Fish, Shellfish and Nearshore Habitat: Exploring the Land-water Interface

Denise Breitburg
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Fish, Shellfish and Nearshore Habitat: Exploring the Land-water Interface

Land use & shoreline hardening
Diel-cycling hypoxia and acidification

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Effects of land use and shoreline hardening on fish and crabs

Land Cover

Shoreline hardening & alteration

Funding: NOAA-CSCOR (Jordan et al)

Examined Abundance Patterns for 16 species

Littoral-Benthic


Mummichog


Striped Killifish


Grass Shrimp


Naked Goby

Planktivores


At. Silverside


Bay Anchovy


Atlantic Menhaden


Gizzard Shad


Juv. Centrarchids

Benthivore/Piscivores


Atlantic Croaker


White Perch


Striped Bass

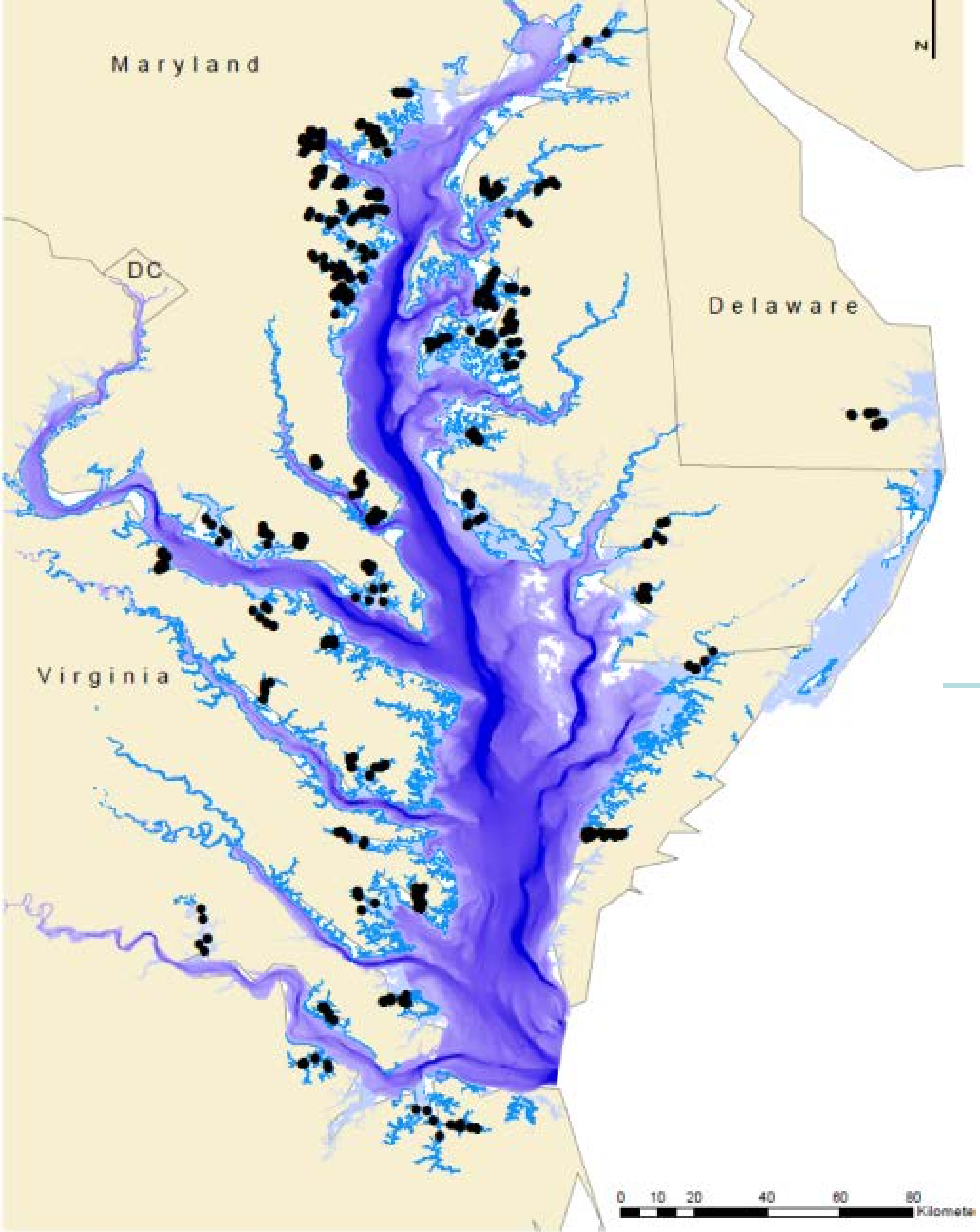

Hogchoker


Silver Perch


Adult Centrarchids


Spot


Blue Crab



Effects of land use and shoreline hardening on fish and crabs

- data spanning 45 subestuaries and 648 samples
- ≈800,000 individuals

Data Contributors

Denise Breitburg/Matt Kornis (SERC)
Rochelle Seitz (VIMS)
Donna Bilkovic (VIMS)
Richard Baloskus/Tim Targett (U-Delaware)
Denise Breitburg (SERC)
Ryan King (Baylor U, formerly of SERC)
Jim Uphoff (Maryland DNR)
Steve Giordano & David Bruce (NOAA CBO)
John Jacobs (NOAA Oxford Lab)

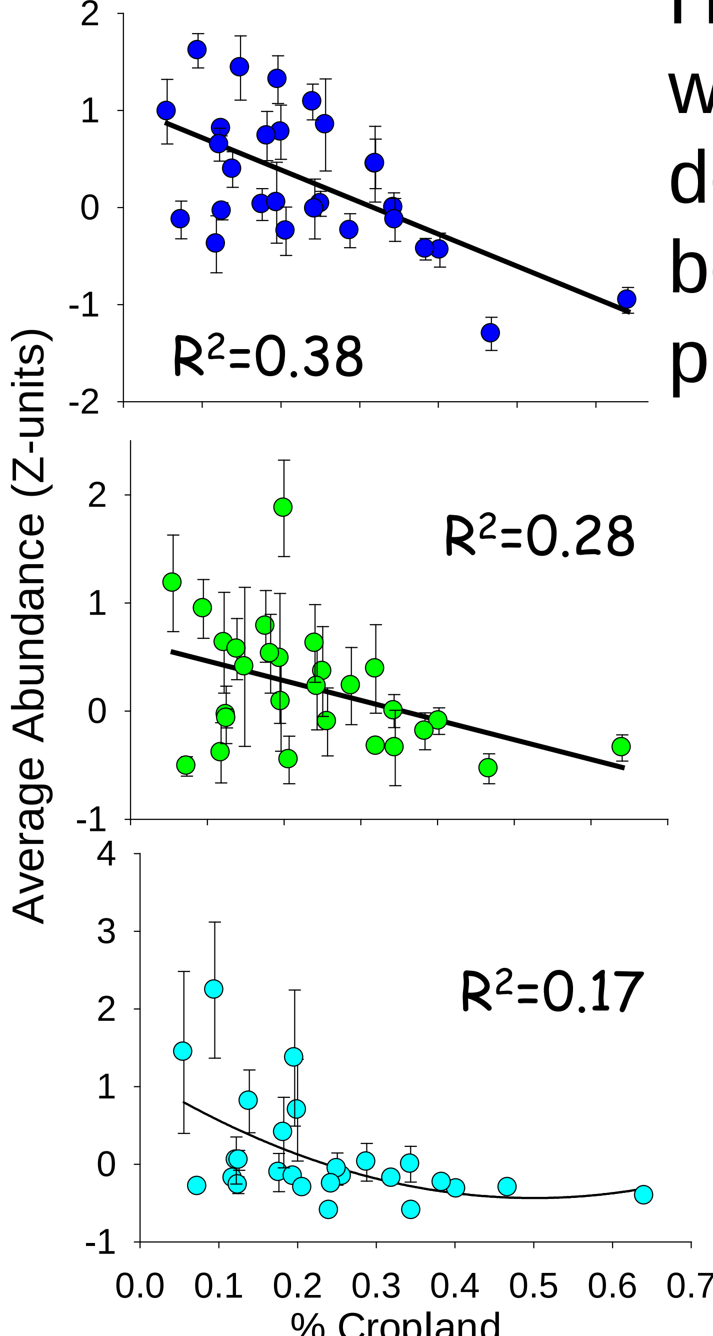
Kornis et al., in revision

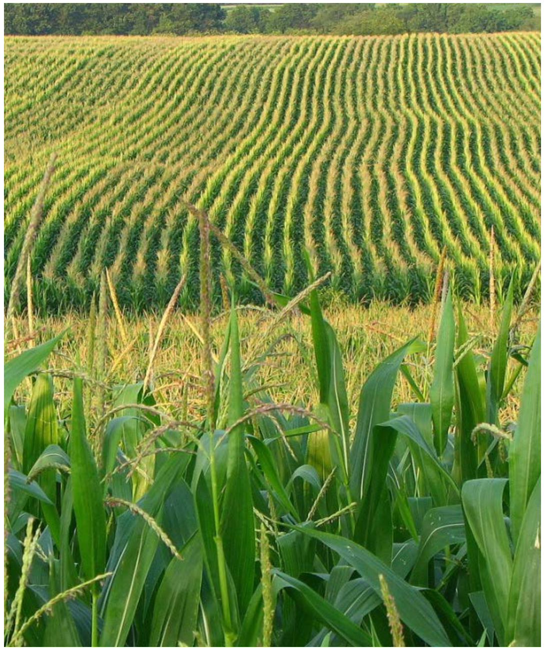
High % cropland in watershed: declines in several benthivore/ piscivores

Blue Crab

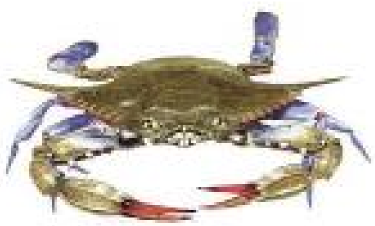
Spot

Atlantic Croaker

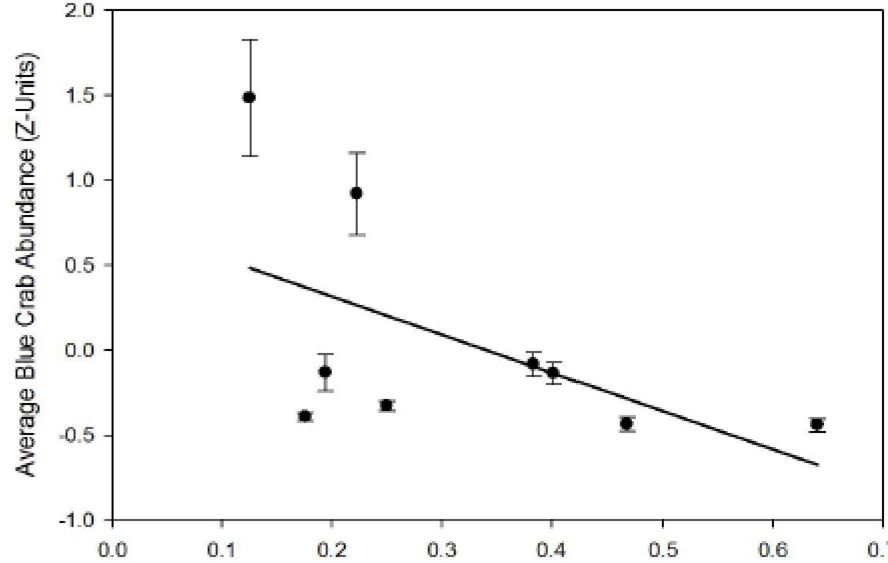




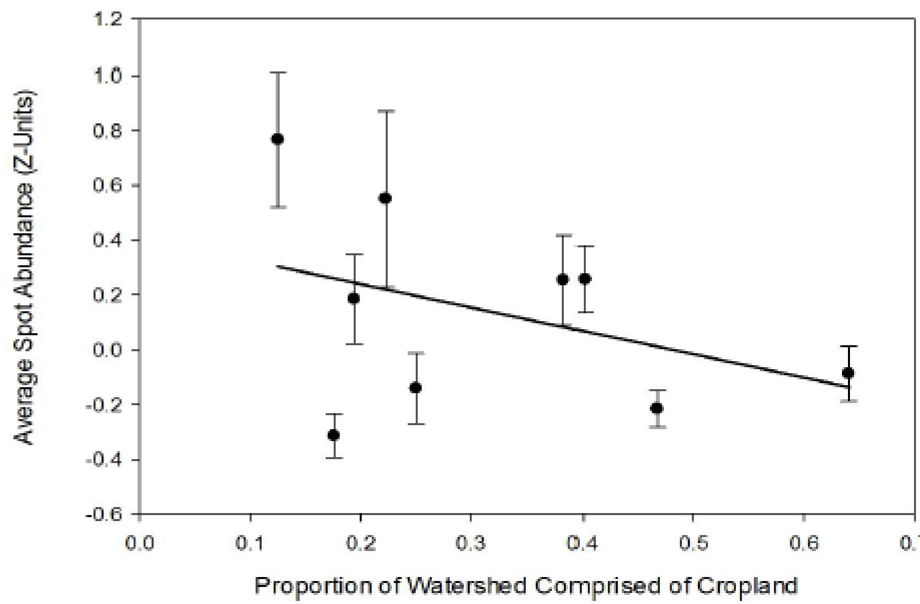
Reduced abundance is not just a shift offshore



Blue Crab



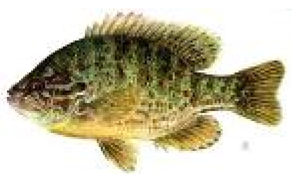
Spot



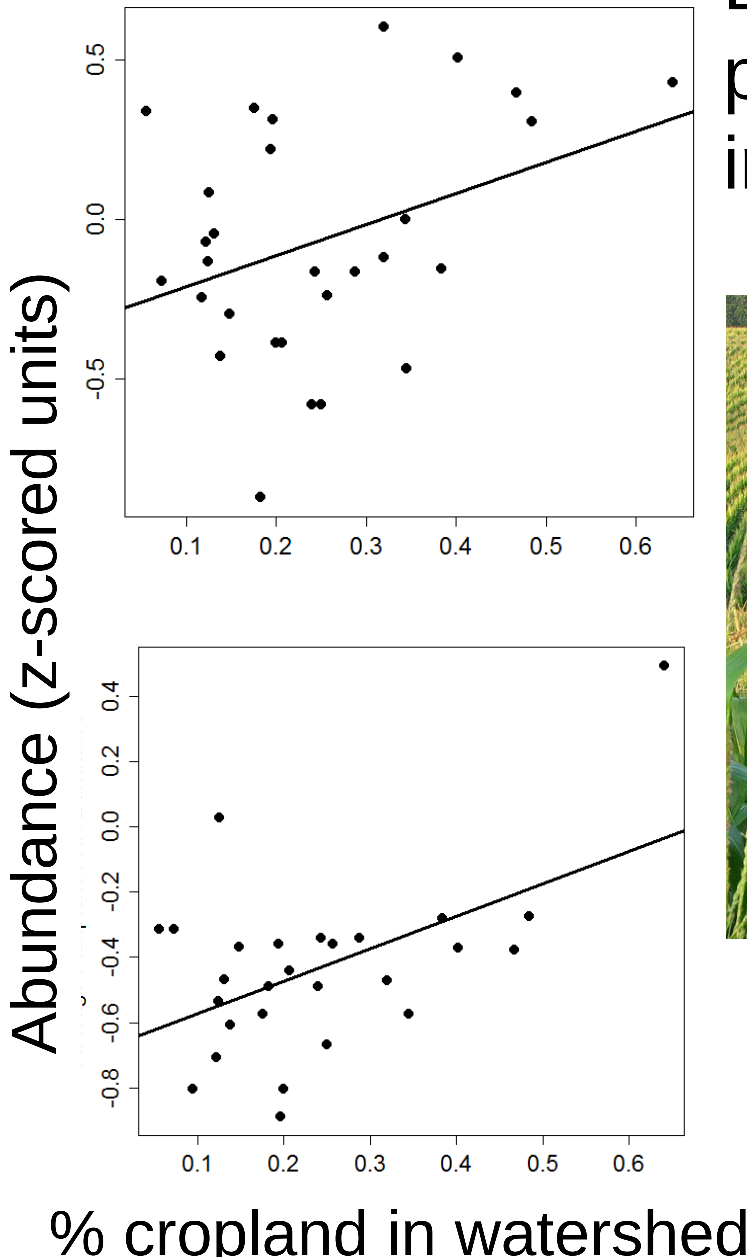
Data: Jim Uphoff, MD-DNR

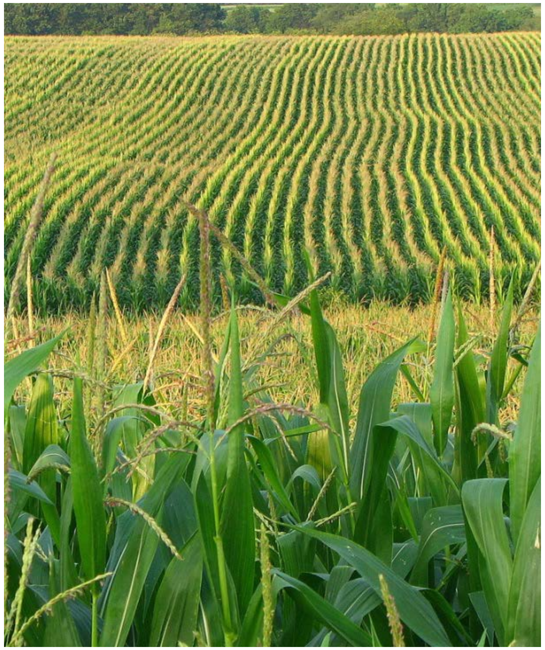
But some planktivores increase

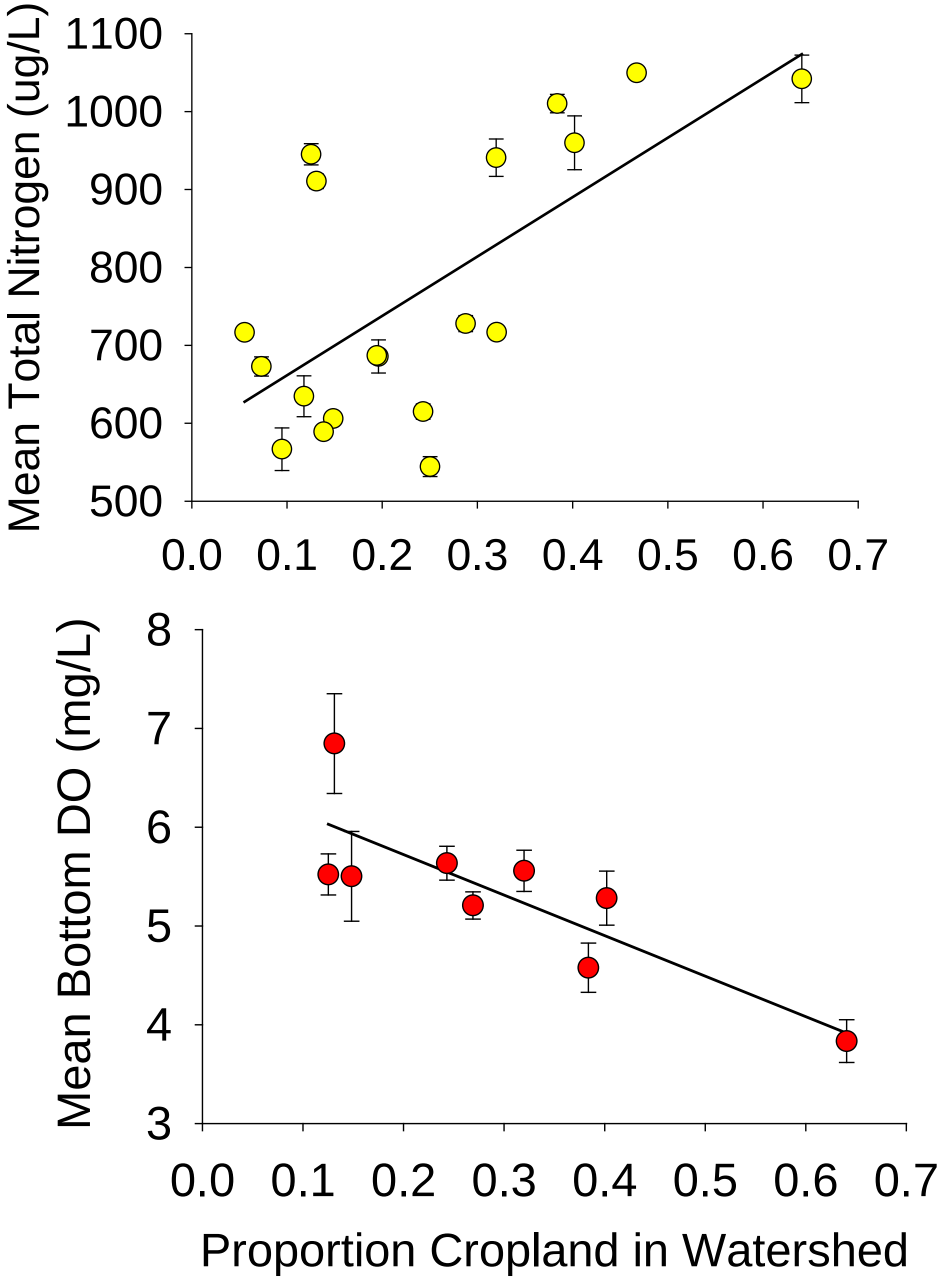
Atlantic Menhaden

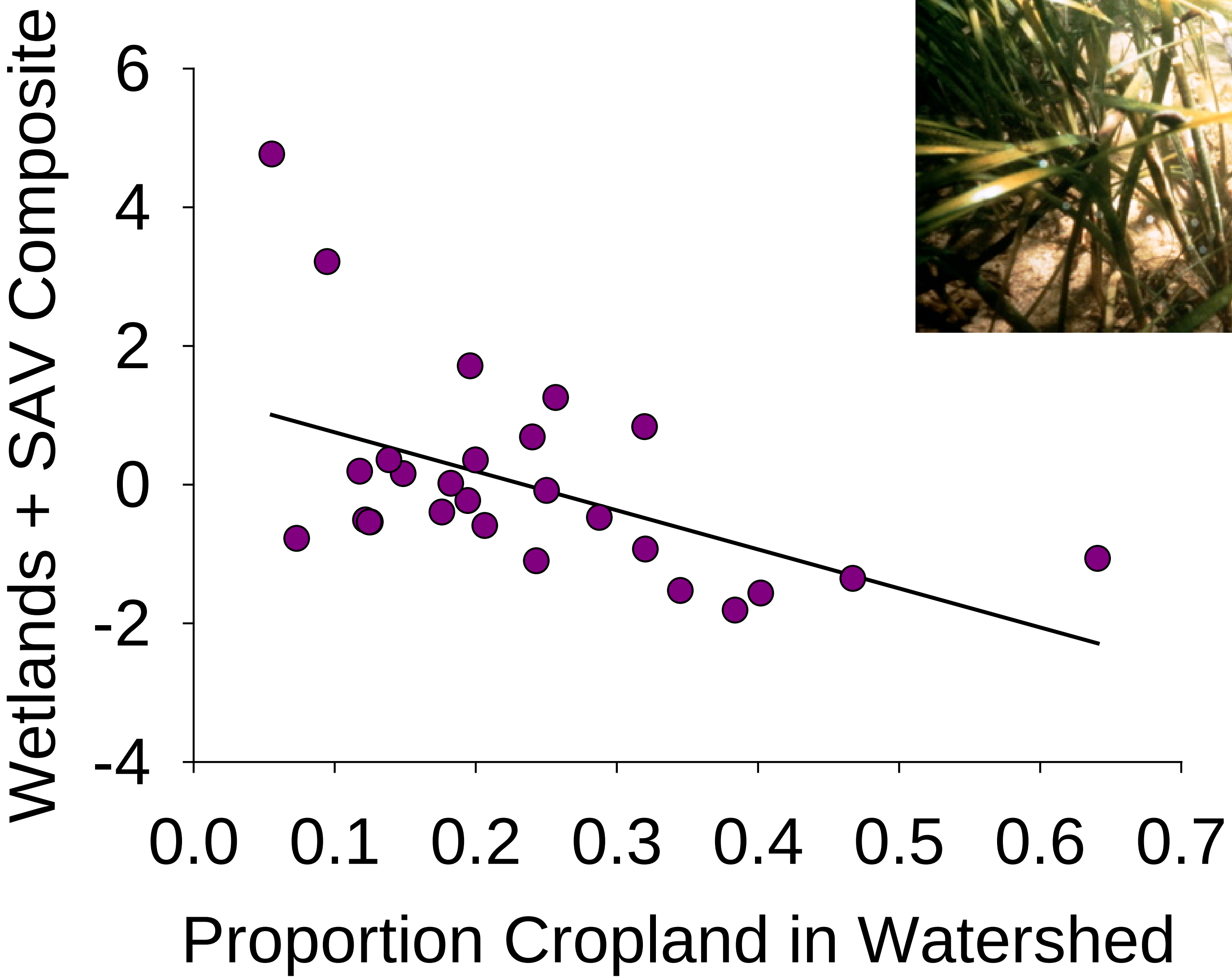


Juvenile Centrarchids





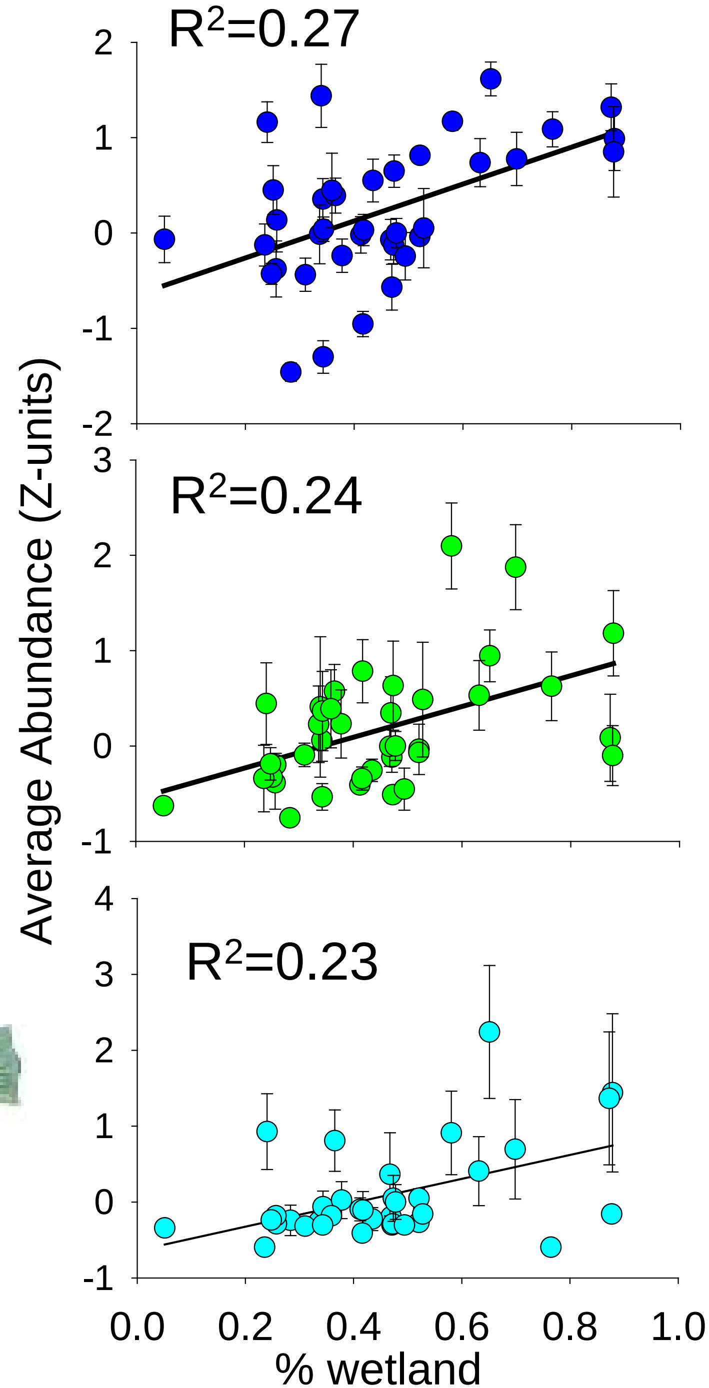

Mean Total Nitrogen (ug/L)
1100
1000
900
800
700
600
500
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Mean Bottom DO (mg/L)
8
7
6
5
4
3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Proportion Cropland in Watershed


Wetlands + SAV Composite
6
4
2
0
-2
-4
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Proportion Cropland in Watershed

Blue Crab

Spot

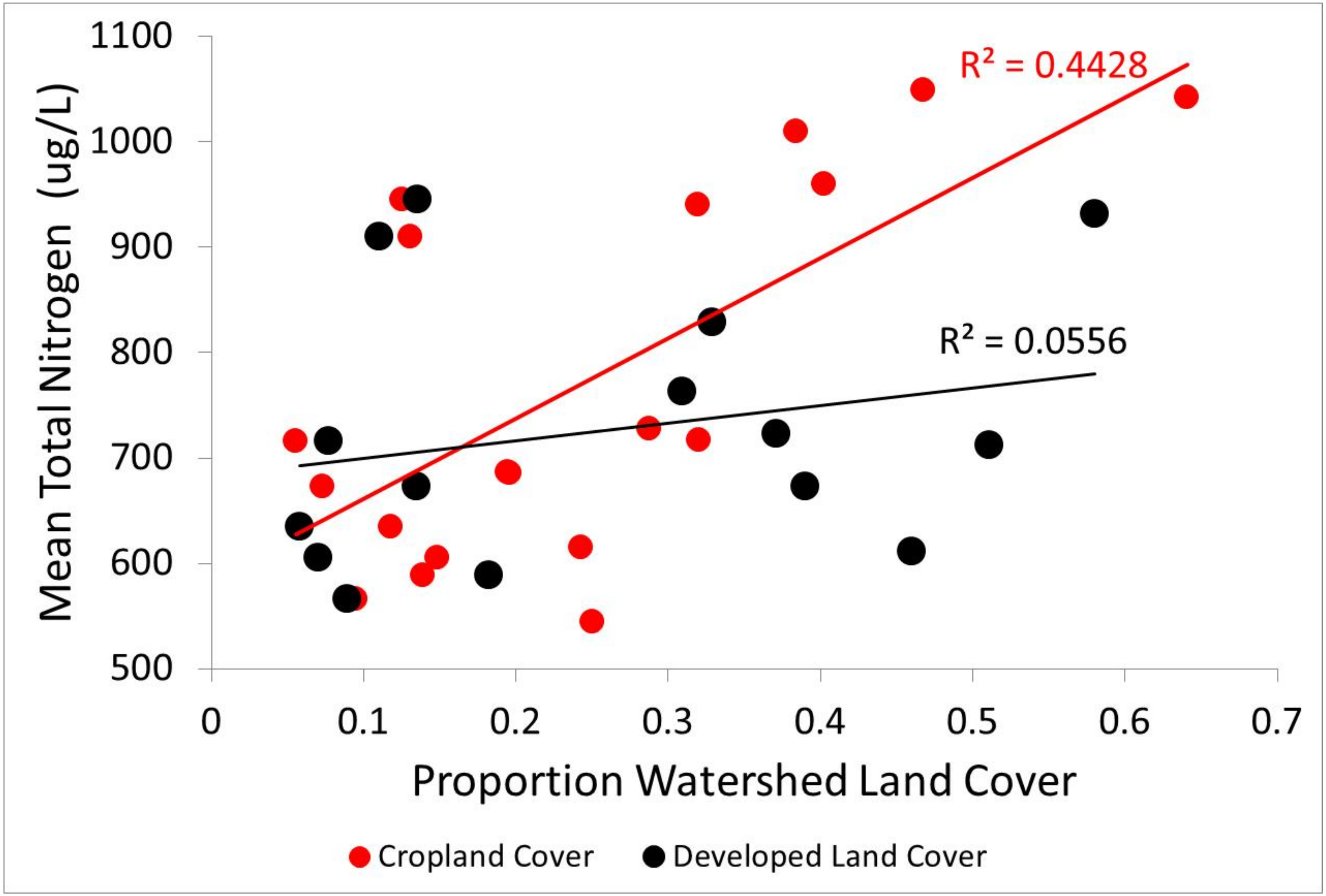
Atlantic
Croaker



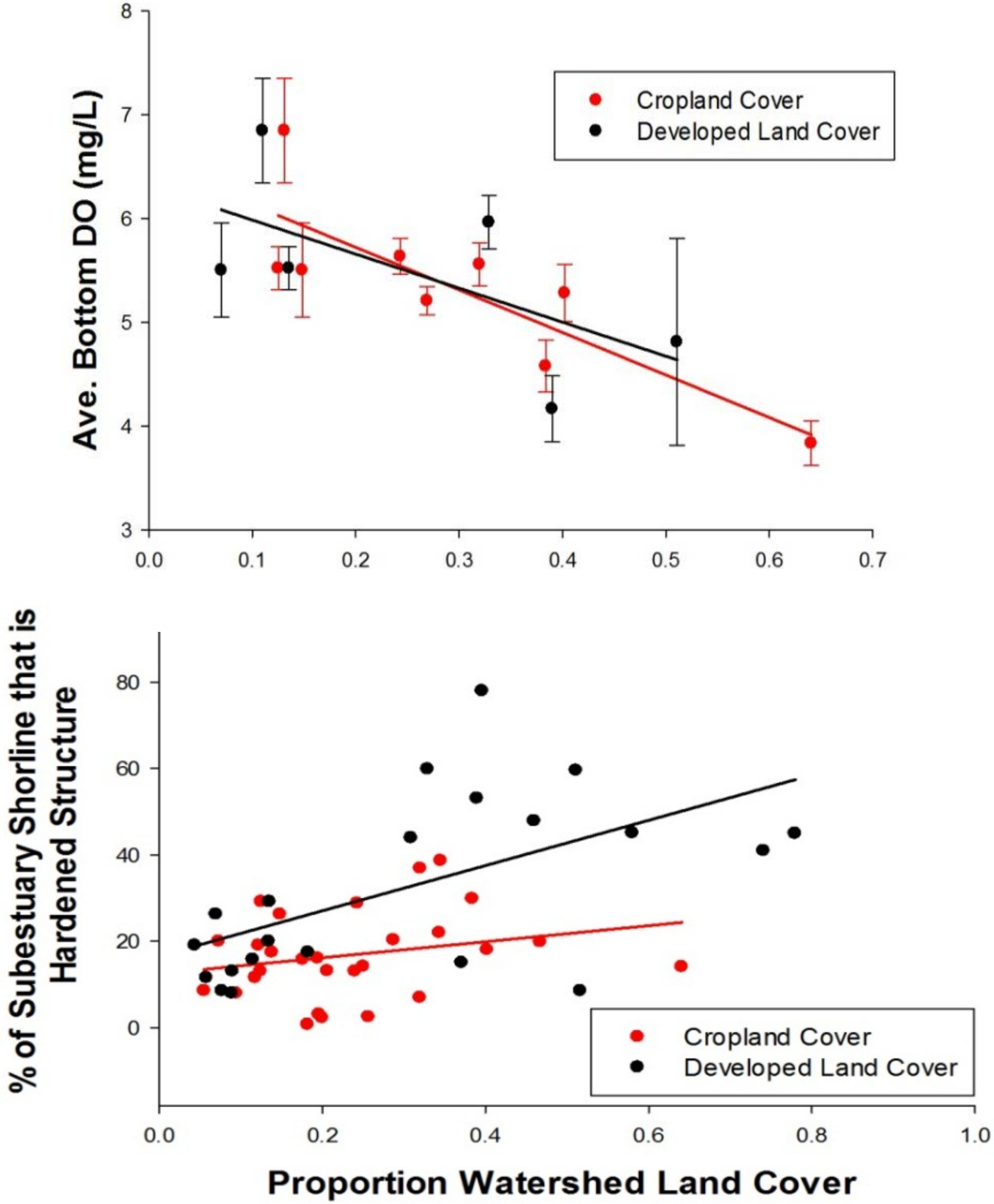
Proportion of land
within 100 m
of shoreline that
is wetland

Systems without high % developed land

	% variation among subestuaries explained if model includes:			
	Cropland	SAV	TN	SAV+TN
Blue crab	**67**	**66**	**69**	66
Croaker	71	**93**	84	94
Spot	71	**98**	57	92
Menhaden (w/o outlier)	35	0	**85** pos	94
Juvenile Centrarchidae	61	65	81 pos	81



Mean Total Nitrogen (ug/L)
1100
1000
900
800
700
600
500
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Proportion Watershed Land Cover
R² = 0.4428
R² = 0.0556
Cropland Cover
Developed Land Cover



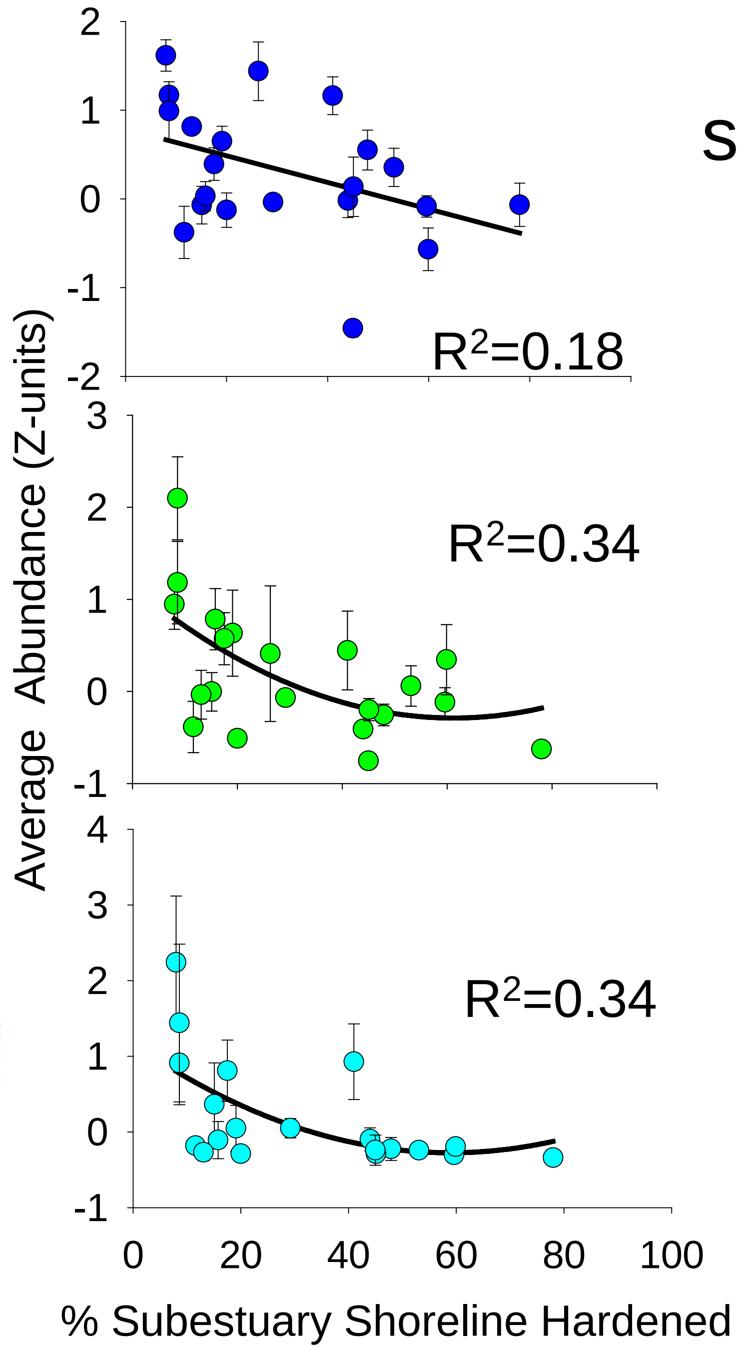
Ave. Bottom DO (mg/L)
Cropland Cover
Developed Land Cover
8
7
6
5
4
3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
% of Subestuary Shorline that is Hardened Structure
80
60
40
20
0
Cropland Cover
Developed Land Cover
0.0
0.2
0.4
0.6
0.8
1.0
Proportion Watershed Land Cover

Percent of shoreline that is hardened

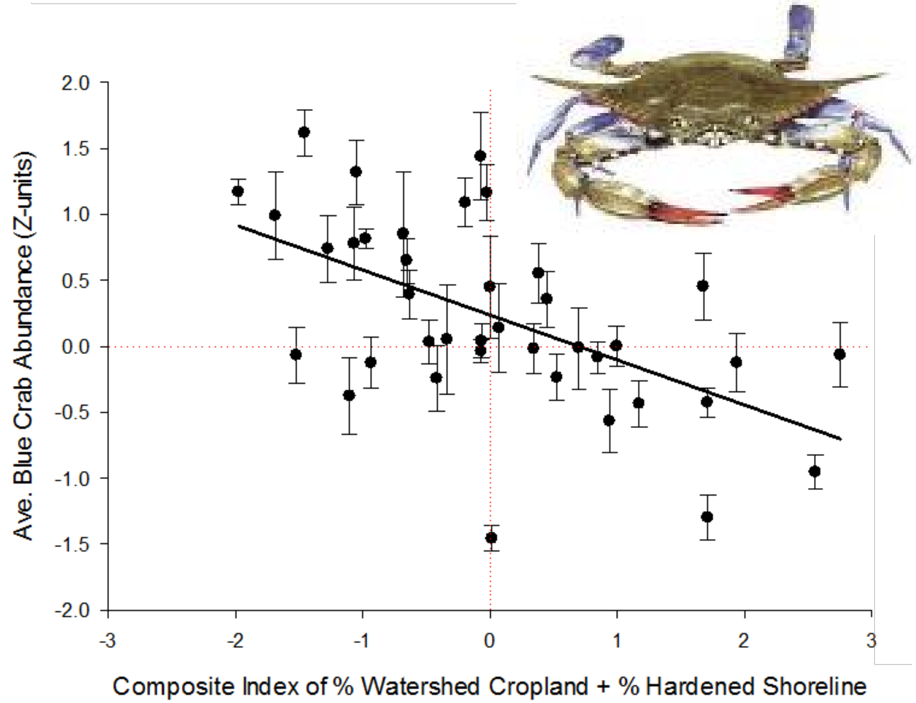
Blue Crab

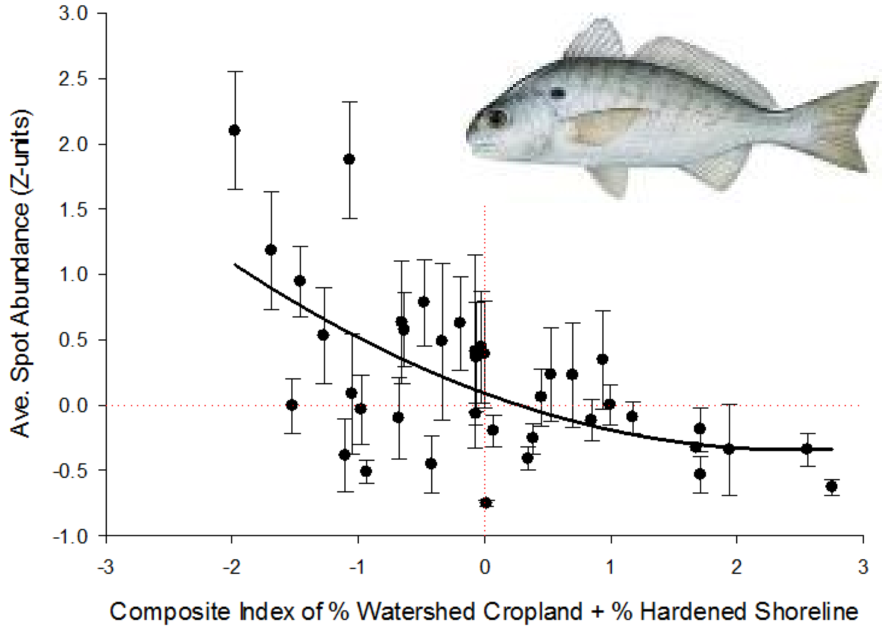
Spot

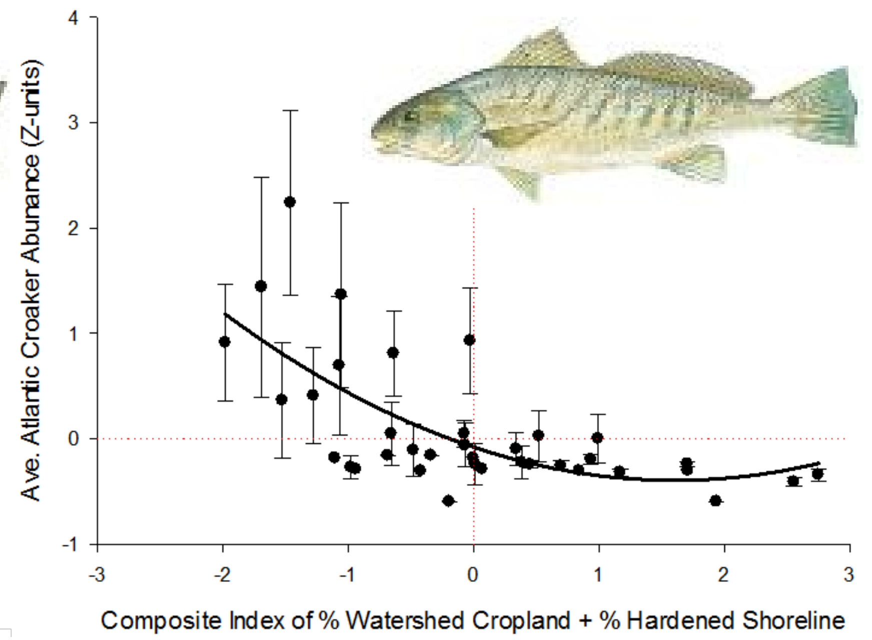
Atlantic Croaker



Variation among subestuaries



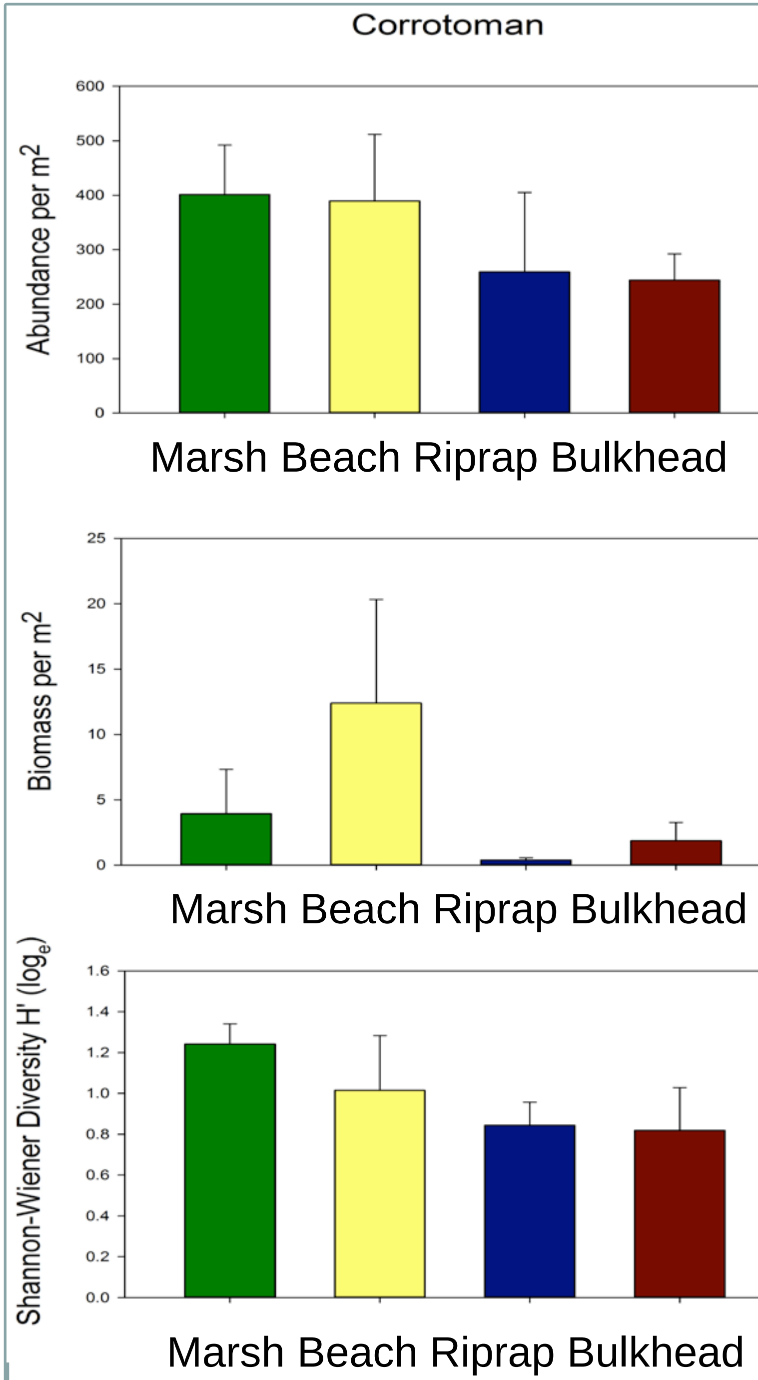




Loss of wetlands and SAV, and higher N loads may be proximate mechanisms for land use and riprap effects on fish/crabs/shrimp

<u>Natural shoreline</u> habitats have higher abundance, biomass, and diversity of benthic invertebrates than developed habitats

(e.g.,Corrotoman River)



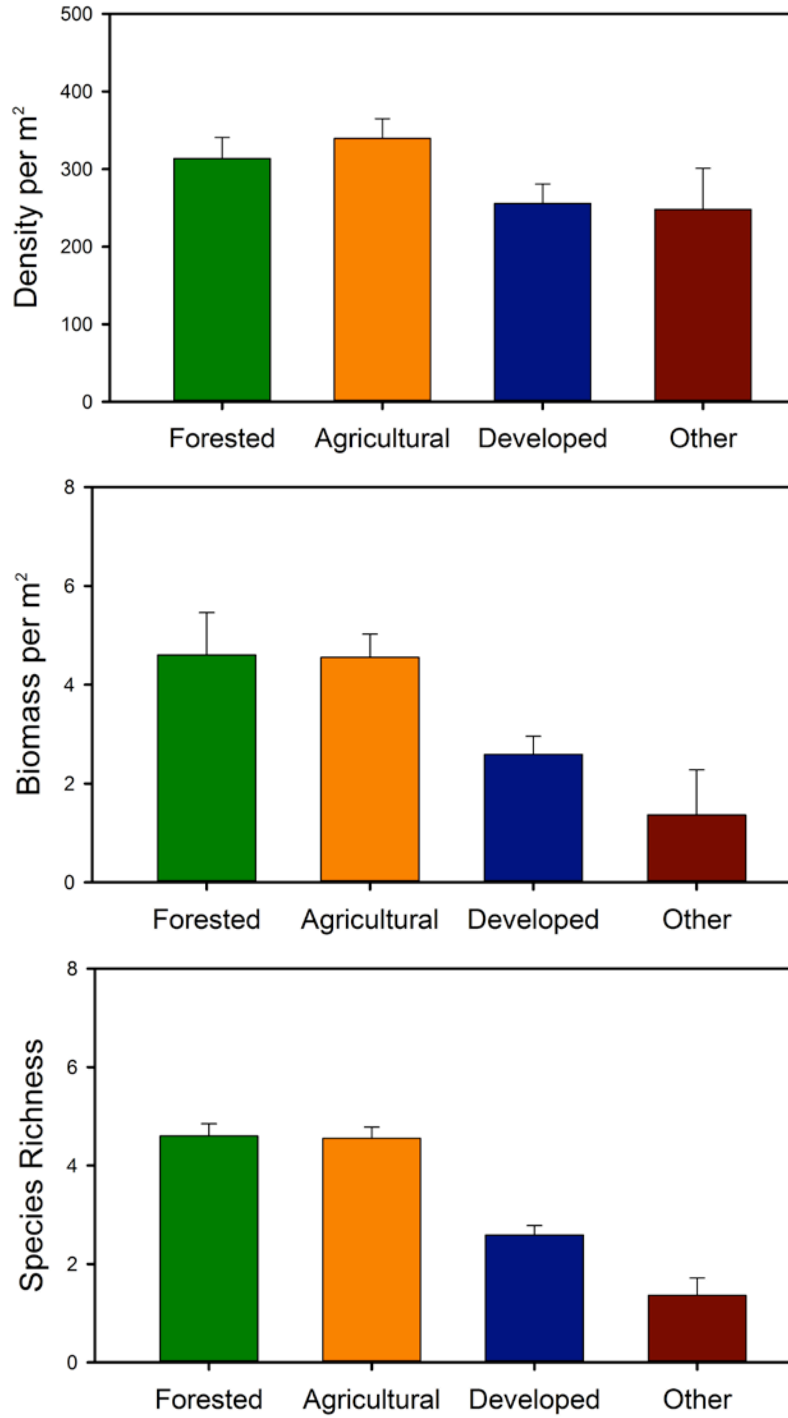
Rochelle Seitz

VIMS | William & Mary

Virginia Institute of Marine Science

1940-2015 75 Years

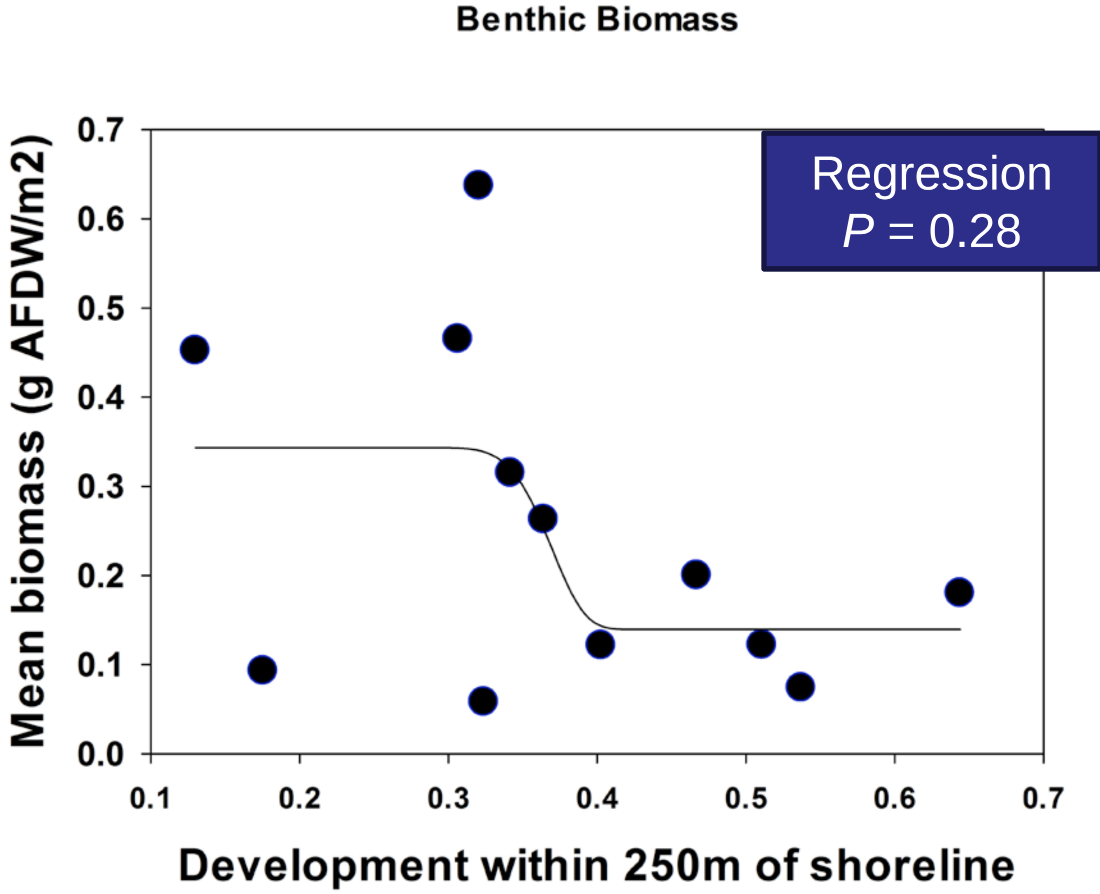
<u>Developed and mixed-developed watersheds</u> have reduced benthic density, biomass, & richness



Rochelle Seitz

Threshold for loss of benthic biomass with ~35% upland **development**

Rochelle Seitz



Diann Prosser

Rochelle Seitz

Denise Breitburg
Tim Targett, Matt Kornis

Both **shoreline hardening** and **watershed land use** affect economically and ecologically important species in Chesapeake Bay & Delaware Coastal Bays

Jordan et al., shoreline project
Funding from NOAA-NCOS

Climate change in the shallows – interacting effects of diel-cycling hypoxia and acidification

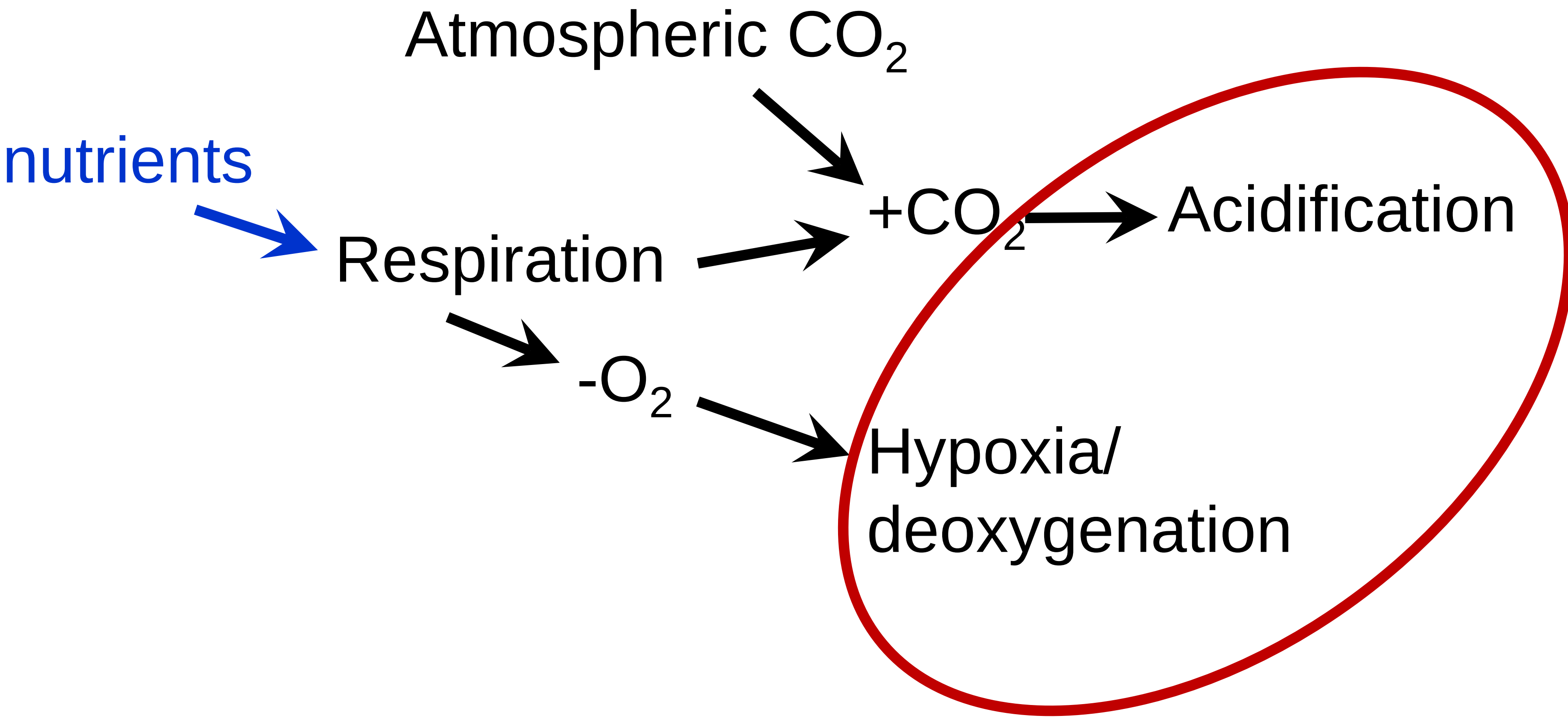
Denise Breitburg
Andrew Keppel Seth
Miller Rebecca
Burrell

Smithsonian Institution

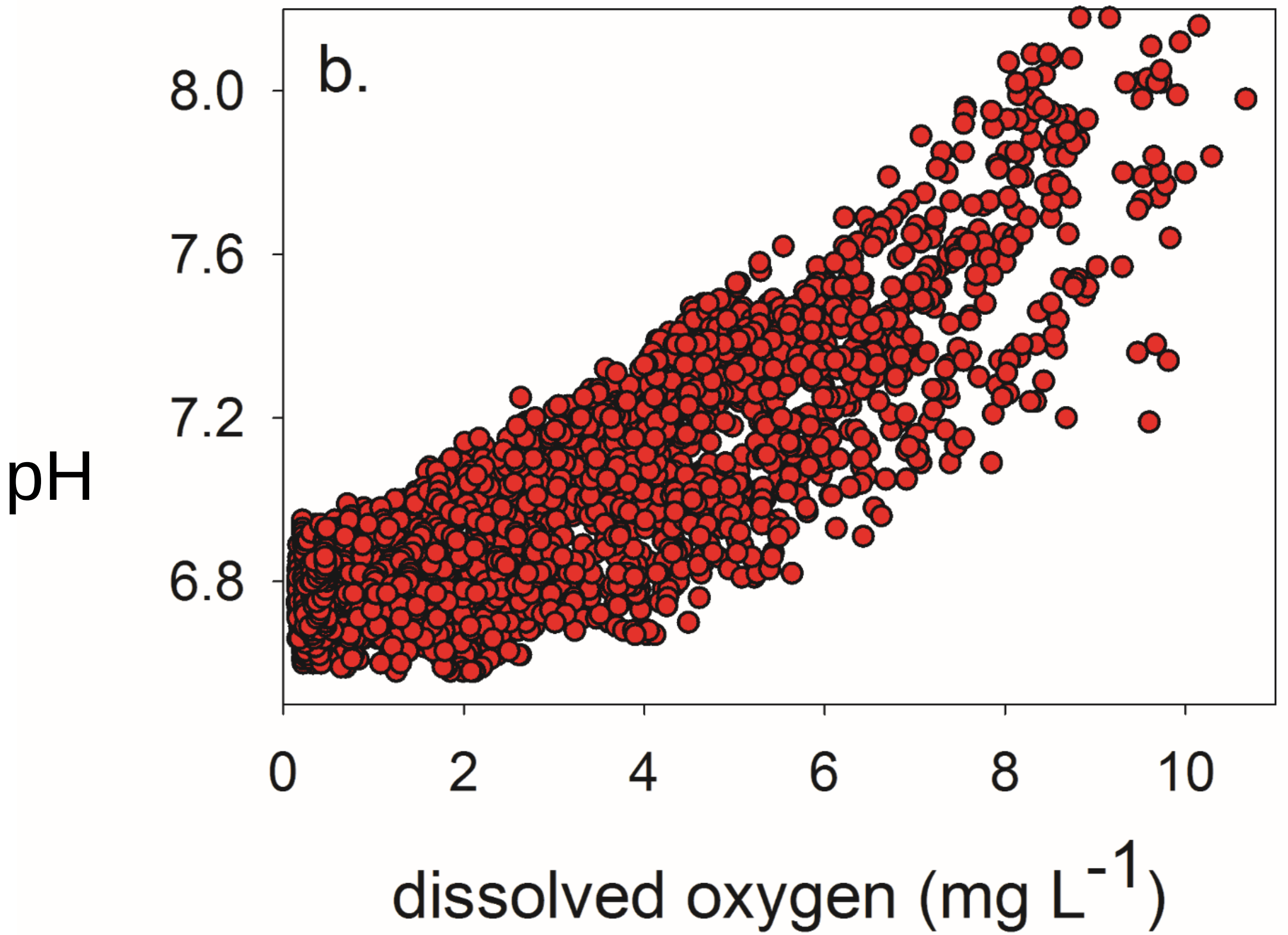
NOAA

Center for Sponsored Coastal Ocean Research

Multiple stressors – management, understanding



Estuarine salt marsh
1 m – Rhode River



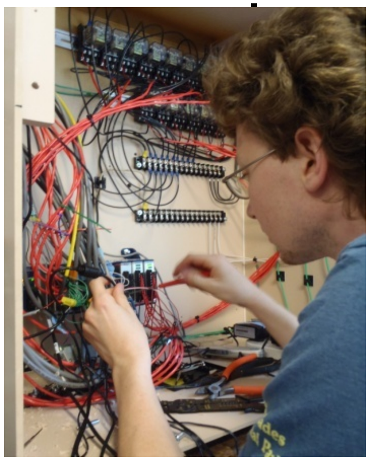
Breitburg et al., unpublished

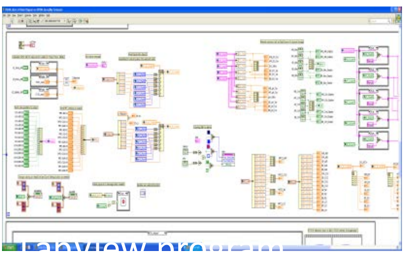
Eastern Oyster
(*Crassostrea virginica*)

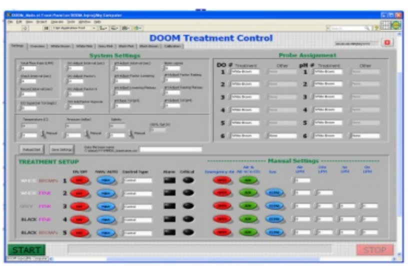
Atlantic & inland silversides
(*Menidia menidia & M. beryllina*)

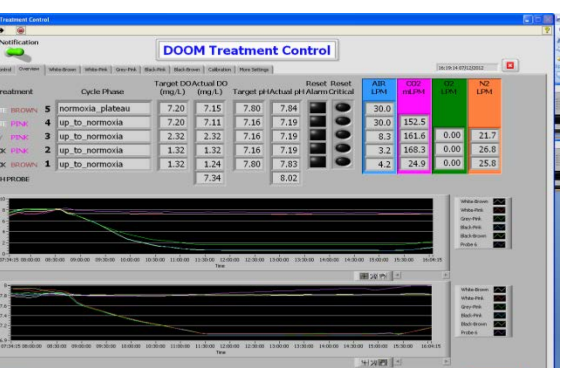
Disease
Growth

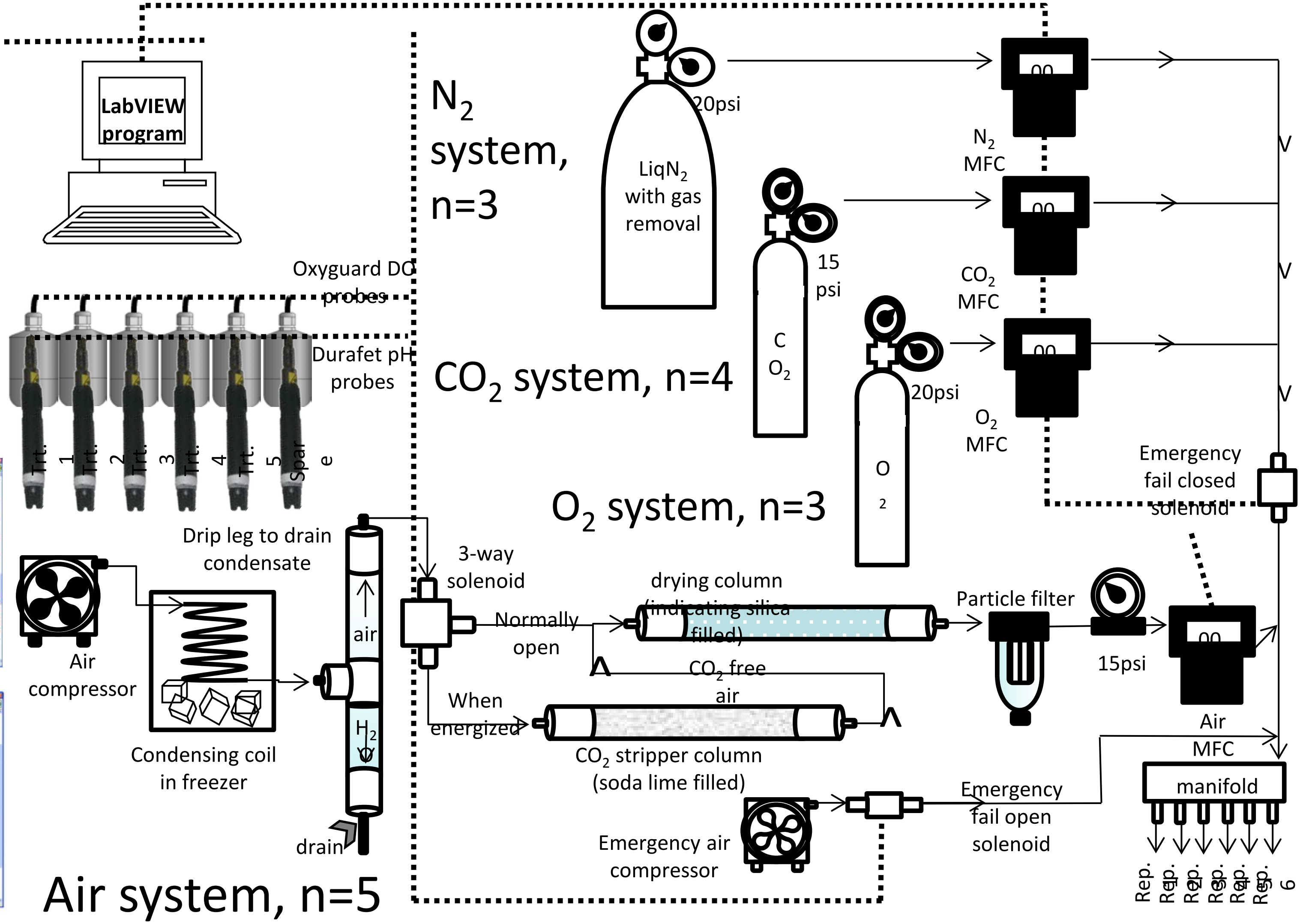
Growth
Sensitivity to hypoxia



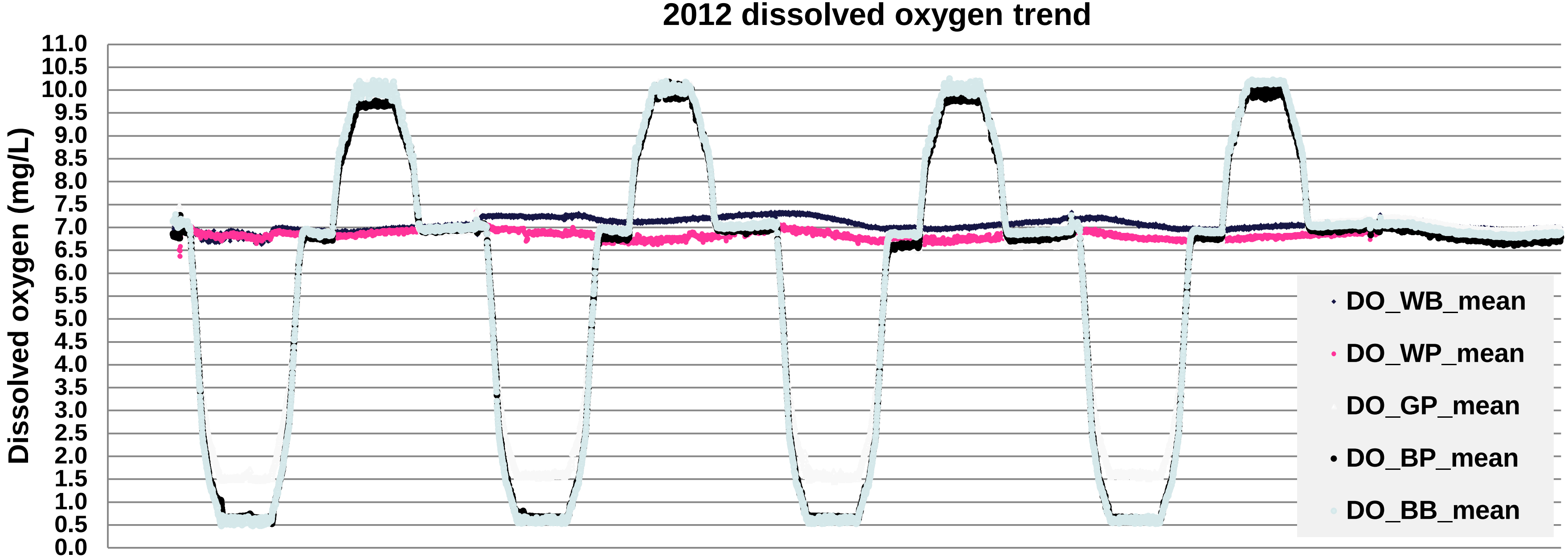


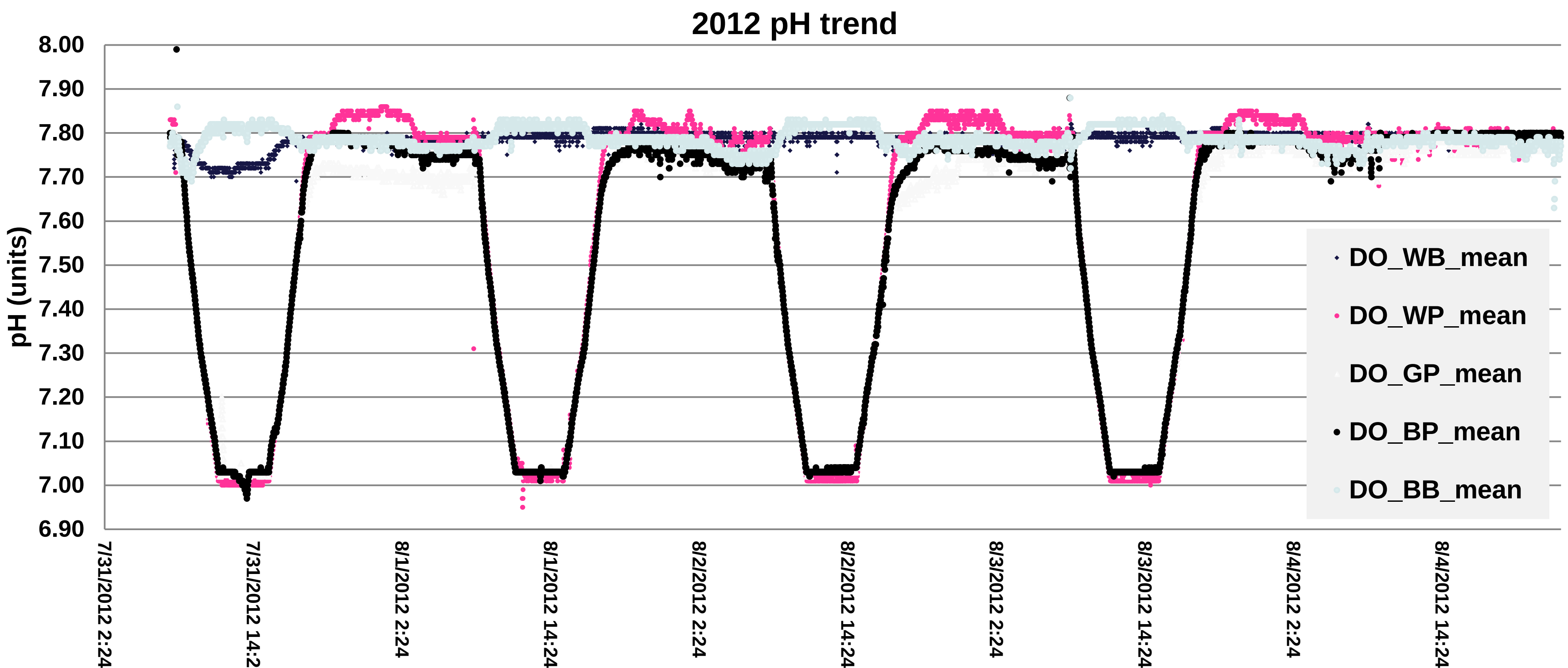




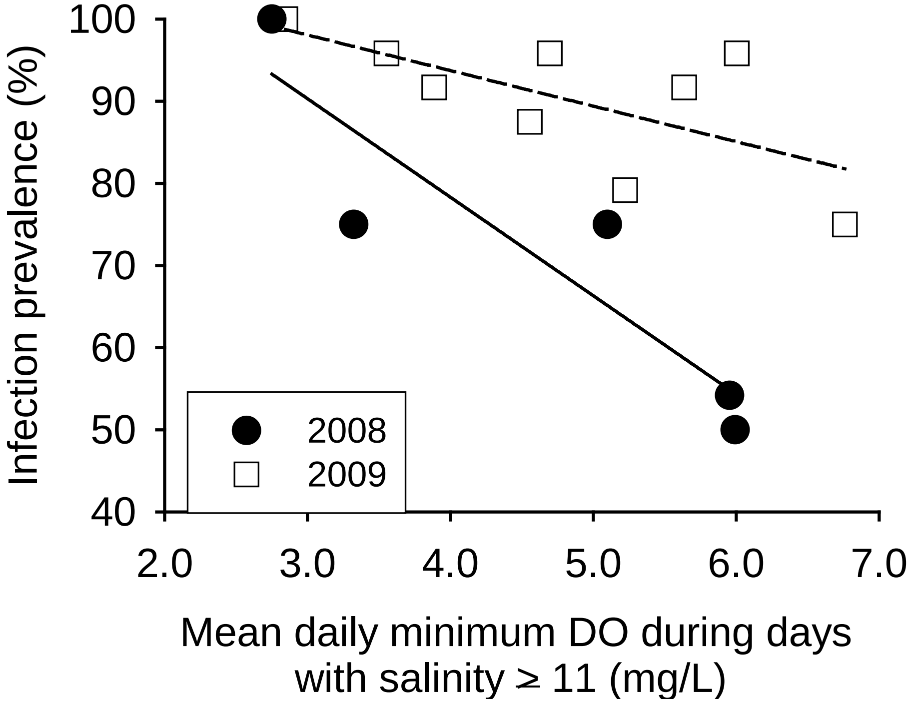


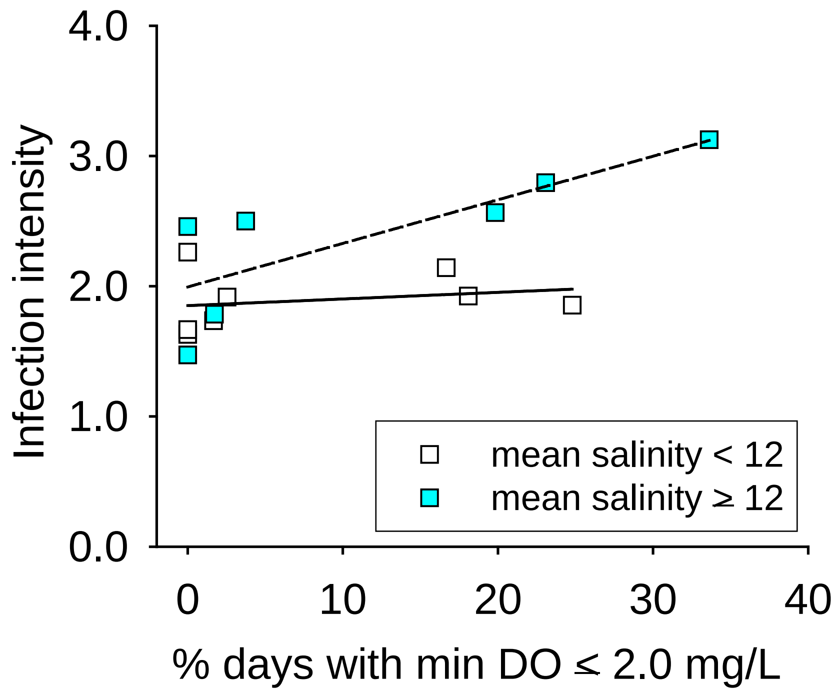
Burrell et al., accepted pending revision


2012 dissolved oxygen trend
Dissolved oxygen (mg/L)
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
DO_WB_mean
DO_WP_mean
DO_GP_mean
DO_BP_mean
DO_BB_mean


2012 pH trend
pH (units)
8.00
7.90
7.80
7.70
7.60
7.50
7.40
7.30
7.20
7.10
7.00
6.90
DO_WB_mean
DO_WP_mean
DO_GP_mean
DO_BP_mean
DO_BB_mean
7/31/2012 2:24
7/31/2012 14:2
8/1/2012 2:24
8/1/2012 14:24
8/2/2012 2:24
8/2/2012 14:24
8/3/2012 2:24
8/3/2012 14:24
8/4/2012 2:24
8/4/2012 14:24

Diel-cycling increases prevalence and intensity of *Perkinsus* infections in oysters (Breitburg et al., 2015)



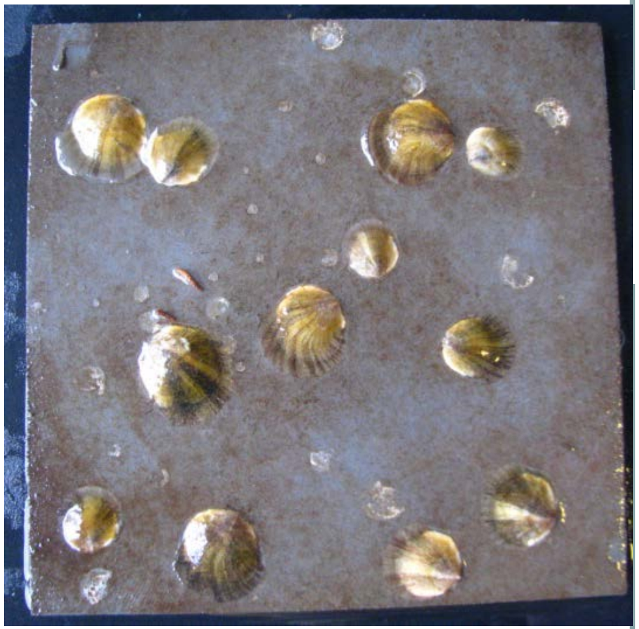


Juvenile growth

cycling down to DO = 0.5, pH = 7.1

Low salinity year

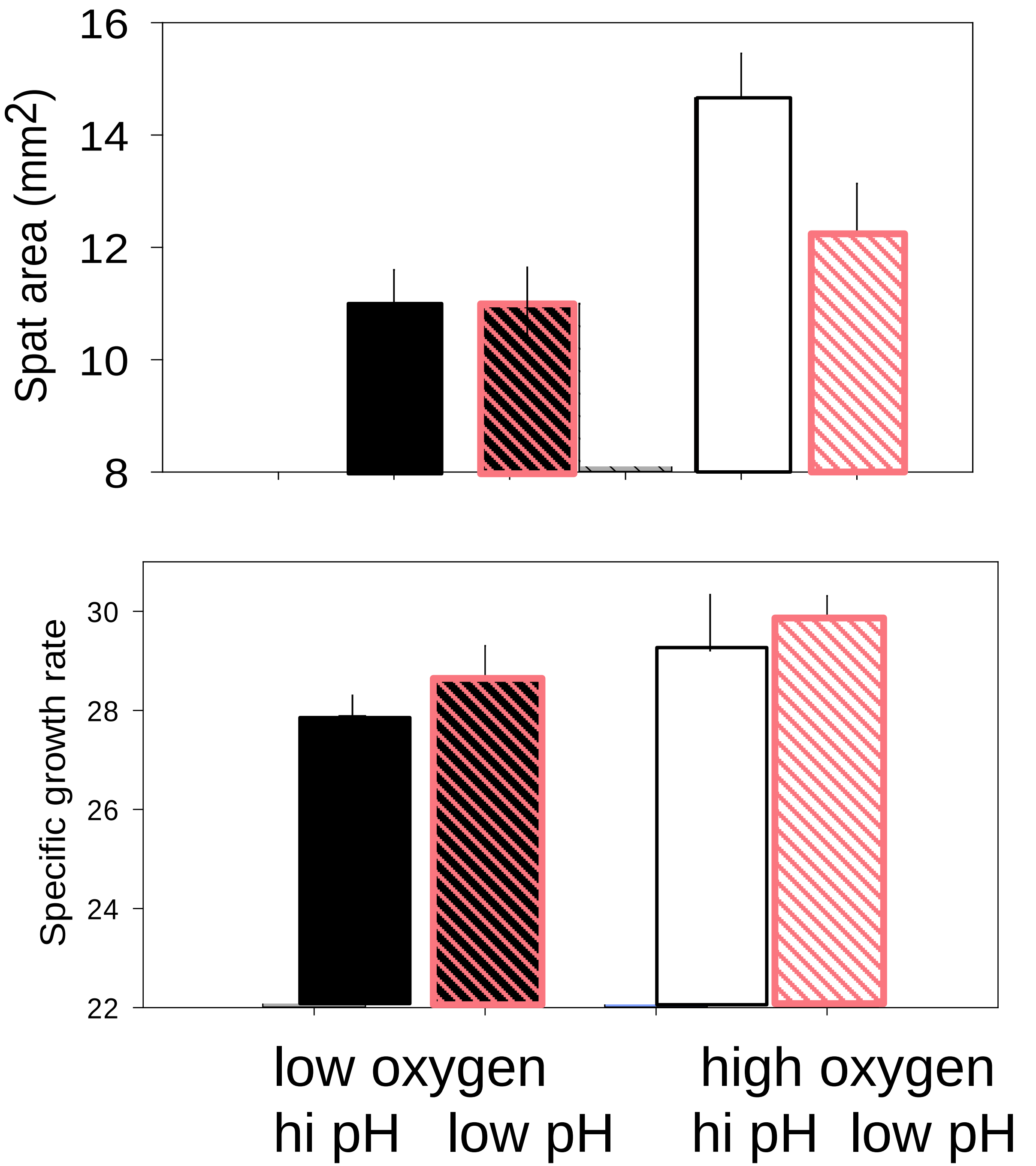
$\Omega_{Calcite}$ =0.69



High salinity year

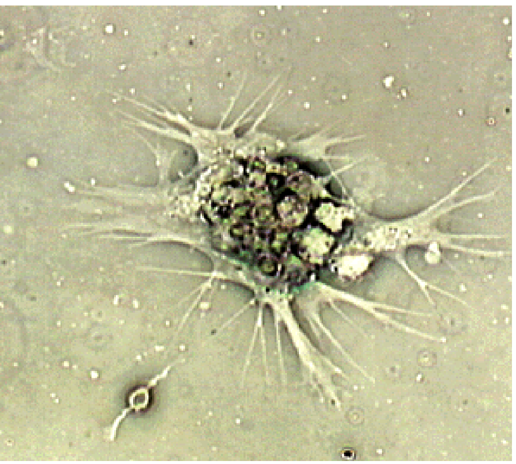
$\Omega_{Calcite}$ =1.87

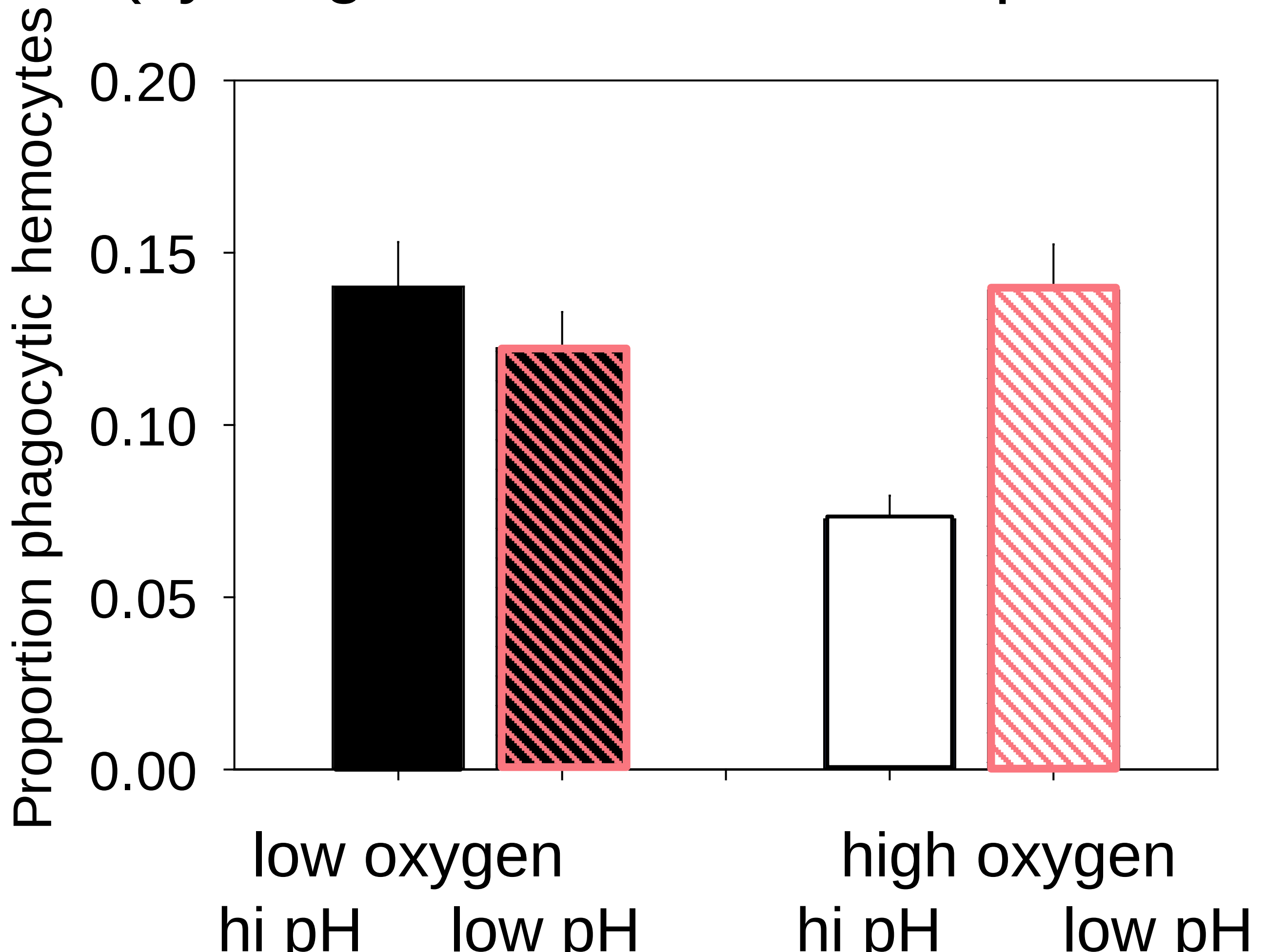
Keppel 2014



Cycling (DO, CO_2, $DO+CO_2$) stimulates hemocyte function

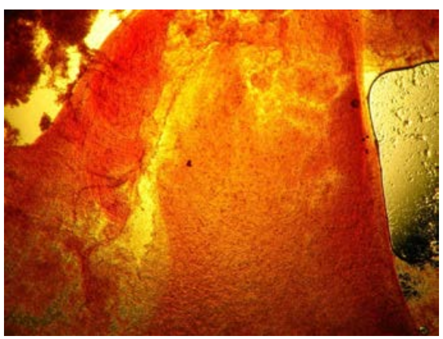
(cycling down to DO = 0.5, pH = 7.1)

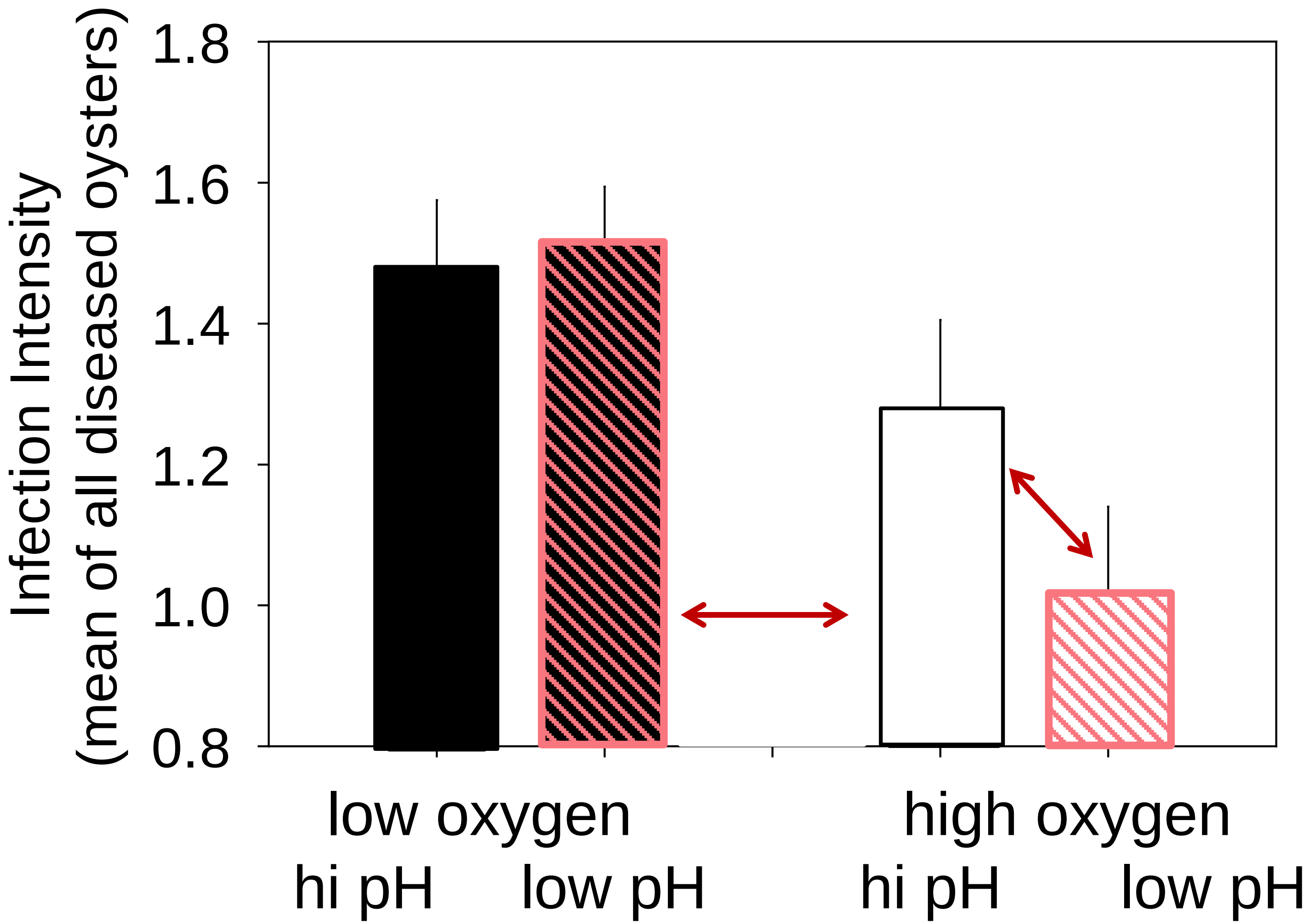




Keppel et al., in review

Stimulation of hemocytes only reduces infection progression when oxygen is high

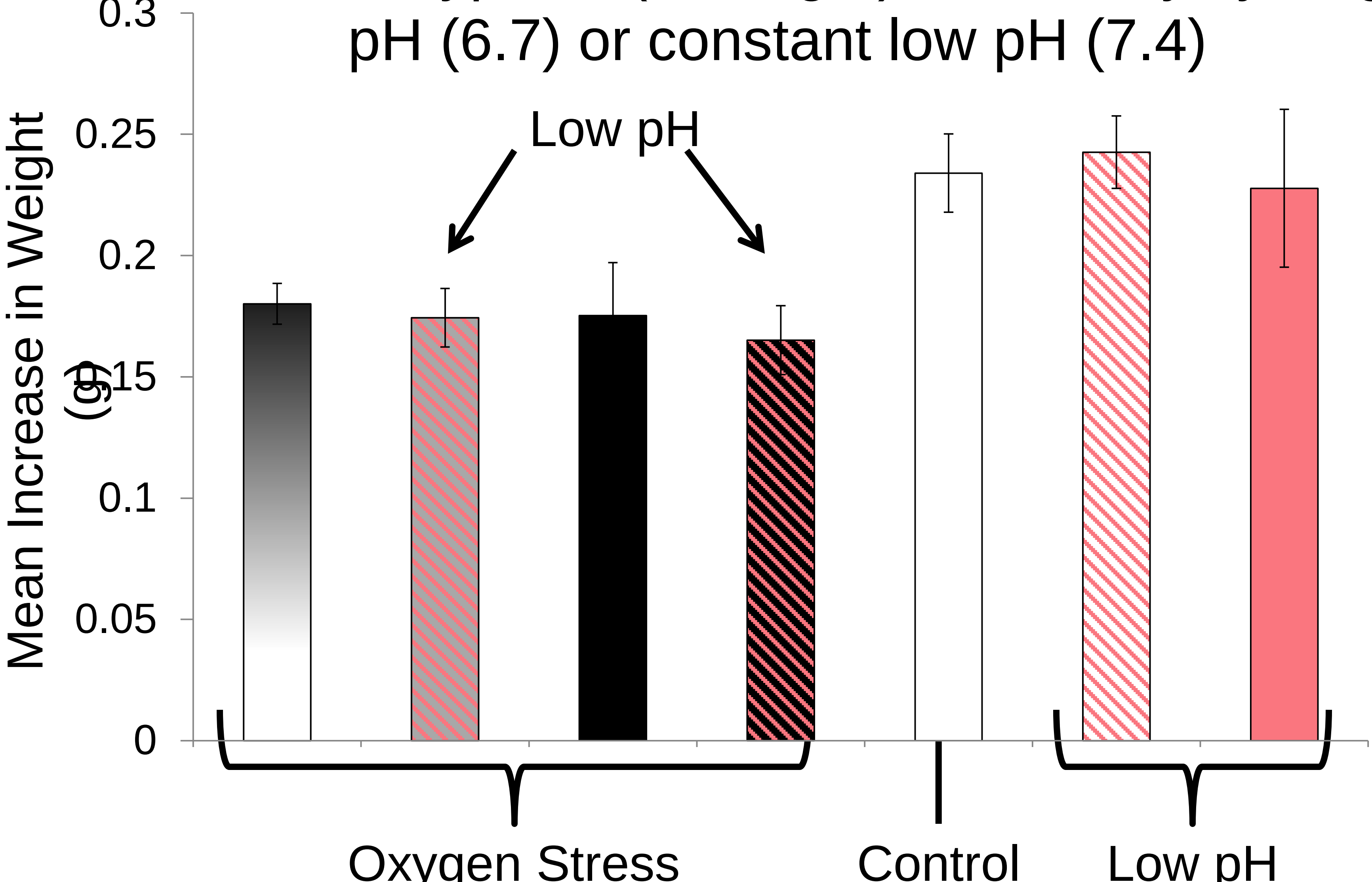




Keppel et al., in review

Atlantic and inland Silversides- Growth, Aquatic Surface Respiration & Mortality

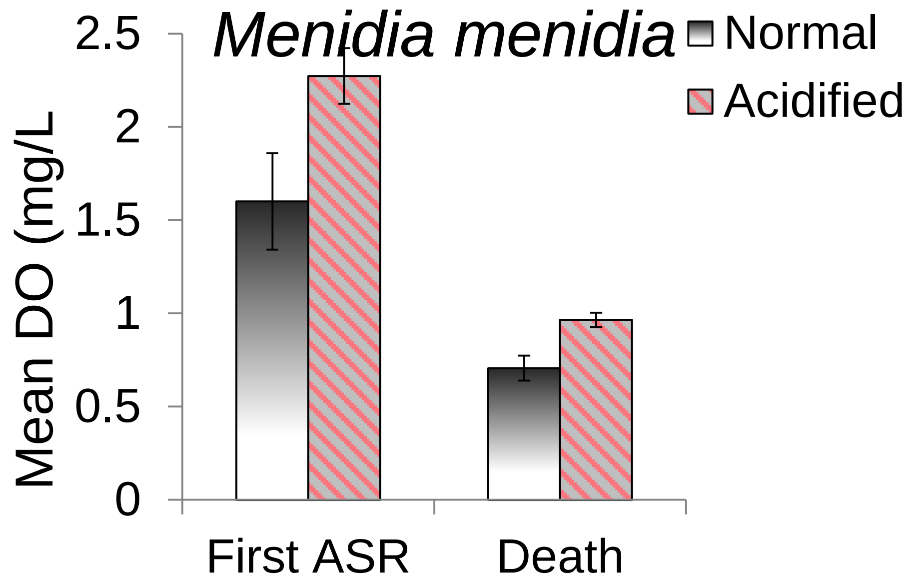
Juvenile growth reduced by diel-cycling dissolved oxygen (1.7 mg/L) & constant hypoxia (2.2 mg/L) but not by cycling pH (6.7) or constant low pH (7.4)

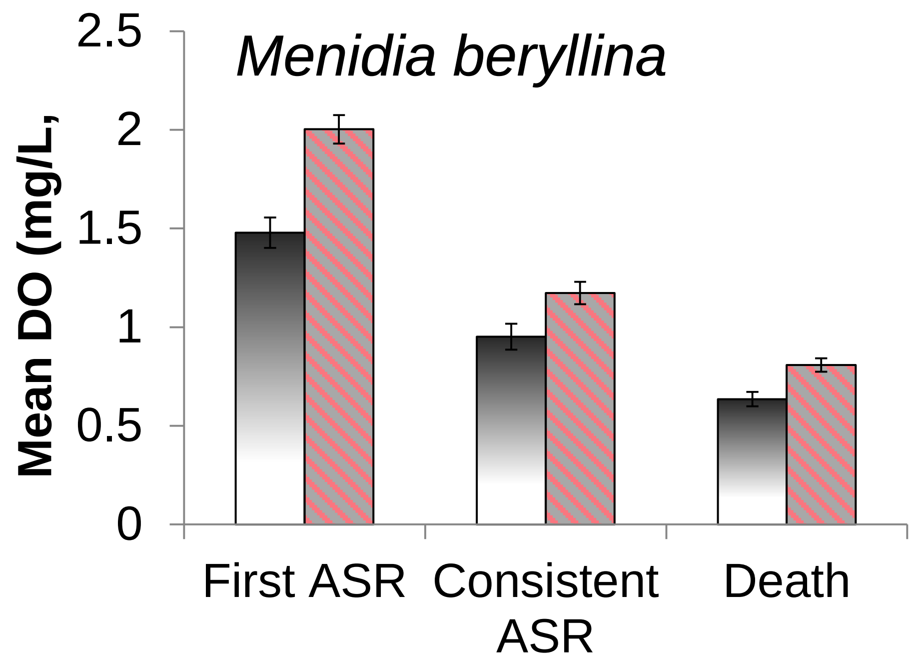


Simultaneous exposure to low pH made fish more sensitive to low oxygen

© Dave Conover

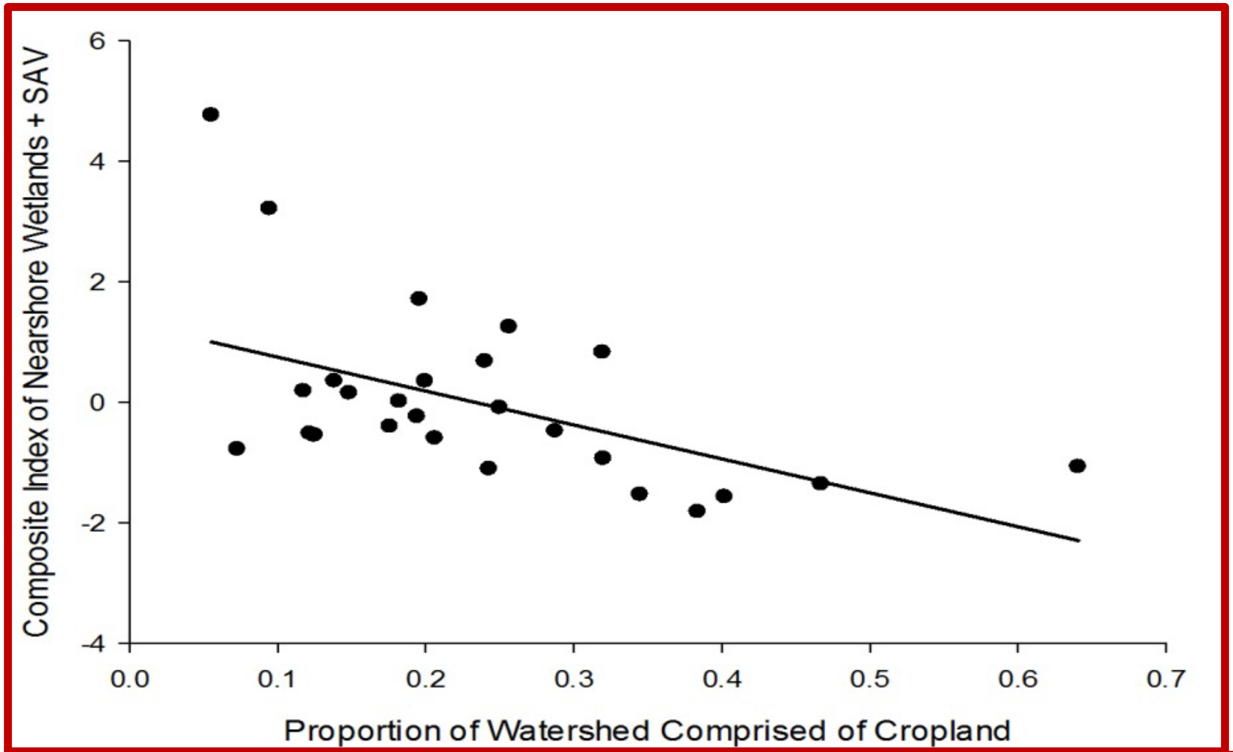
CO2 suppresses ventilatory response to low oxygen

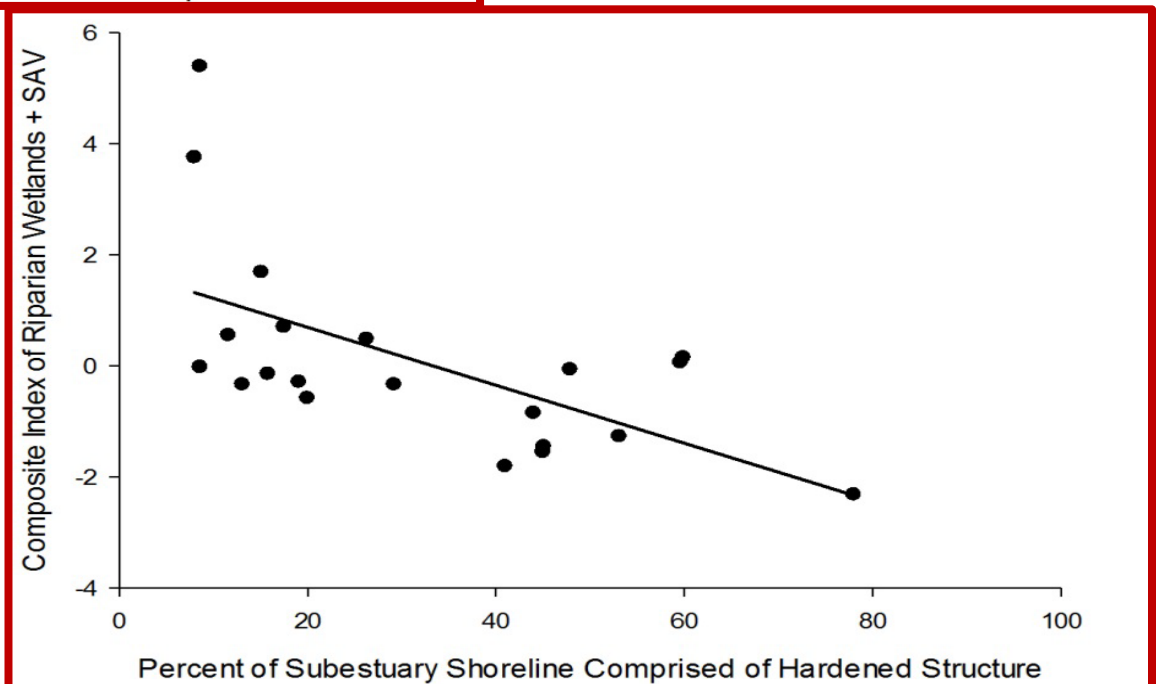




Fish, shellfish and Nearshore Habitat: The Land-water Interface is Important

Fish and shellfish are strongly affected by
- Land use
- Shoreline hardening
- Current levels of diel-cycling hypoxia and acidification


Composite Index of Nearshore Wetlands + SAV
6
4
2
0
-2
-4
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Proportion of Watershed Comprised of Cropland


Composite Index of Riparian Wetlands + SAV
6
4
2
0
-2
-4
0
20
40
60
80
100
Percent of Subestuary Shoreline Comprised of Hardened Structure