UPDATE: Bay Wide Approach: Threshold effects of altered shorelines and other stressors on forage species in Chesapeake Bay

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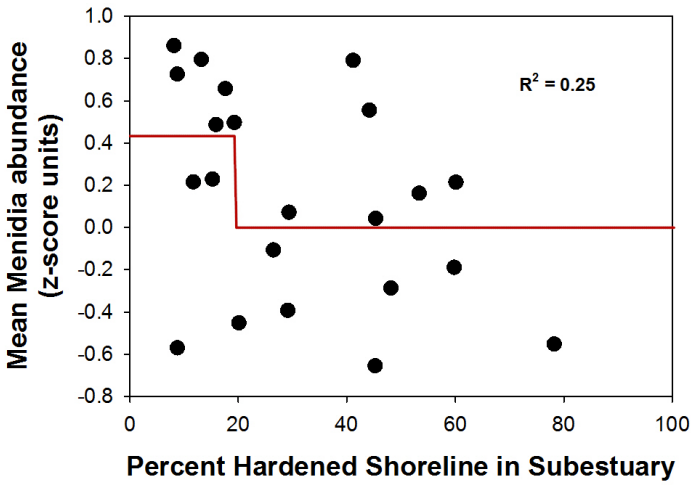
Bay-wide Approach: Methods

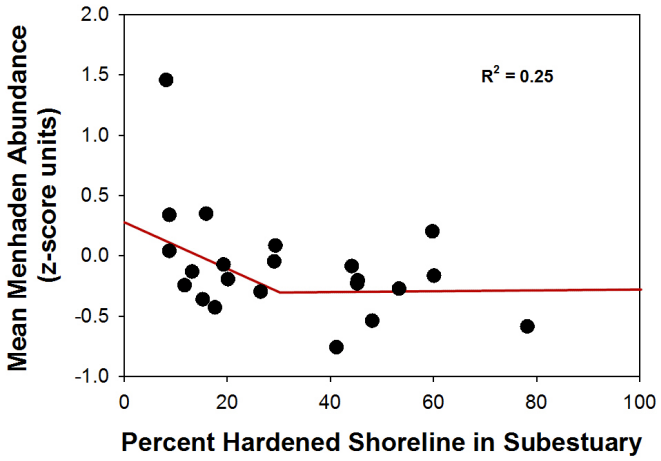
- Examine previously compiled Bay-wide data sets (588 sites Kornis et al. 2017) for threshold shoreline condition effects on important forage species (identified in Ihde et al. 2015 report)
- Graphical approach fitting non-linear curves (piecewise, sigmoidal)
- Examine new data sets (e.g., juvenile blue crab survey and Bay-wide blue crab dredge survey) for threshold shoreline condition effects for blue crabs

Results: Curves for thresholds - forage fish

***Menidia* sp.**
Sigmoidal

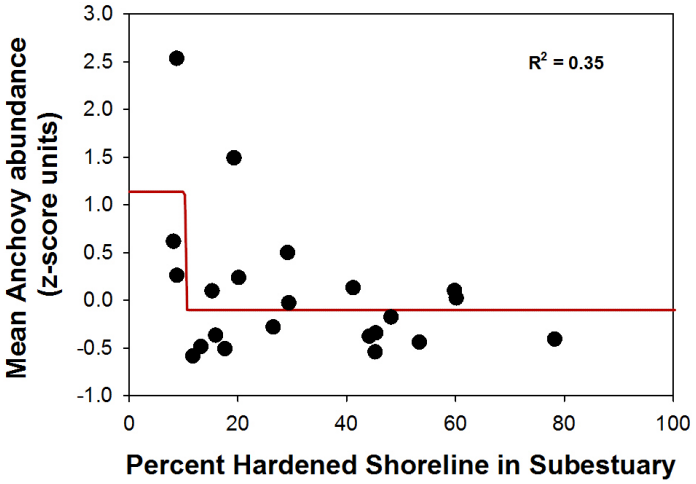


Atlantic Menhaden
Piecewise Regression

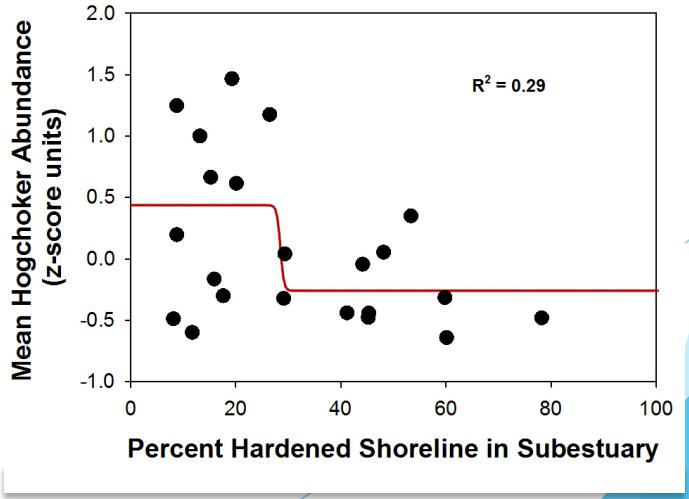


All improved over linear:
-*Menidia*
R^2 0.25>0.16
-Anchovy
R^2 0.35>0.13
-Menhaden
R^2 0.25>0.18
-Hogchoker
R^2 0.29>0.19

Bay Anchovy
Sigmoidal

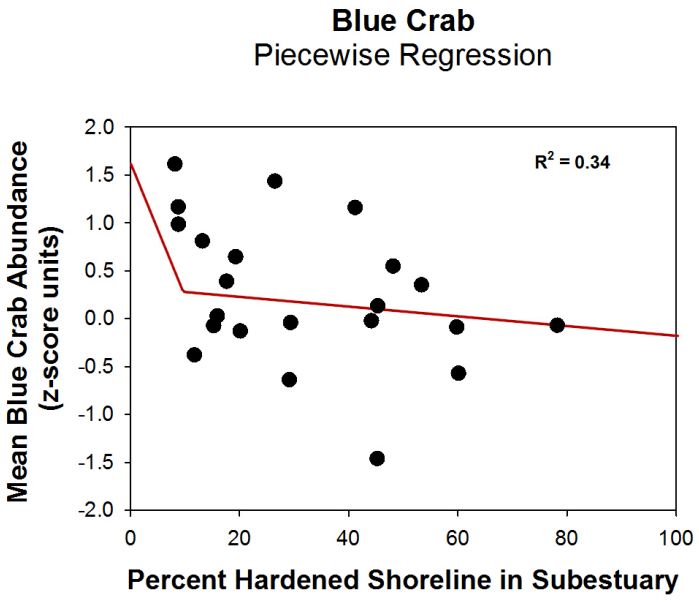


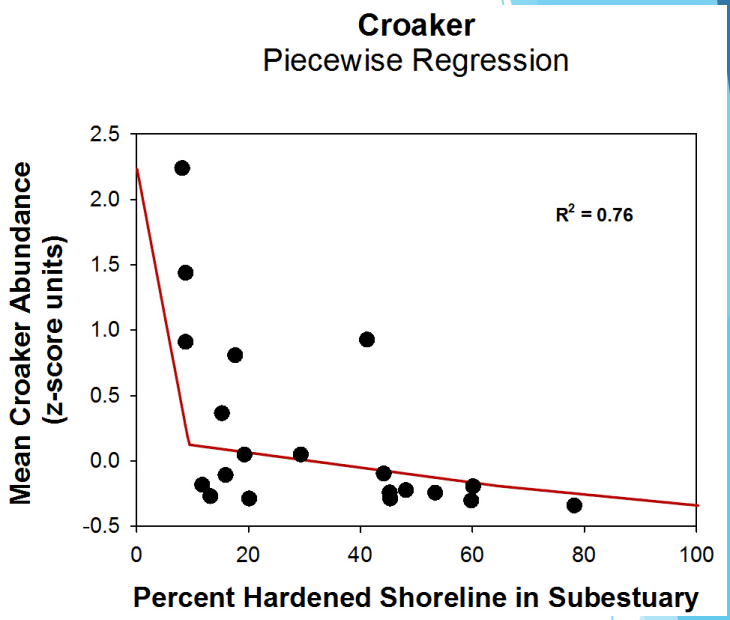
Hogchoker
Sigmoidal

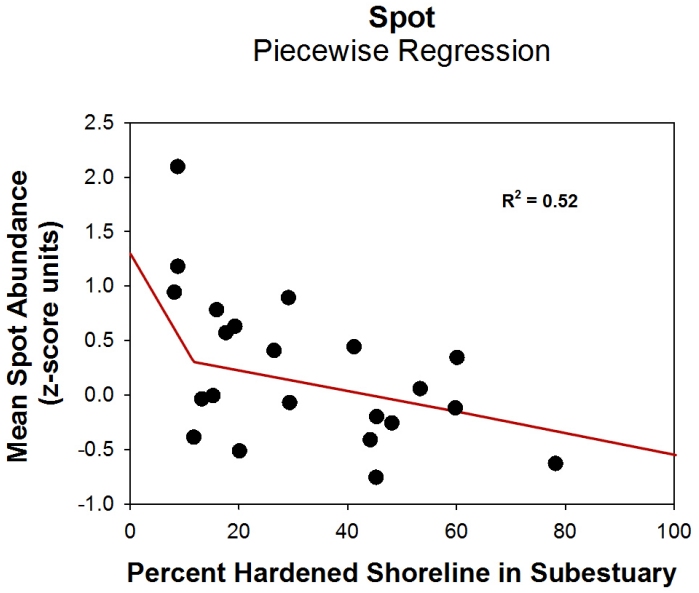


Threshold levels:
-*Menidia* 20%
-Anchovy 10%
-Menhaden 30%
-Hogchoker 30%

Results: Curves for thresholds - Crab, Spot, Croaker



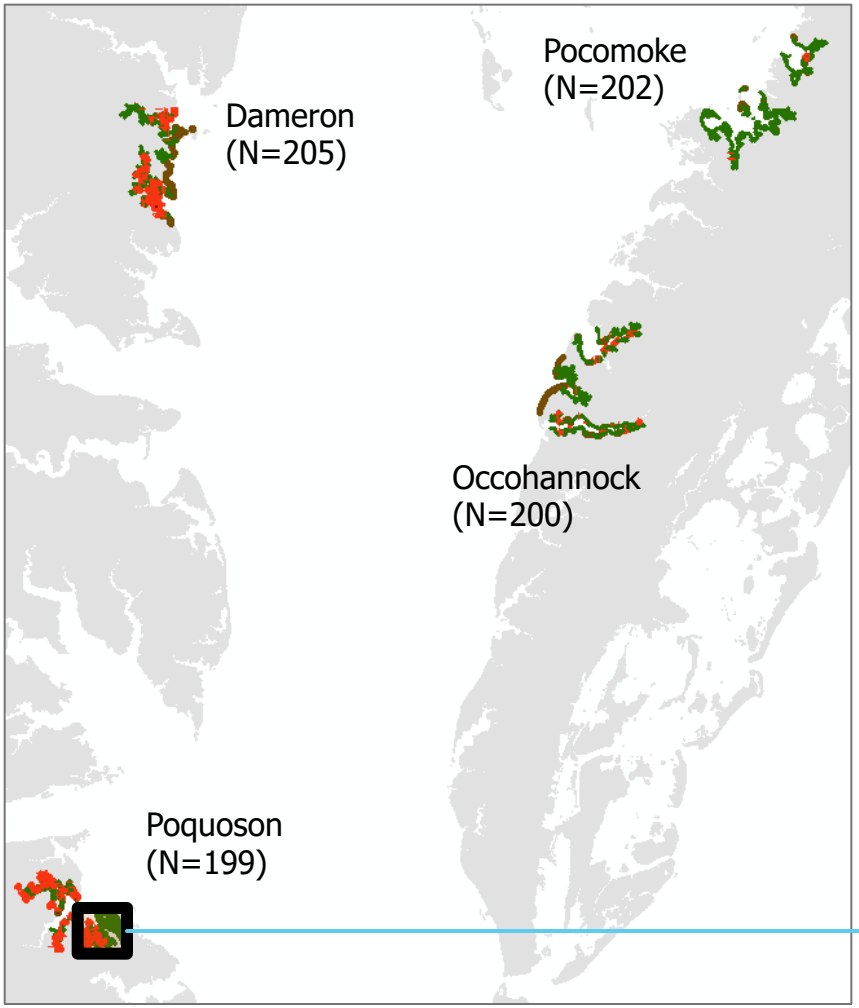


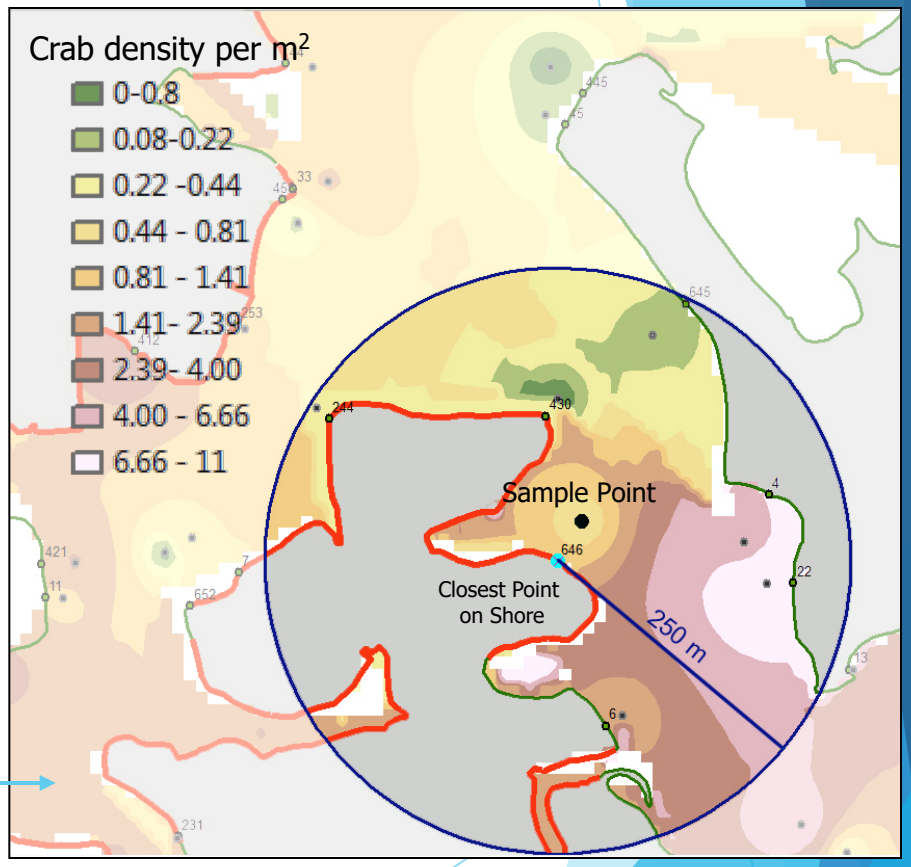


All improved over linear:
-Crab
R^2 0.34>0.16
-Spot
R^2 0.52>0.29
-Croaker
R^2 0.76>0.29

Threshold levels:
-Crab 10%
-Spot 10%
-Croaker 10%

Juvenile Crab Survey
Methods: 4 locations – link crab sample to nearest shoreline



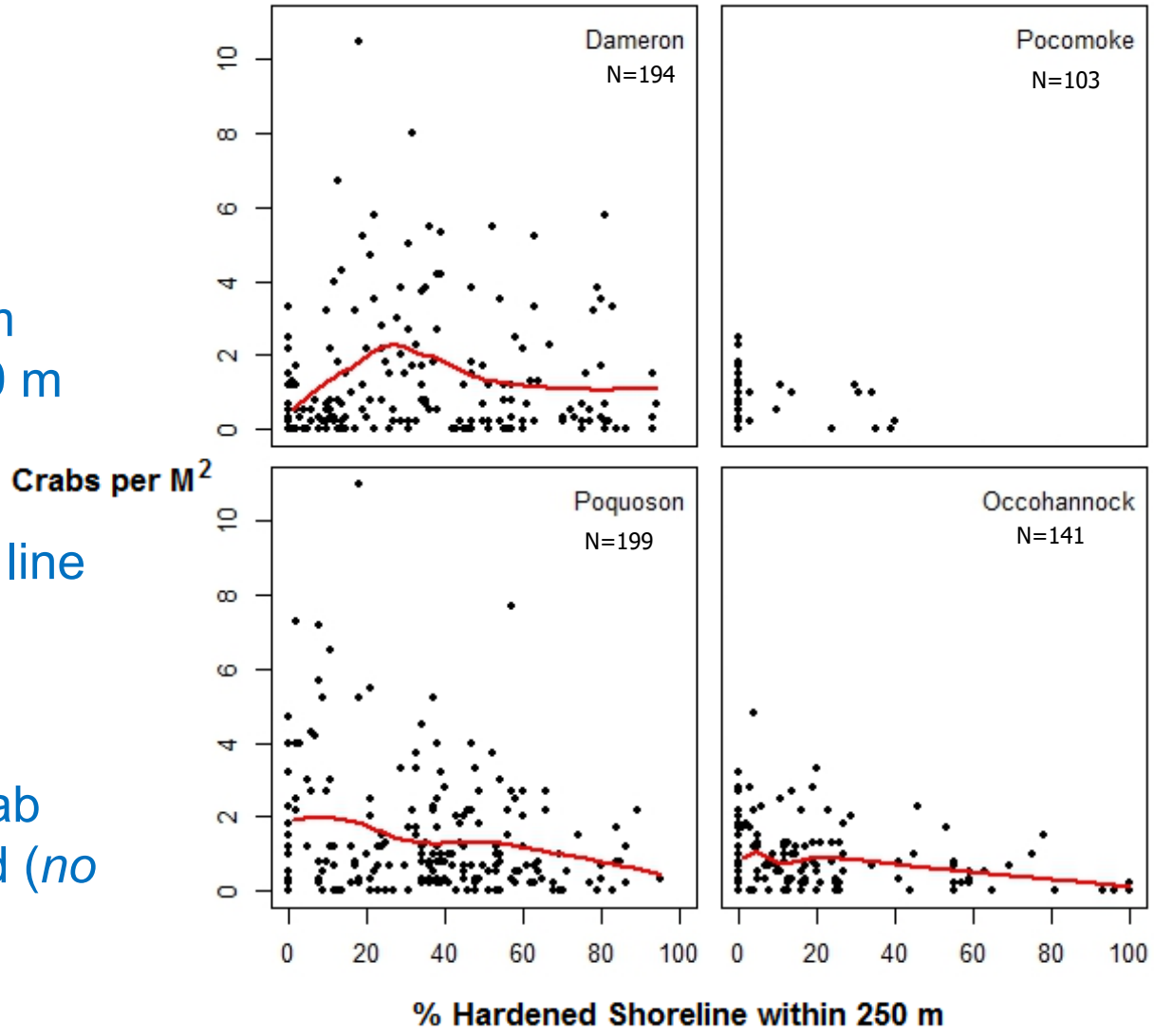


Shoreline Key
Red = developed
Green + Brown = natural

Used only points <250 m from shore
Calculated % developed within 250 m of that point

Juvenile blue crab survey: threshold with % hardened shore?

- Only points within 250 m from land and using 250 m shoreline buffer
- Red is Loess smoothed line through data
- Results: declining linear relationship between crab density and % hardened (*no threshold*)
- AIC used to compare influence of % hardened shore and upland use



Model	Variables (Estimate and SE)						
	Intercept	Area	Temperature (°C)	Salinity (psu)	Dissolved O_2 (mg/L)	Shoreline %Hardened	Upland Use %Developed
g_1	B_0	B_1-B_3	B_4	B_5	B_6	B_7	B_8
g_2	B_0	B_1-B_3		B_5		B_7	B_8
g_3	B_0	B_1-B_3				B_7	B_8
g_4	B_0	B_1-B_3					B_8
g_5	B_0	B_1-B_3				B_7	
g_6	B_0	B_1-B_3					
g_7	B_0						

Model	k	AIC	ΔAIC	w_i
g_1	10	2730.9	0.9	0.35
g_2	8	2730.0	0.0	0.56
g_3	7	2735.7	5.7	0.03
g_4	6	2738.3	8.3	0.01
g_5	6	2735.3	5.3	0.04
g_6	5	2738.0	8.0	0.01
g_7	2	2746.5	16.5	0.00

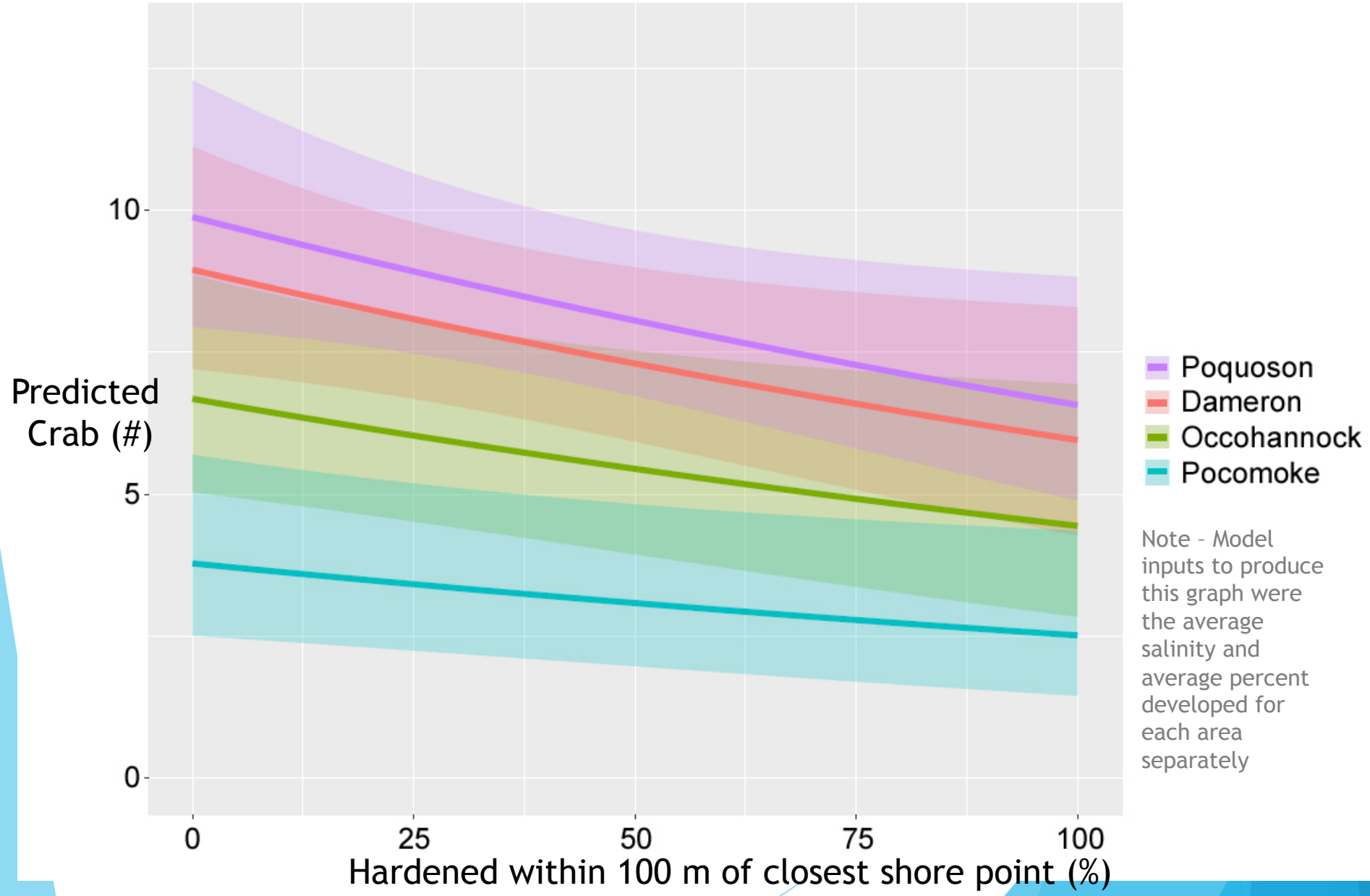
Coefficient		Estimate	SE	IRR
Intercept		0.8235	0.5434	2.279
AREA	Occohannock	-0.5318	0.1978	0.588
	Pocomoke	-1.1447	0.2583	0.318
	Poquoson	-0.2844	0.1903	0.752
Salinity		0.0894	0.0336	1.094
Shoreline %Hardened		-0.0041	0.0019	0.996
Upland Use %Developed		-0.0020	0.0032	0.998

Interpretation of the Incidence Rate Ratio (IRR) for significant variables

1. There are 41.2% fewer and 68.2% fewer crabs in Occohannock and Pocomoke compared to Dameron
2. For every 1 psu increase in salinity, there is a 9.6% increase in crabs
3. For every 1 % increase in hardened shoreline there is 0.4% decrease in crabs

Best Model (w_i= 0.56)

Crabs ~ Area + Salinity + Hardened Shoreline in 100 m + Developed in 500 m



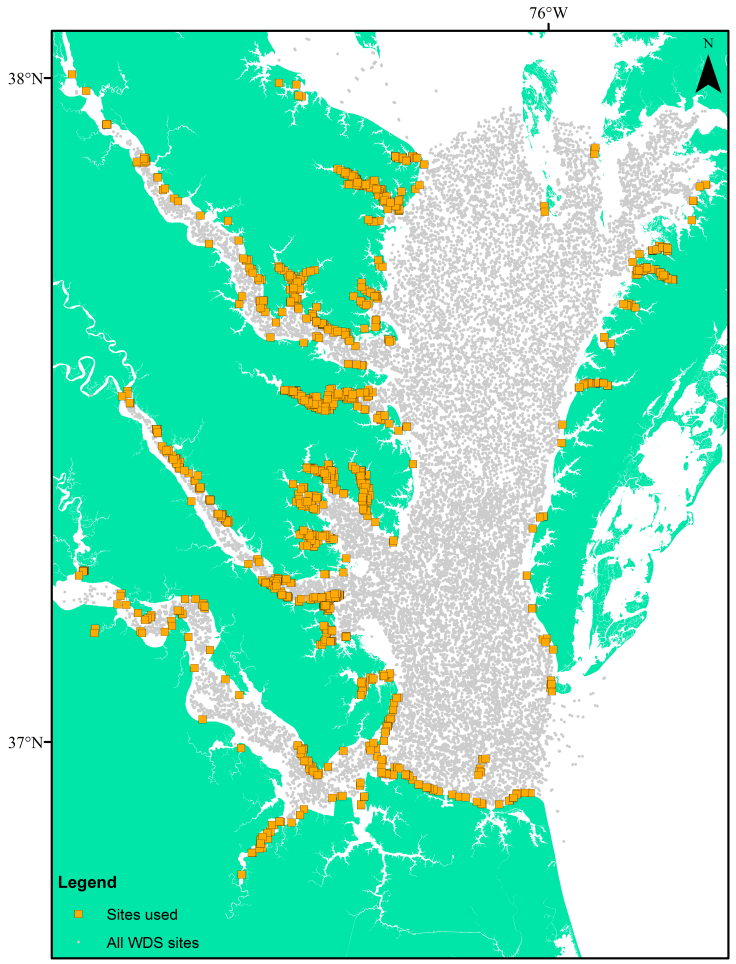
Note – Model inputs to produce this graph were the average salinity and average percent developed for each area separately

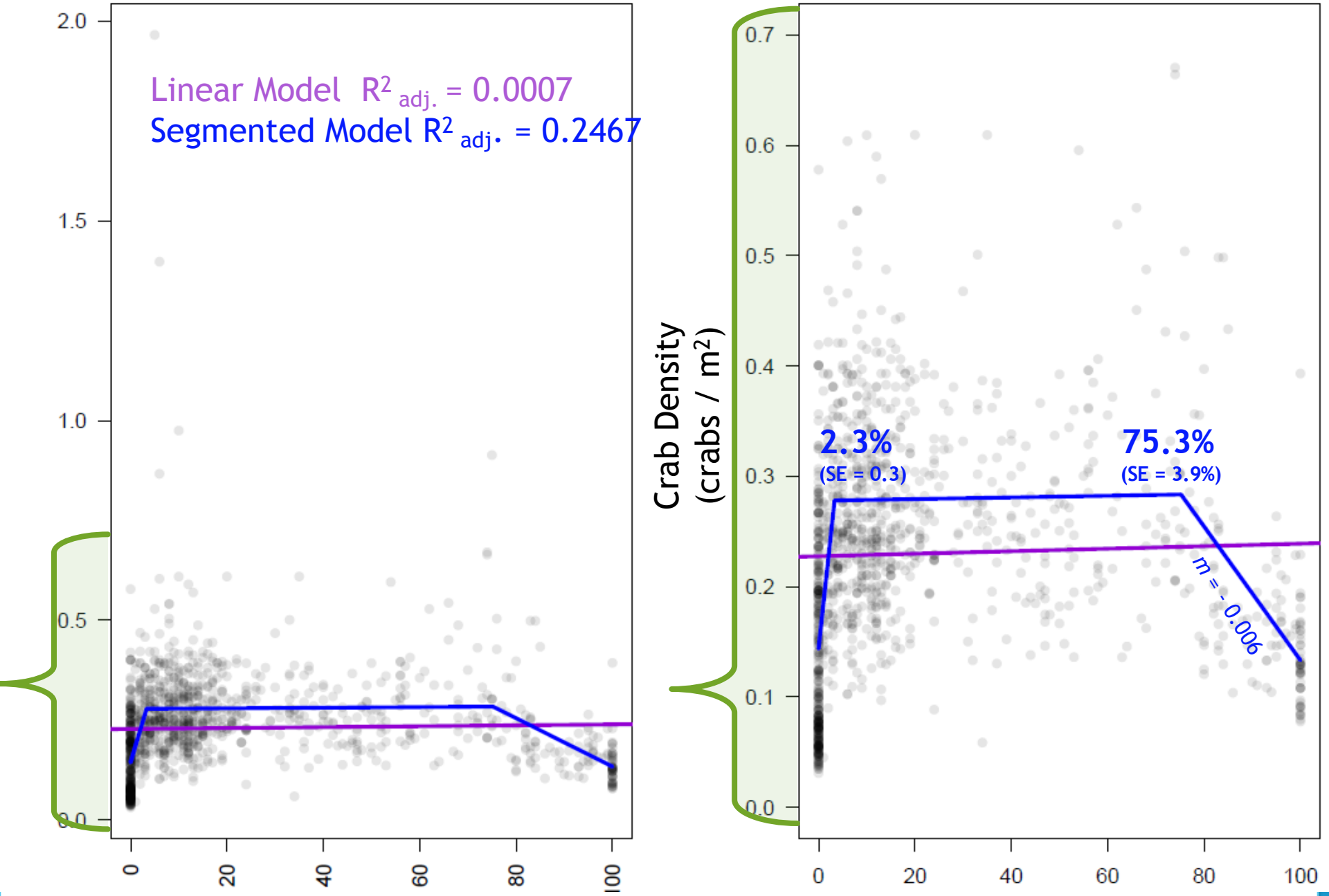
Blue Crab Winter Dredge Survey

LOESS line between % upland developed and crabs suggested a threshold, thus, we used a segmented model

Note- since only 1% of dredge points fell within 100 m of shore, % hardened shoreline was excluded from analyses, but Upland development examined

Used dredge survey sites within 500 m of shore (yellow)




Linear Model $R^2_{adj.}$ = 0.0007
Segmented Model $R^2_{adj.}$ = 0.2467
Crab Density (crabs / m²)
2.3%
(SE = 0.3)
75.3%
(SE = 3.9%)
m = - 0.006
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80
100
Developed within 500 m of closest shore point (%)

Conclusions & Future Directions

- Continue analyses and explore curve-fitting for subset of upland use
- Comparison of Bay-wide and Subestuary-scale approach
- Coordination with CBT
- Propose a numerical threshold for shoreline hardening for some species but not others
  - Of the 7 species with thresholds, range was 10-30% shoreline development
  - Mean was 17%
- Juvenile blue crabs show general decline with shoreline development
  - For every 1% increase in hardened shoreline, there was a 0.4% decrease in crabs
- Development and upland-use decisions should consider reductions in forage species
- *We thank Chesapeake Bay Trust for funding*