

Ecosystem services of restored oyster reefs in a Chesapeake Bay tributary: abundance and foraging of estuarine fishes

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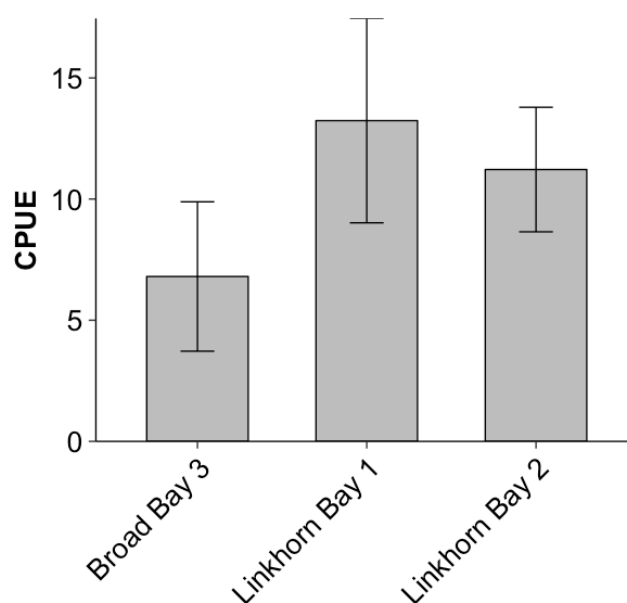


Figure S1: Comparison of mean (\pm 1 SE) fish catch per unit effort (CPUE; no. of fish caught hour⁻¹ gill net set) between three oyster reef sites in the Lynnhaven River System, Virginia. Differences among sites were not statistically significant when tested using a generalized linear model (assuming a negative binomial distribution and a log-link function) including site as an explanatory variable and soak time as an offset term.

Table S1: Summary of environmental conditions observed at all sites during the study period (April – October 2016).

Month	Salinity (psu)			Water temperature (°C)			Dissolved oxygen (mg L ⁻¹)		
	Mean (SE)	Min.	Max.	Mean (SE)	Min.	Max.	Mean (SE)	Min.	Max.
April/May	24.3 (0.1)	23.6	24.8	19.5 (0.2)	18.3	20.9	7.8 (0.1)	7.1	8.2
June	21.8 (0.2)	20.4	23.6	26 (0.2)	23.7	27.7	6.9 (0.3)	5.1	8.6
July	23.5 (0.3)	22.2	25.4	30.2 (0.3)	28.3	31.4	6.4 (0.3)	5.1	8.3
August	25.1 (0.2)	24.0	26.2	29.2 (0.3)	27.5	31.7	5.7 (0.3)	4.1	8.1
September	25.1 (0.2)	24.1	26.0	26.9 (0.2)	25.7	28.0	7.6 (0.2)	6.9	8.2
October	18 (0.4)	15.5	21.1	20.3 (0.5)	17.0	22.5	7.8 (0.1)	6.9	9.1

Table S2: AIC results for generalized linear model analysis of fish abundance and Atlantic croaker *Micropogonias undulatus* presence-absence. A) Total fishes, b) spot *Leiostomus xanthurus*, c) silver perch *Bairdiella chrysoura*, d) Atlantic croaker. The five models with the lowest AICc values are listed for each response, and ranked in order of increasing AIC value. Δ AICc = difference in AICc from top model, k = model degrees of freedom, and w_i = Akaike weights. See Table 1 for model descriptions. Hab = habitat, WT = Water temperature, Sal = salinity, (Site) = Sampling site (random effect term), Hab*Month = model including both additive and interactive effect of habitat and month.

A) Total catch				
Model	k	AICc	Δ AICc	w_i
g ₆ : Hab + WT	4	599.98	0	0.51
g ₉ : Hab + WT + Sal	5	601.56	1.58	0.23
g ₁₁ : Hab + WT + (Site)	5	601.71	1.72	0.22
g ₈ : Hab + Month + Tide	9	606.03	6.05	0.02
g ₃ : Hab + Month	7	608.19	8.21	0.01
B) Spot catch				
Model	k	AICc	Δ AICc	w_i
g ₆ : Hab + WT	4	458.5	0	0.41
g ₁₁ : Hab + WT + (Site)	5	460.03	1.53	0.19
g ₁₀ : Hab + Month + (Site)	8	460.48	1.98	0.15
g ₉ : Hab + WT + Tide	5	460.67	2.17	0.14
g ₈ : Hab + Month + Tide	9	462.14	3.63	0.07
C) Silver perch catch				
Model	k	AICc	Δ AICc	w_i
g ₁ : Intercept-only	2	207.27	0	0.22
g ₄ : Hab*Month	9	207.68	0.41	0.18
g ₃ : Hab + Month	6	207.81	0.54	0.17
g ₂ : Hab	3	208.53	1.26	0.12
g ₁₀ : Hab + Month + (Site)	7	208.86	1.59	0.1
D) Croaker presence-absence				
Model	k	AICc	Δ AIC	w_i
g ₂ : Month	5	90.34	0	0.36
g ₈ : Month + Tide	7	90.71	0.37	0.30
g ₄ : Month + Hab	6	92.30	1.96	0.13
g ₅ : Month * Hab	10	92.65	2.31	0.11
g ₁₀ : Month + Hab + Tide	8	93.10	2.75	0.09

Table S3: Parameter estimates from the most likely generalized linear models for a) total fish catch, b) spot *Leiostomus xanthurus* catch, c) silver perch *Bairdiella chrysoura* catch, and d) Atlantic croaker *Micropogonias undulatus* presence or absence. Bold values indicate statistically significant estimates ($\alpha = 0.1$ level). List of possible models given in Table 1, and AICc model rankings in Table S4.

A) Total catch				
Model: g ₆ , AICc = 599.98, k = 4				
Variable	Estimate	SE	Z-Statistic	P
(Intercept)	-2.82	0.67	-4.23	<0.005
Habitat: Reef	-0.33	0.18	-1.83	0.07
Water temperature	0.16	0.02	6.27	<0.005
B) Spot catch				
Model g ₆ , AICc = 458.50, k = 4				
Variable	Estimate	SE	Z-Statistic	P
(Intercept)	-7.32	1.11	-6.59	<0.005
Habitat: Reef	-0.49	0.26	-1.86	0.06
Water temperature	0.29	0.04	7.08	<0.005
C) Silver perch catch				
Model: g ₁ , AICc = 207.27, k = 2				
Variable	Estimate	SE	Z-Statistic	P
(Intercept)	-1.48	0.23	-6.45	<0.005
D) Croaker presence-absence				
Model: g ₂ , AIC = 90.33, k = 5				
Variable	Estimate	SE	Z-Statistic	P
(Intercept)	0.875	0.532	1.645	0.1
Month: July	-1.212	0.791	-1.532	0.13
Month: August	-0.423	0.719	-0.589	0.56
Month: September	-2.485	0.94	-2.644	< 0.1
Month: October	-3.709	1.158	-3.201	< 0.001

Table S4: AICc results for generalized linear model analysis of a) silver perch *Bairdiella chrysoura*, b) spot *Leiostomus xanthurus* and c) Atlantic croaker *Micropogonias undulatus* stomach fullness during the monthly survey. Models ranked in order of increasing AICc value. $\Delta AICc$ = difference in AICc from top model, k = model degrees of freedom, and w_i = Akaike weights. Habitat*Month = Model including both additive and interactive effect of habitat and month.

A) Silver perch				
Model	k	AICc	$\Delta AICc$	w_i
Intercept-only	2	122.75	0	0.61
Habitat	3	124.03	1.27	0.32
Habitat + Month	6	127.45	4.7	0.06
Habitat * Month	9	132.17	9.41	0.01
B) Spot				
Model	k	AICc	$\Delta AICc$	w_i
Habitat + Month	7	199.15	0	0.69
Intercept-only	2	201.39	2.24	0.22
Habitat	3	203.52	4.37	0.08
Habitat * Month	11	207.26	8.1	0.01
C) Atlantic croaker				
Model	k	AICc	$\Delta AICc$	w_i
Intercept-only	2	120.74	0	0.74
Habitat	3	123.01	2.27	0.24
Habitat + Month	7	127.42	6.68	0.03
Habitat * Month	9	136.46	15.72	0

Table S5: Parameter estimates from the best-fit generalized linear models for a) silver perch *Bairdiella chrysoura*, b) spot *Leiostomus xanthurus* and c) Atlantic croaker *Micropogonias undulatus* stomach fullness during the monthly survey. Bolded values indicate statistically significant estimates ($\alpha = 0.1$ level). AICc model rankings in Table S6. *Model did not perform better than an intercept only model.

A) Silver perch - AICc = 91.9, $k = 3$*				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-7.83	0.49	-15.89	<0.005
Habitat: Reef	0.65	0.66	0.99	0.33

B) Spot - Model: g_3, AICc = 190.02, $k = 7$				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-6.743	0.319	-21.126	< 0.001
Habitat: Reef	-0.102	0.268	-0.382	0.7
Month: July	-1.162	0.426	-2.732	0.008
Month: Aug.	-1.3	0.374	-3.474	< 0.001
Month: Sept.	-1.014	0.437	-2.323	0.024
Month: Oct.	-0.812	0.437	-1.86	0.068

C) Atlantic croaker - Model: g_2, AICc = 123.01, $k = 3$*				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-6.685	0.438	-15.253	< 0.001
Habitat: Reef	-0.087	0.592	-0.147	0.88

Table S6: AICc results for generalized linear model analysis of a) silver perch *Bairdiella chrysoura*, b) spot *Leiostomus xanthurus* and c) Atlantic croaker *Micropogonias undulatus* stomach fullness during the 24-hour survey. Models ranked in order of increasing AICc value. ΔAICc = difference in AICc from top model, k = model degrees of freedom, and w_i = Akaike weights.

A) Silver perch				
Model	k	AICc	ΔAICc	w_i
Habitat	3	85.67	0	0.44
Intercept-only	2	87.4	1.73	0.18
Habitat + Set time	8	87.86	2.19	0.15
Habitat + Month	5	88.35	2.68	0.11
Set Time	7	88.47	2.8	0.11
Habitat + Month + Set time	9	92.93	7.26	0.01
B) Spot				
Model	k	AICc	ΔAICc	w_i
Habitat + Month	5	54.34	0	1
Habitat	3	69.36	15.03	0
Intercept-only	2	69.69	15.35	0
Habitat + Month + Set time	9	70.73	16.4	0
Set Time	7	83.43	29.1	0
Habitat + Set time	8	84.37	30.04	0
C) Atlantic croaker				
Model	k	AICc	ΔAICc	w_i
Intercept-only	2	35.7	0	0.69
Habitat	3	37.59	1.89	0.27

Table S7: Parameter estimates from the best-fit generalized linear models for a) silver perch (*Bairdiella chrysoura*), b) spot (*Leiostomus xanthurus*), and c) Atlantic croaker (*Micropogonias undulatus*) stomach fullness during the 24-hour survey. Bold values indicate statistically significant estimates ($\alpha = 0.1$ level). AICc model rankings in Table S8. *Model did not perform (higher AICc) than the intercept-only model.

A) Silver perch - AICc = 85.67, $k = 3$				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-7.038	0.461	-15.26	< 0.001
Habitat: Reef	1.331	0.652	2.04	0.055

B) Spot - AICc = 54.34, $k = 5$				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-6.72	0.25	-27.24	< 0.005
Habitat: Reef	-0.61	0.29	-2.11	0.05
Month: September	-1.39	0.29	-4.81	< 0.005

C) Atlantic croaker - AICc = 37.6, $k = 3^*$				
Variable	Estimate	SE	t-Statistic	P
(Intercept)	-5.980	0.438	-15.25	< 0.001
Habitat: Reef	-0.661	0.658	-1.00	0.342