Acidification Issues in Coastal Waters of the SAML Region: Responses of Organisms

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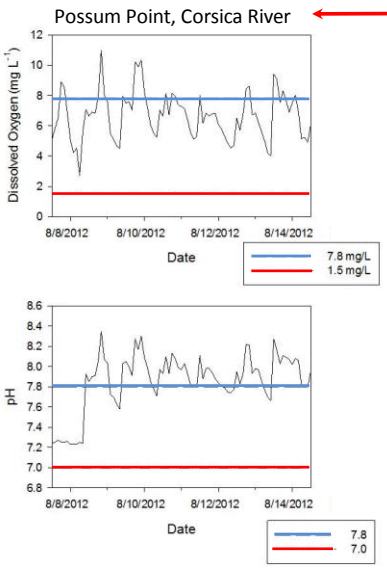
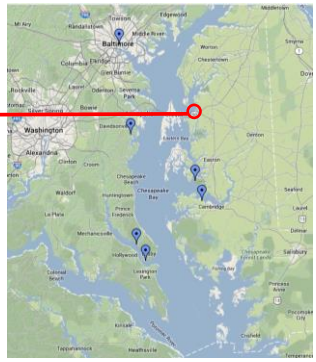
SAML Meeting 2014

Diel cycling of hypoxia and hypercapnia

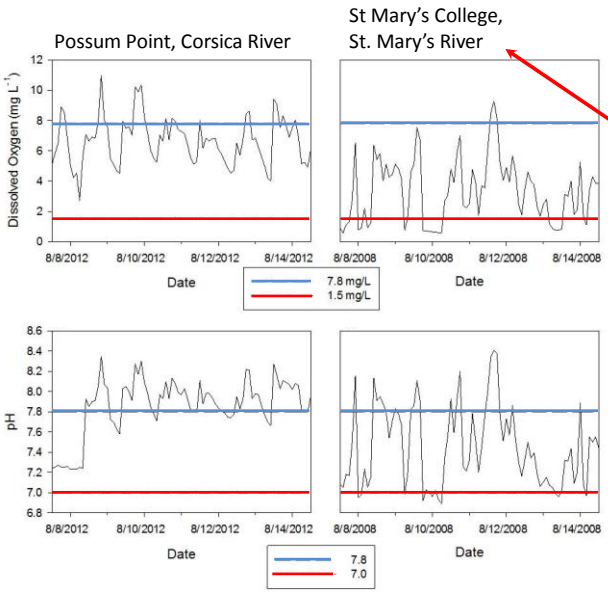


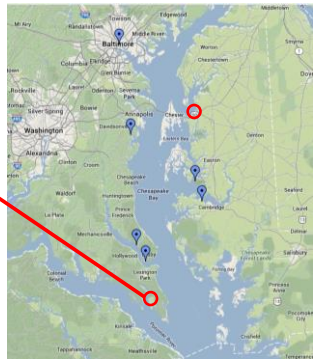


Data from MD DNR's EyesOnTheBay.net

Slide borrowed from M.S. Thesis Defense of Virginia Clark Univ. of Maryland.

Diel cycling of hypoxia and hypercapnia





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Additional Water Quality Data

- National Estuarine Research Reserve System
- Centralized Data Management Office (CDMO)
- http://cdmo.baruch.sc.edu/

Field Measurements James Island Creek, SC

Location	Po_2 (torr)	pH	Sal.	Temp.	Pco_2 (torr)	Total Alk.
3 Aug 1994 1800-1900)						
Channel						
surface (2 cm)	142	7.64	5	32	2.7	2.67
bottom (107 cm)	78	7.48	13.8	30.5	2.2	1.86
Grass						
surface (2 cm)	133	7.11	5	31.5	10.8	3.06
bottom (39 cm)	53	7.28	11	30.5	5.3	2.68

Cochran & Burnett 1996

Field Measurements James Island Creek, SC

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bottom (39 cm)	53	7.28	11	30.5	5.3	2.68

92% air saturated

34% air saturated

3,553 µatm

14,210 µatm

Cochran & Burnett 1996

Field Measurements James Island Creek, SC

Location	Po_2 (torr)	pH	Sal.	Temp.	Pco_2 (torr)	Total Alk.
4 Aug 1994 0630-0730)						
Channel						
surface (2 cm)	51	7.08	2	25	10.7	2.58
bottom (88 cm)	31	6.48	12	28	35.6	3.07
Grass						
surface (2 cm)	54	7.11	1.5	25	11.6	2.84
bottom (19 cm)	20	7.06	3	25	12.7	3.10

Cochran & Burnett 1996

Field Measurements James Island Creek, SC

Location	Po_2 (torr)	pH	Sal.	Temp.	Pco_2 (torr)	Total Alk.
4 Aug 1994 0630-073						
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bottom (19 cm)	20	7.06	3	25	12.7	3.10

33% air saturated

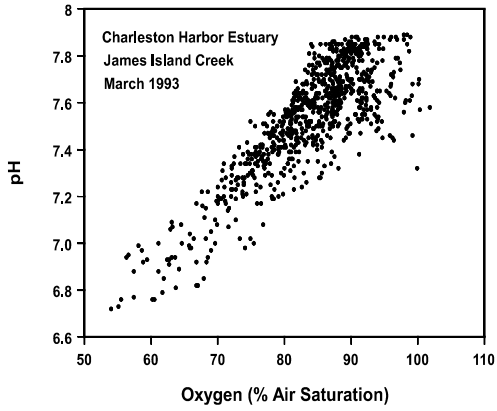
46,840 µatm

13% air saturated

16,710 µatm

Cochran & Burnett 1996

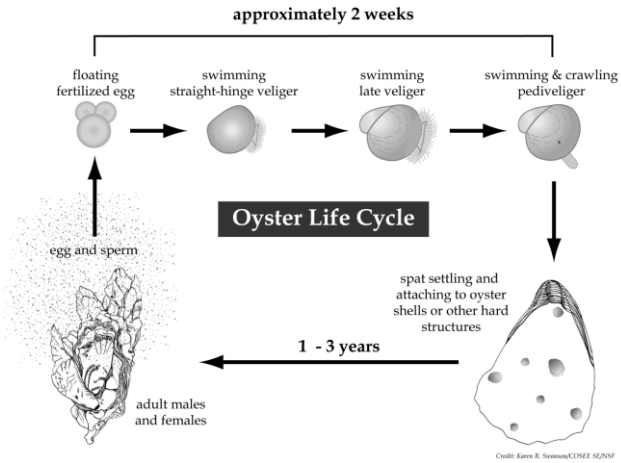
Oxygen and CO_2



Data provided by Phil Dustan, CofC; Burnett 1997 Am. Zool.

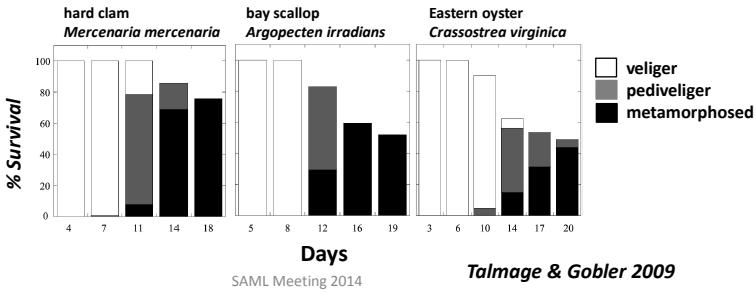
How do organisms respond to hypercapnia?

- Tissue pH depends upon
  - strong ion difference
  - presence of weak acids and bases
  - CO_2
- Hyercapnia generates tissue and cellular acidification.

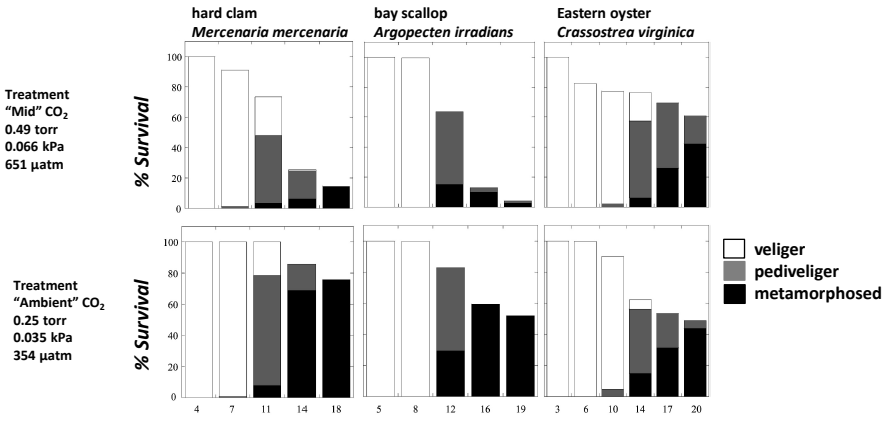


http://score.dnr.sc.gov/

Treatment
"Ambient" CO_2
0.25 torr
0.035 kPa
354 µatm



Talmage & Gobler 2009



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Talmage & Gobler 2009

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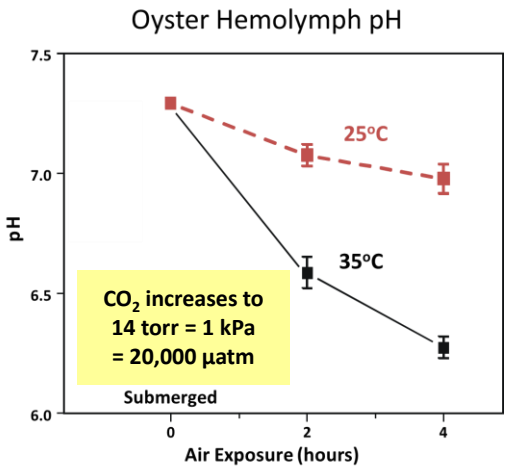
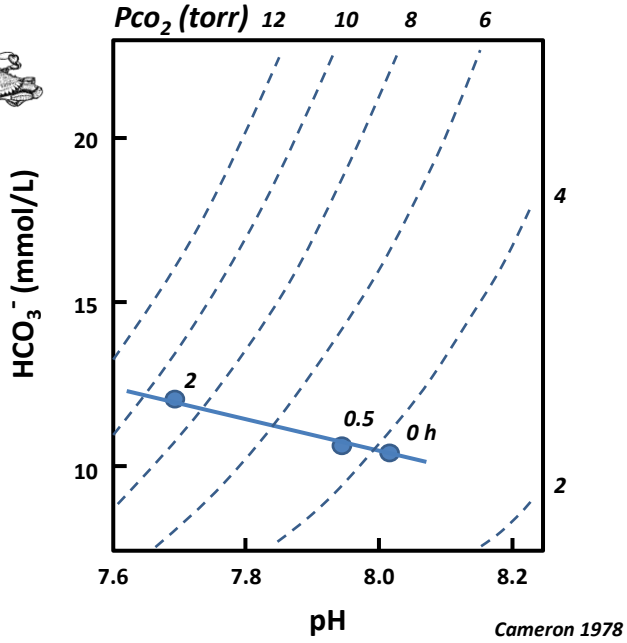
Intertidal Adult Oysters



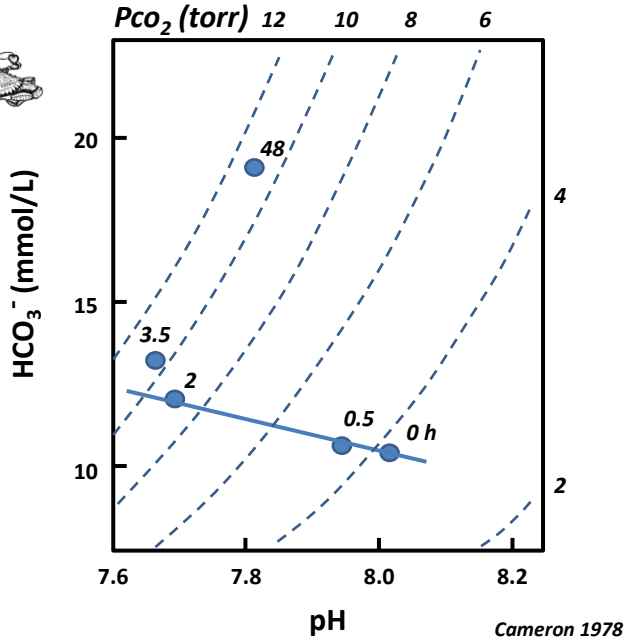
Dwyer & Burnett 1996
Allen & Burnett 2008

Case Study-Blue Crab in 1% CO_2

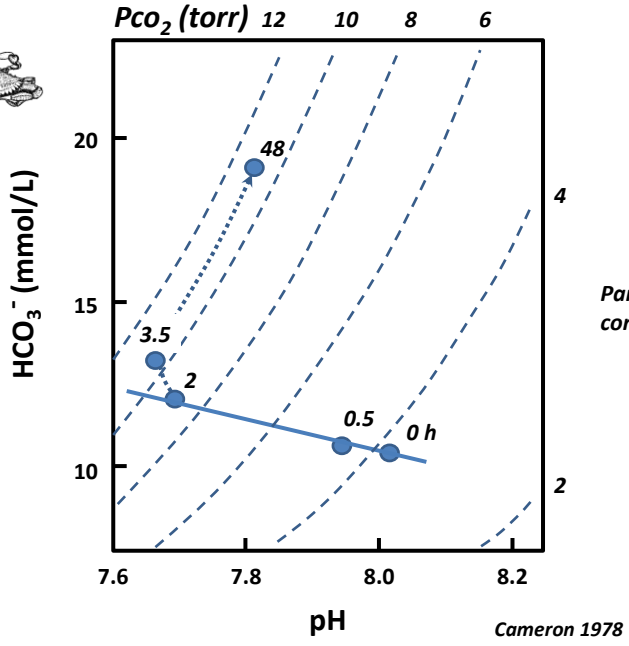
- Cameron, J. N. 1978. J. Comp. Physiol. 123:137-141. (University of Texas at Austin, Port Aransas Marine Laboratory = Marine Science Institute)
- Exposed crabs to 1% CO_2 = 7.5 torr = 1 kPa = 9,868 µatm
- Measured blood acid-base status with time.



Cameron 1978



Cameron 1978



Partial compensation!

Cameron 1978

Treadmill Studies

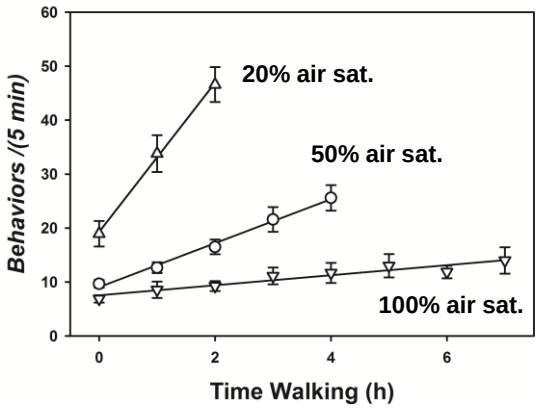
- Today Show, Segment 1: http://www.today.com/id/27906984
- Today Show, Segment 2: http://www.today.com/id/26184891/vp/18424824#27909114
- Other treadmill links, crabs and shrimp: http://burnettl.people.cofc.edu/research/treadmill.php

Shrimp on a Treadmill

Blue Crab Performance

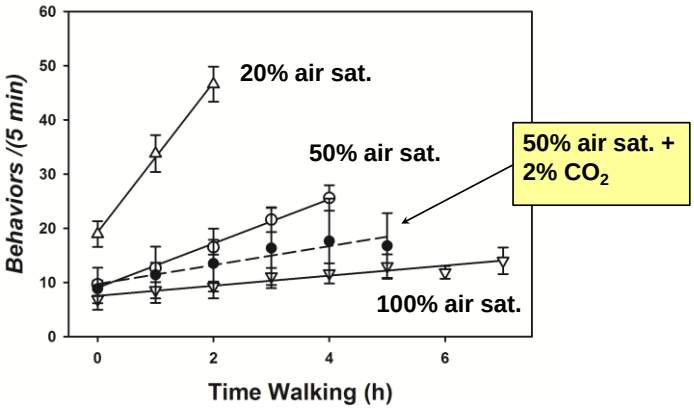
Blue Crab Performance

Fatigue Behaviors in Blue Crabs



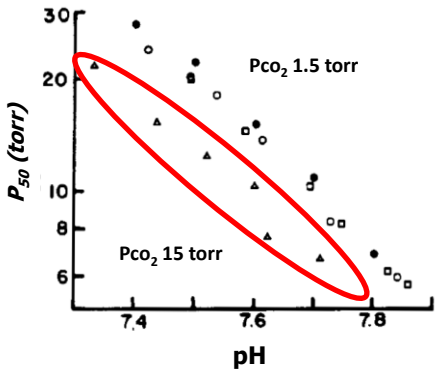
Stover et al. 2013

Fatigue Behaviors in Blue Crabs



Stover et al. 2013

CO_2-specific Effect



large ↑ in O_2 affinity due to CO_2

Mangum & Burnett 1986

Chronic Hypoxia Responses

- Increase concentration of respiratory pigment.
- Increase oxygen affinity of respiratory pigment.
- Blue crabs do this (deFur et al., 1990); response takes days.
  - Increase concentration of hemocyanin.
  - Increase hemocyanin oxygen affinity.

Pacific Whiteleg Shrimp

Litopenaeus vannamei

Pacific Whiteleg Shrimp

- Genes to make hemocyanin are turned on within 24 hours on exposure to hypoxia.
- HOWEVER, exposure to hypercapnia mutes this response to hypoxia (Rathburn et al., 2013)

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- http://cdmo.baruch.sc.edu/
- http://mddnr.chesapeakebay.net/eyesonthebay/