.079**	**0.002**
Season Spring	**1.223**	**0.444**	**2.755**	**0.007**
Season Summer	0.247	0.510	0.484	0.629
Subestuary Mobjack	-0.731	1.497	-0.488	0.626
Subestuary York	-1.112	1.559	-0.713	0.477
Coarse sand	-0.759	0.436	-1.741	0.084
Oyster shell	**-1.032**	**0.399**	**-2.586**	**0.011**
Seagrass	1.024	1.011	1.012	0.313
Shell hash	-0.306	0.309	-0.989	0.324
Habitat volume (L)	-0.199	0.146	-1.364	0.175
Fish density (m^{-2})	0.428	0.306	1.396	0.165
Crab density (m^{-2})	**-2.090**	**0.604**	**-3.463**	**0.001**
Ray pit density (m^{-2})	**-5.019**	**2.008**	**-2.500**	**0.013**
Lynnhaven Site 1	1.662	1.192	1.395	0.165
Lynnhaven Site 2	0.392	1.233	0.318	0.751
Lynnhaven Site 3	1.083	1.130	0.959	0.339
Mobjack Site 1	0.292	0.924	0.316	0.752
Mobjack Site 2	0.644	0.810	0.975	0.428
Mobjack Site 3	0.248	0.890	0.279	0.781
York Site 1	**5.299**	**1.211**	**4.374**	**< 0.001**
York Site 2	**4.592**	**1.205**	**3.810**	**< 0.001**
York Site 3	**3.971**	**1.214**	**3.271**	**0.001**

Table S7. Deep-burrowing and suspension-feeding (DBSF) bivalve abundance generalized linear model results. Model was fit with family = Quasi-Poisson, link = log. Model based on 180 observations. McFadden's pseudo R^2 = 0.19. Null deviance 909.23 on 179 df. Residual deviance 734.06 on 157 df. Significant variables at α = 0.05 are bolded. Samples were collected in a 0.11 m^2 area.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	0.588	0.622	0.945	0.346
Year 2013	-0.184	0.242	-0.758	0.449
Season Spring	0.227	0.315	0.721	0.472
Season Summer	-0.096	0.358	-0.267	0.790
Subestuary Mobjack	-0.410	0.579	-0.709	0.479
Subestuary York	0.285	0.537	0.530	0.597
Coarse sand	0.190	0.613	0.309	0.757
Oyster shell	0.341	0.540	0.631	0.529
Seagrass	0.834	0.570	1.463	0.146
Shell hash	0.931	0.473	1.968	0.051
Habitat volume (L)	**0.282**	**0.125**	**2.260**	**0.025**
Fish density (m^{-2})	-0.083	0.387	-0.215	0.830
Crab density (m^{-2})	-0.583	0.545	-1.069	0.287
Ray pit density (m^{-2})	-0.962	1.863	-0.516	0.606
Lynnhaven Site 1	-0.170	0.541	-0.314	0.754
Lynnhaven Site 2	0.141	0.471	0.300	0.764
Lynnhaven Site 3	-0.437	0.536	-0.814	0.417
Mobjack Site 1	0.153	0.509	0.301	0.764
Mobjack Site 2	-0.265	0.562	-0.472	0.638
Mobjack Site 3	-0.298	0.548	-0.542	0.588
York Site 1	**-1.559**	**0.728**	**-2.143**	**0.034**
York Site 2	-0.072	0.510	-0.141	0.888
York Site 3	**-1.491**	**0.752**	**-1.983**	**0.049**

Table S8. Thin-shelled and surface-dwelling (TSSD) bivalve abundance generalized linear model results. Model was fit with family = Quasi-Poisson, link = log. Model based on 180 observations. McFadden's pseudo R^2 = 0.47. Null deviance 1735.26 on 179 df. Residual deviance 914.26 on 157 df. Significant variables at α = 0.05 are bolded. Samples were collected in a 0.11 m^2 area.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	1.319	0.972	1.357	0.177
Year 2013	0.130	0.339	0.384	0.702
Season Spring	0.023	0.494	0.047	0.963
Season Summer	**1.192**	**0.583**	**2.046**	**0.042**
Subestuary Mobjack	-1.536	0.827	-1.857	0.065
Subestuary York	**-2.014**	**0.981**	**-2.052**	**0.042**
Coarse sand	0.348	0.946	0.367	0.714
Oyster shell	0.653	0.853	0.766	0.445
Seagrass	0.678	0.822	0.825	0.411
Shell hash	0.183	0.794	0.230	0.818
Habitat volume (L)	0.435	0.221	1.966	0.051
Fish density (m^{-2})	-1.021	0.696	-1.467	0.145
Crab density (m^{-2})	-1.898	1.022	-1.857	0.065
Ray pit density (m^{-2})	-5.002	3.098	-1.614	0.108
Lynnhaven Site 1	**-2.561**	**0.984**	**-2.602**	**0.010**
Lynnhaven Site 2	**-2.733**	**0.986**	**-2.771**	**0.006**
Lynnhaven Site 3	-0.229	0.629	-0.364	0.717
Mobjack Site 1	1.189	0.646	1.840	0.068
Mobjack Site 2	**1.194**	**0.613**	**1.947**	**0.053**
Mobjack Site 3	**1.459**	**0.544**	**2.684**	**0.008**
York Site 1	-1.192	1.597	-0.747	0.456
York Site 2	-2.941	3.139	-0.937	0.350
York Site 3	-0.419	1.320	-0.317	0.752

Table S9. Armored (ARM) bivalve abundance generalized linear model results. Model was fit with family = Quasi-Poisson, link = log. Model based on 180 observations. McFadden's pseudo R^2 = 0.36. Null deviance 447.09 on 179 df. Residual deviance 286.85 on 157 df. Significant variables at α = 0.05 are bolded. Samples were collected in a 0.11 m^2 area.

	Estimate	*Std. Error*	*t value*	*p*
Intercept	**-2.345**	**0.951**	**-2.467**	**0.015**
Year 2013	**0.860**	**0.308**	**2.798**	**0.006**
Season Spring	-0.561	0.385	-1.457	0.147
Season Summer	-0.772	0.424	-1.823	0.070
Subestuary Mobjack	0.766	0.845	0.907	0.366
Subestuary York	1.005	0.855	1.175	0.242
Coarse sand	0.698	0.835	0.835	0.405
Oyster shell	**1.988**	**0.650**	**3.059**	**0.003**
Seagrass	**1.569**	**0.753**	**2.085**	**0.039**
Shell hash	1.034	0.644	1.605	0.111
Habitat volume (L)	**0.400**	**0.153**	**2.613**	**0.010**
Fish density (m^{-2})	0.593	0.413	1.436	0.153
Crab density (m^{-2})	0.102	0.504	0.203	0.840
Ray pit density (m^{-2})	3.424	2.170	1.578	0.117
Lynnhaven Site 1	0.170	0.794	0.213	0.831
Lynnhaven Site 2	-0.401	0.920	-0.436	0.663
Lynnhaven Site 3	0.438	0.761	0.576	0.566
Mobjack Site 1	-0.342	0.598	-0.571	0.569
Mobjack Site 2	-1.513	0.870	-1.739	0.084
Mobjack Site 3	0.378	0.521	0.726	0.469
York Site 1	**-2.986**	**1.202**	**-2.484**	**0.014**
York Site 2	0.641	0.628	1.020	0.309
York Site 3	-0.311	0.805	-0.386	0.700

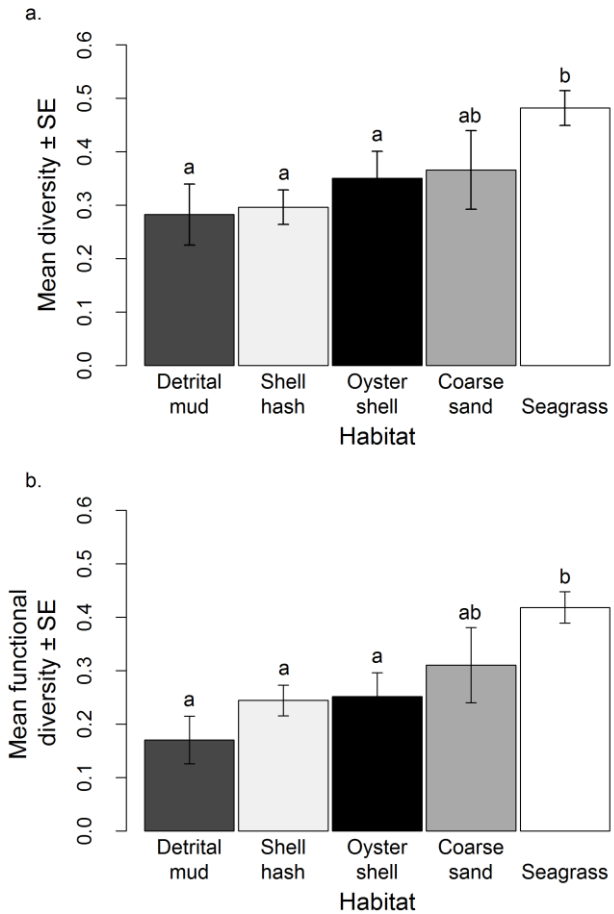

Figure S1. Bivalve diversity in different habitats. Means ±1 standard error (SE) for a) Gini-Simpson diversity index and b) functional diversity (Gini-Simpson diversity index of functional groups) in different habitat types in lower Chesapeake Bay. Samples were collected in detrital mud (n = 21), shell hash (n = 61), oyster shell (n = 30), coarse sand (n = 13), and seagrass (n = 55). Letters denote significant differences at $\alpha = 0.05$.