Sustainable Fisheries GIT

Blue crab: ecology and exploitation in a changing climate.

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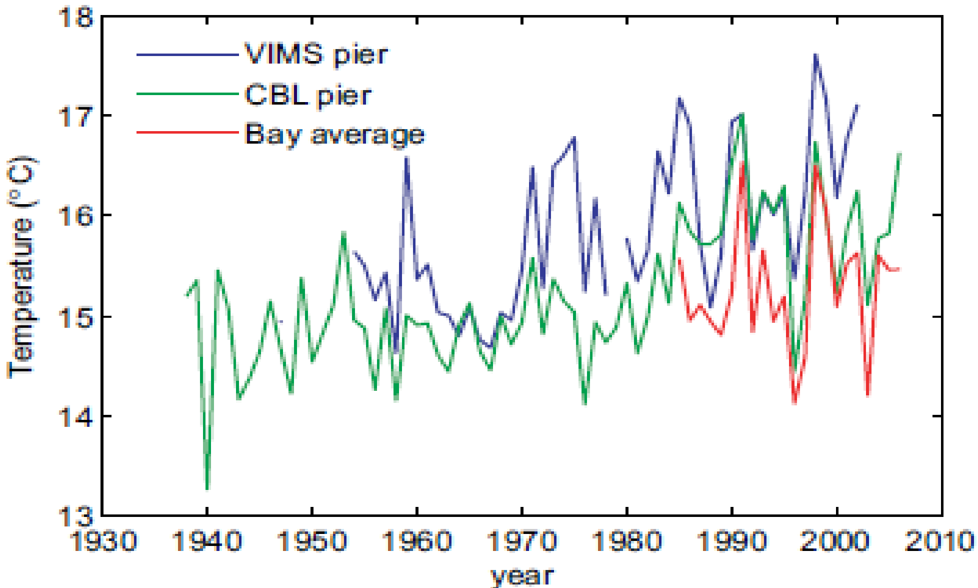
Chesapeake Bay Climate



Najjar et al. 2010

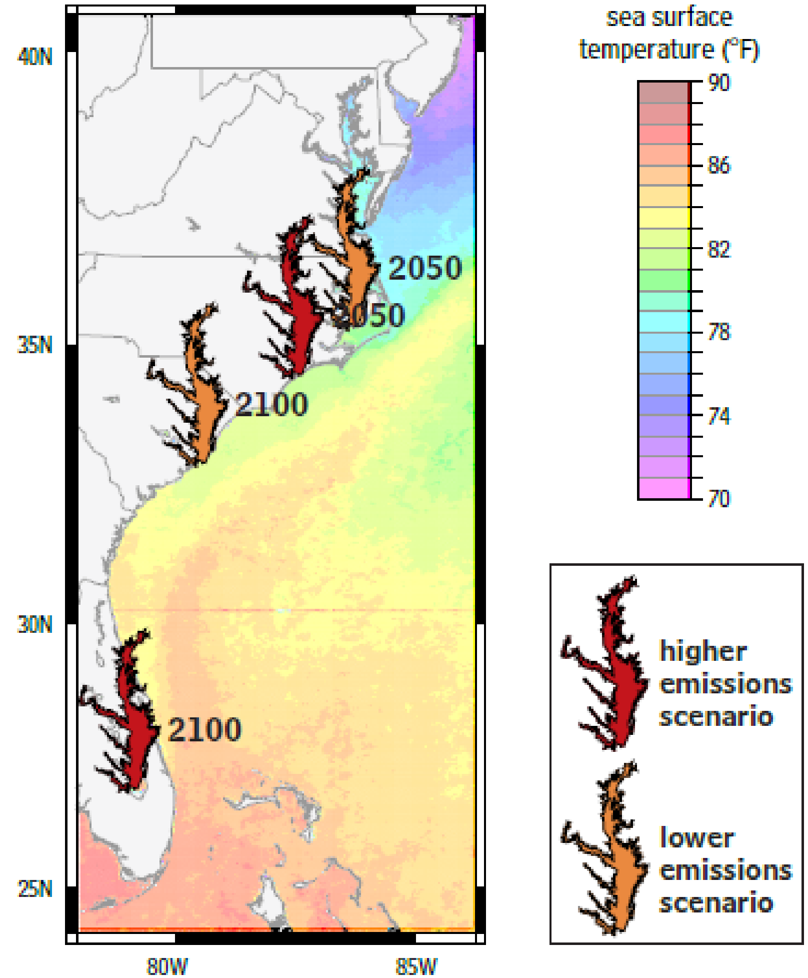
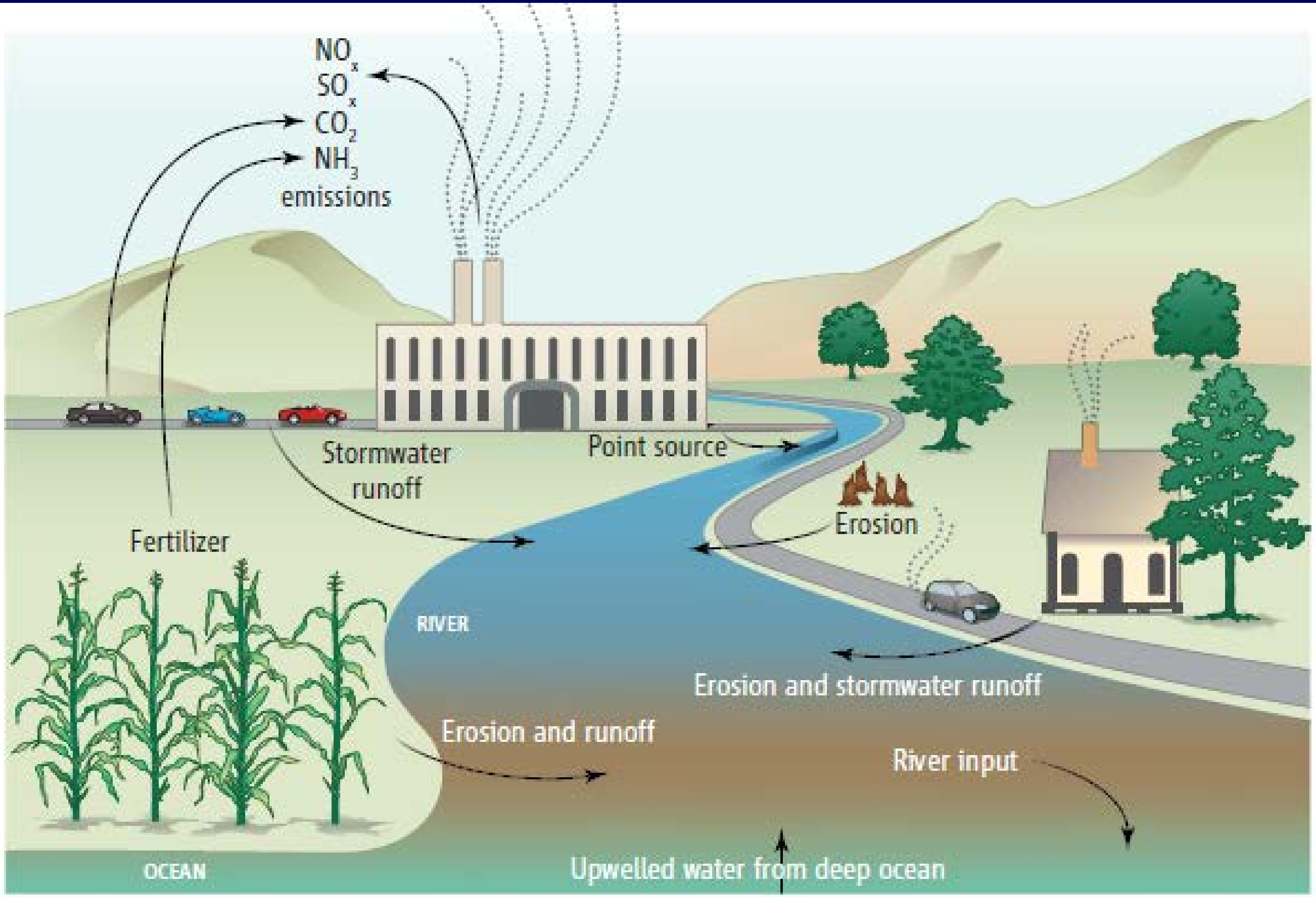


Figure 4.7. Summertime surface water temperatures in the Chesapeake Bay are projected to approximate those of estuaries well down the Atlantic Coast by 2050 and 2100.

Boesch et al. 2008

Climate Change in Estuaries



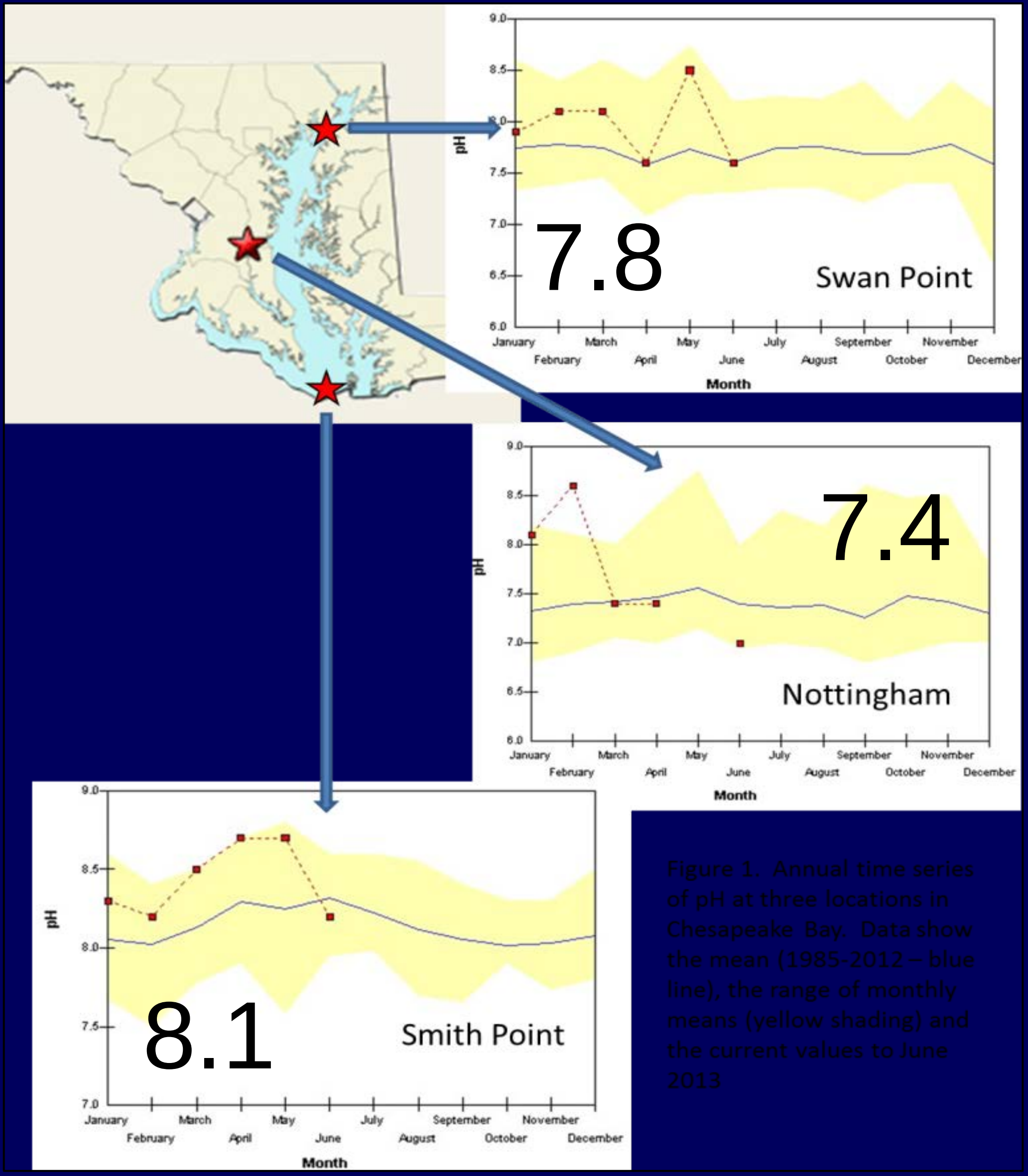
Contributors to ocean acidification. In addition to global atmospheric CO_2, this figure depicts the major local (within 10 to 100 km) sources contributing to coastal ocean acidification.

Kelly et al. 2011

Ocean Acidification

pH variability (1985-2012)

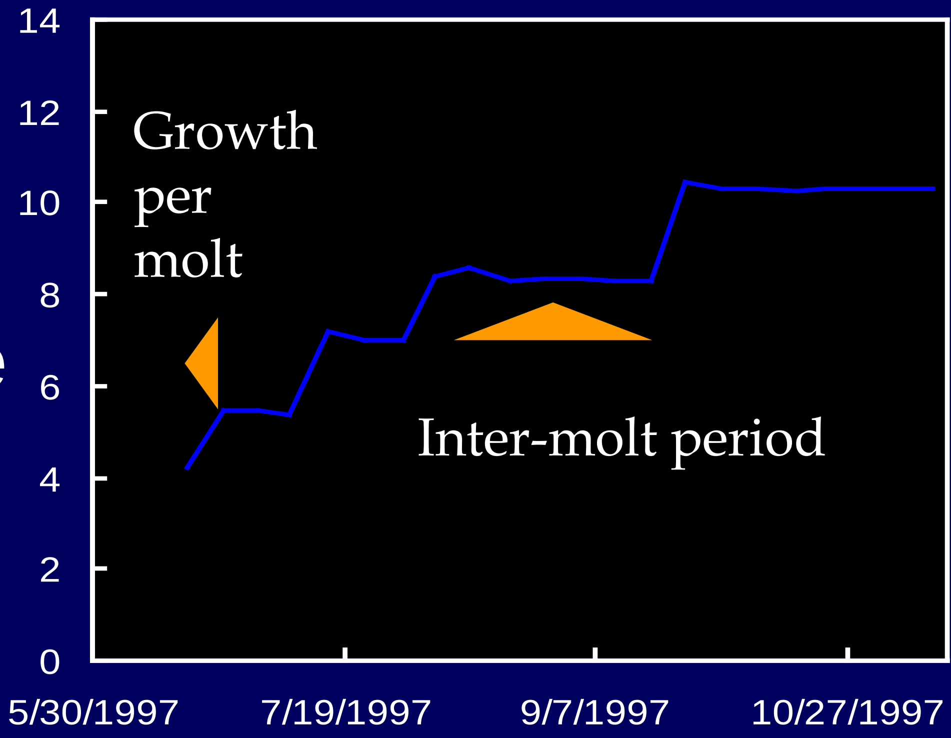
- Estuarine environments naturally variable
  - Gradients within estuaries spatially, seasonally and inter-annually
  - O.A. v3.0
- Blue crab are complex calcifiers
  - Mobilize Ca^{++} and $HCO3^{-}$ on every molt
  - Energetically costly



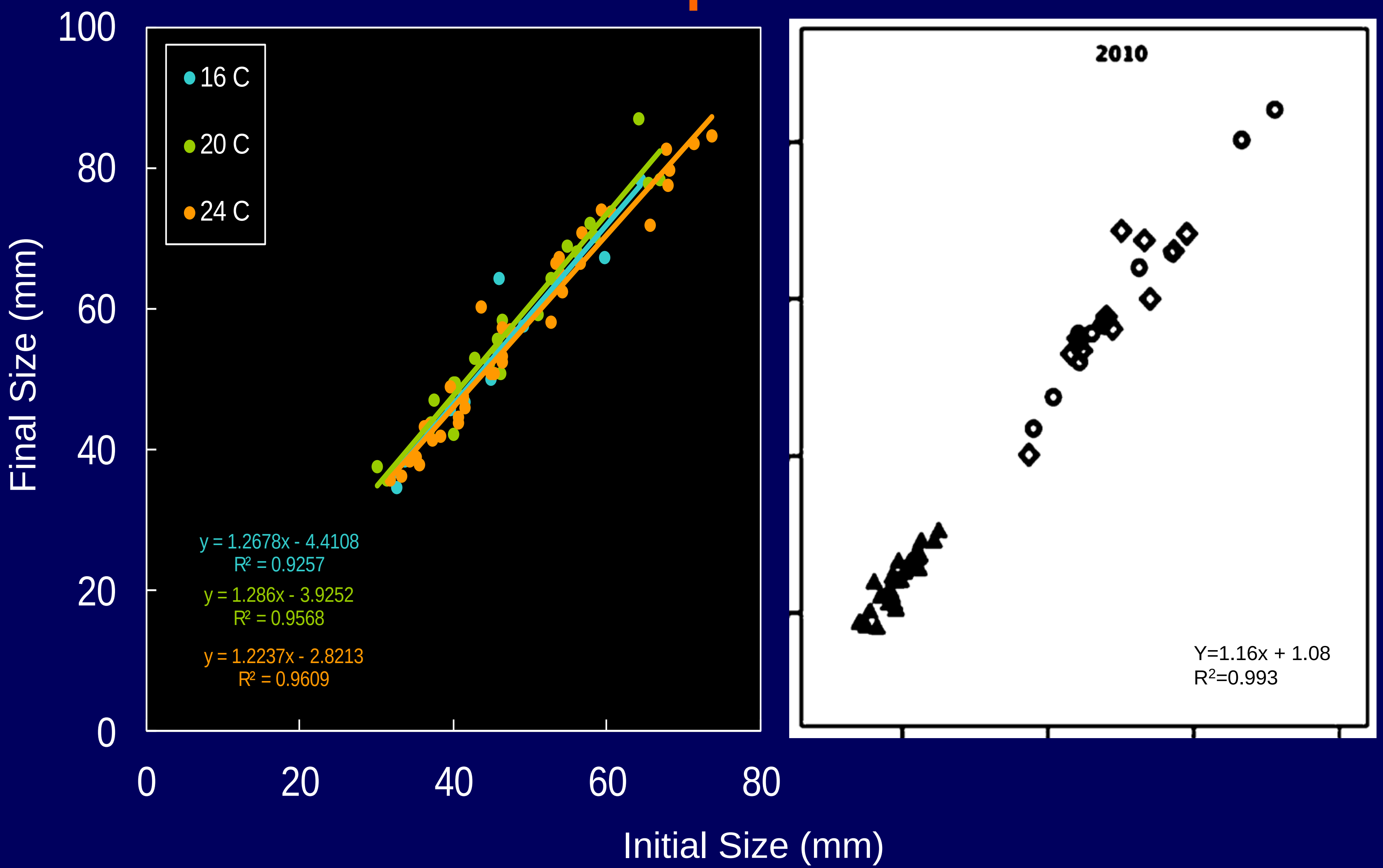
http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm

Growth

- Growth by molting
- May molt up to 20 times to reach adult size
- Characterized by periods of stasis and rapid increases in size, during which the shell is soft



Growth per molt

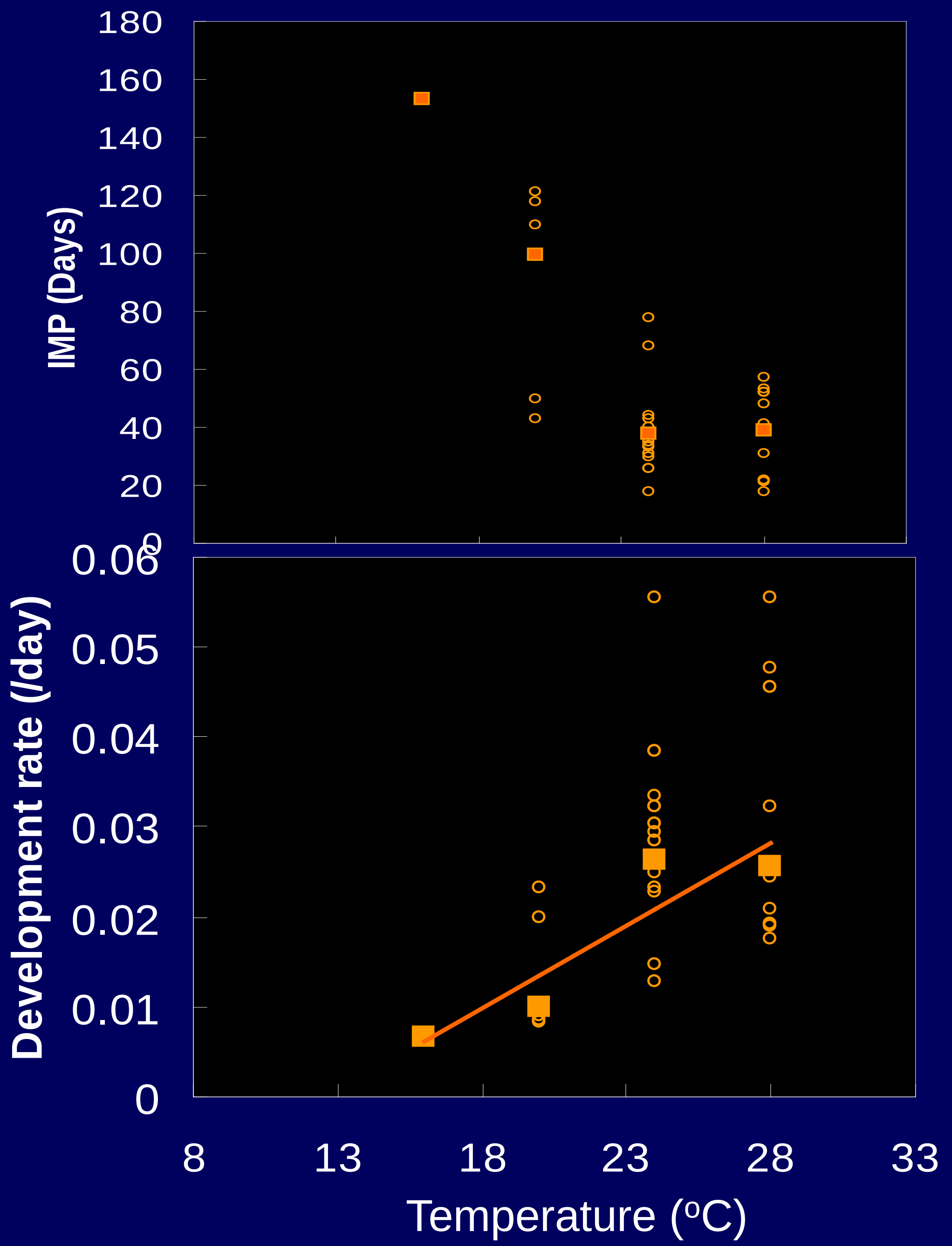


Brylawski et al. 2006

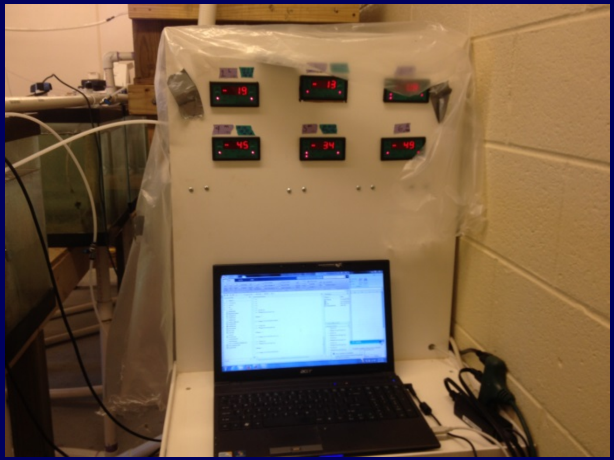
Bilen et al. 2014

Intermolt period

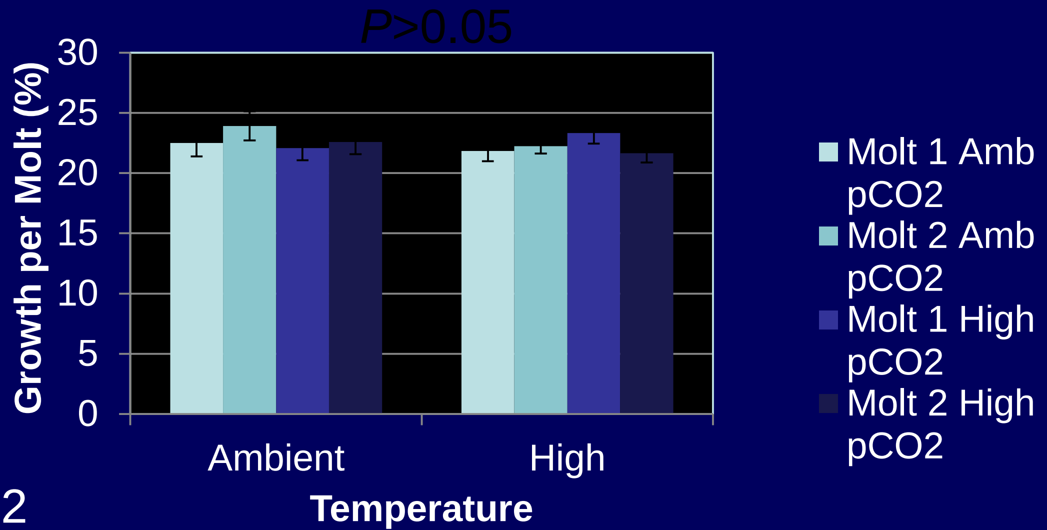
- Intermolt period decreases significantly with temperature
- Development rate increases with temperature and predicts overwintering at ~10-11°C
- IMP increases slightly with size



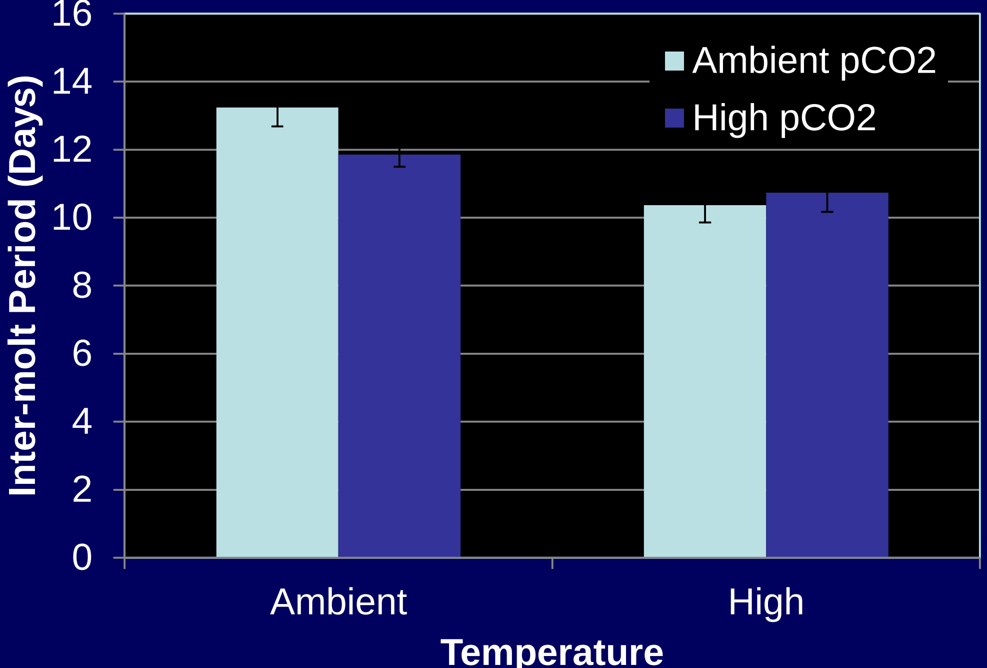
Methods: Acidification Growth Experiment



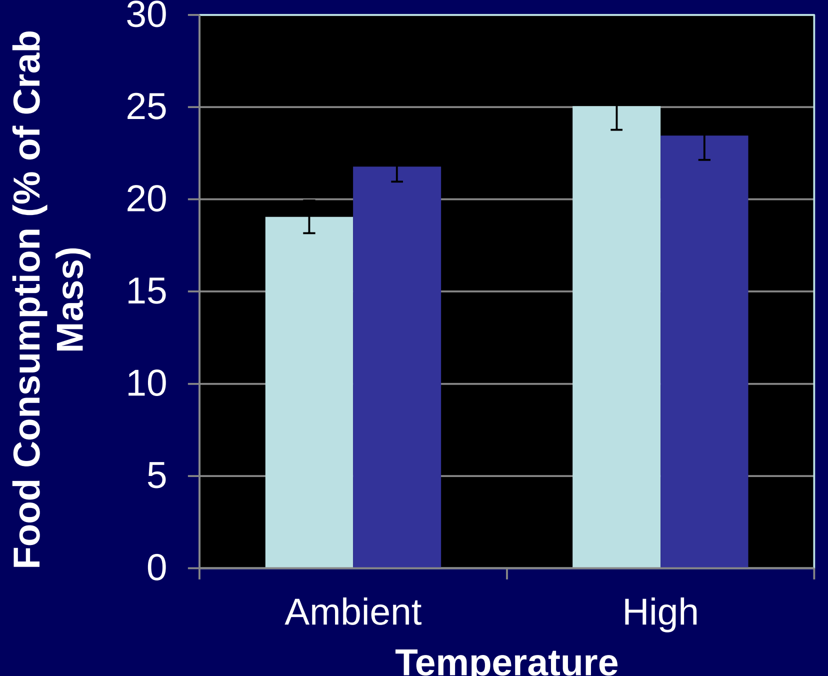
Results: Growth Experiment



Temp: P=0.002
pCO2: P>0.05



Temp: P=0.007
pCO2: P>0.05



Conclusions: Temperature Effects

Response	Temperature
Growth per Molt	No effect
Growth Rate	Increase
Consumption	Increase
Gut Energy Content Muscle Energy Content	No effect No effect
Carapace Thickness	Decrease*
Carapace [Ca]	Decrease
Carapace % CaCO3	Decrease
Carapace [Mg]#	Increase

In warmer water, crabs grew faster and ate more food but did not change their energy storage patterns. These crabs had thinner shells with less [Ca], lower %CaCO3, and more [Mg].

Faster Growth =

Bigger in less time
Increased food consumption
Molting more frequently
Less protective shell

Conclusions: pCO2 Effects

Response	pCO2
Growth per Molt	No effect
Growth Rate	No effect
Consumption	No effect
Gut Energy Content	Decrease
Muscle Energy Content	Decrease
Carapace Thickness	Decrease*
Carapace [Ca]	Increase*
Carapace % CaCO3	Increase*
Carapace [Mg][#]	Increase

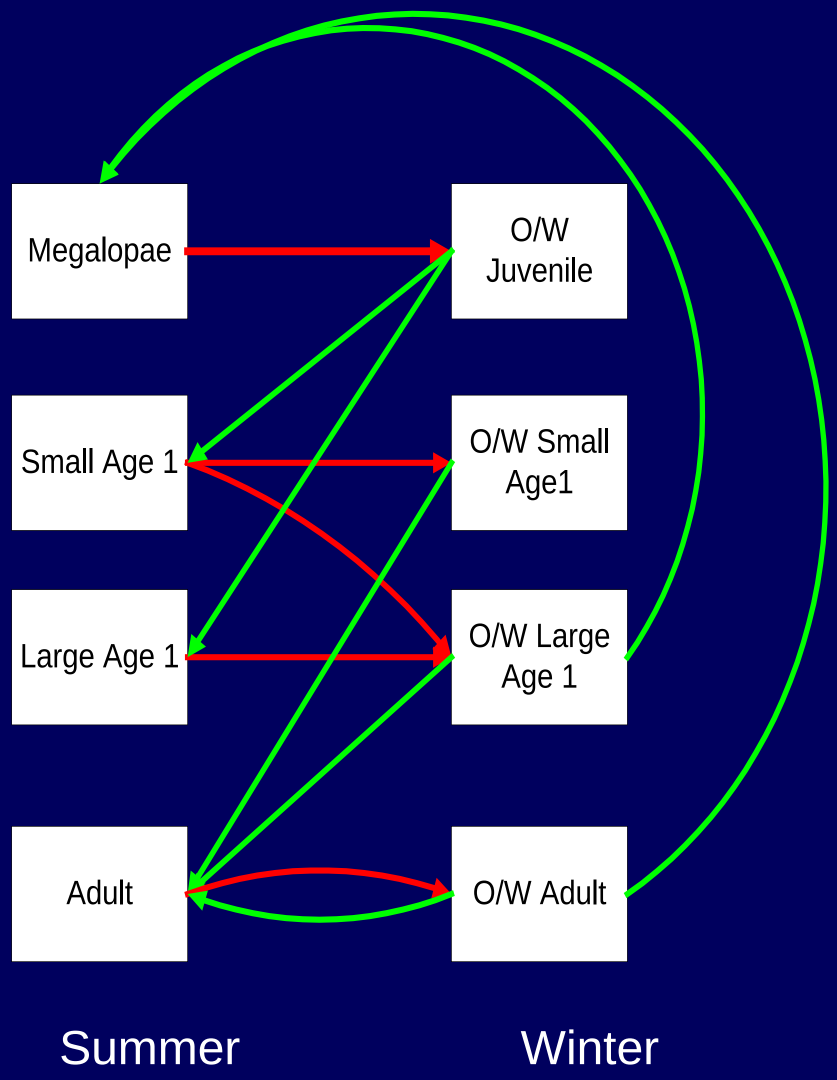
Crab growth was not impacted in more acidic water, but energy storage was decreased. These crabs also had thinner shells but with more [Ca], higher %CaCO3, and more [Mg].

Maintenance of Growth = **Less stored energy**
Less protective shell (?)

So what is the impact on the population

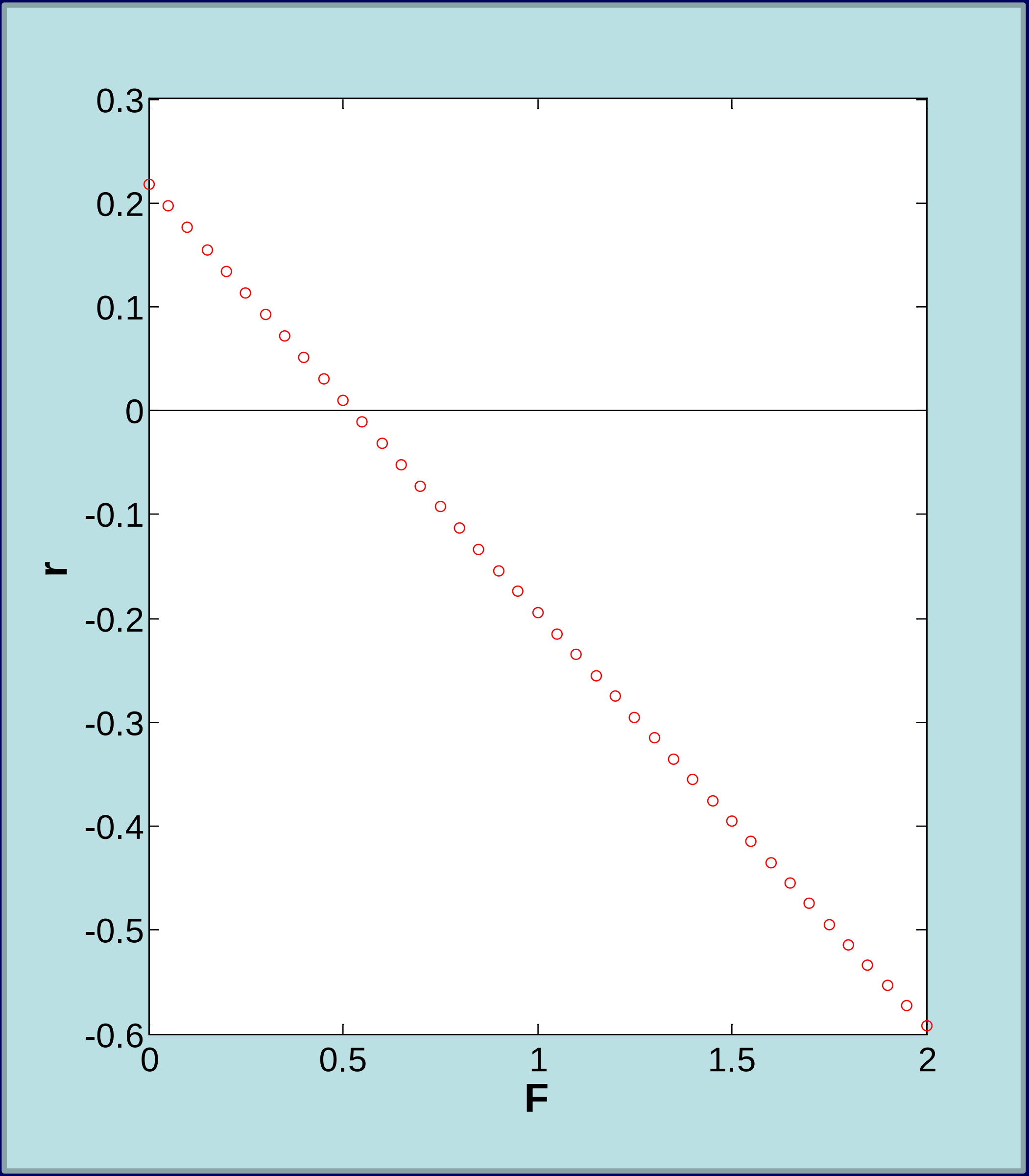
Seasonal model

- Stage based probabilities are functions of M, F, and f, the “growth” rate
- Projection matrix A=Aw*As
- Eigen analysis of A provides r=0, an index of Fmsy



Current conditions

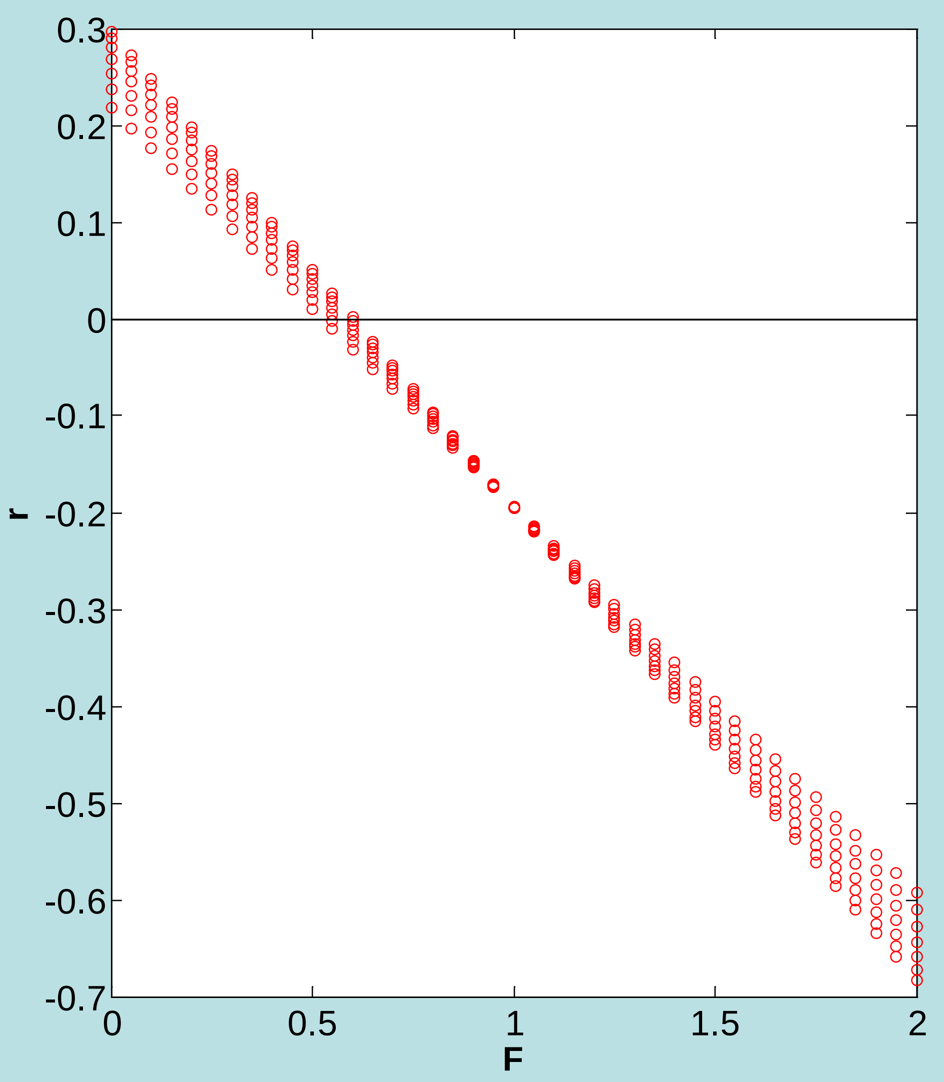
- r=0 occurs at F=0.55



Miller 2001

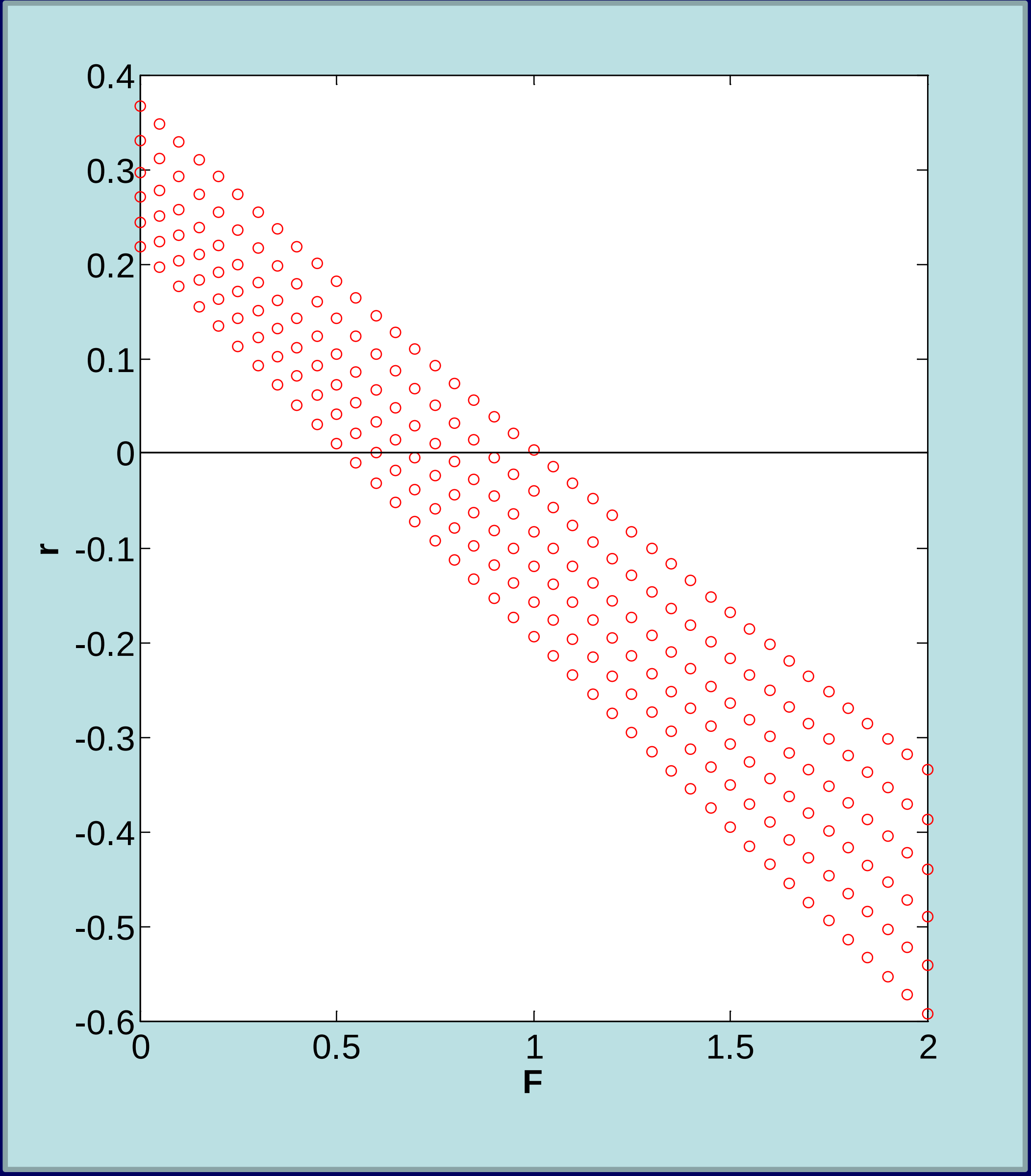
Changing conditions

- r=0 occurs at F_{crit}=0.55
- If increasing "growth" rate doesn't affect time to maturity
  - then increasing growth rotates the iscolines, leaving F_{crit} relatively unaffected



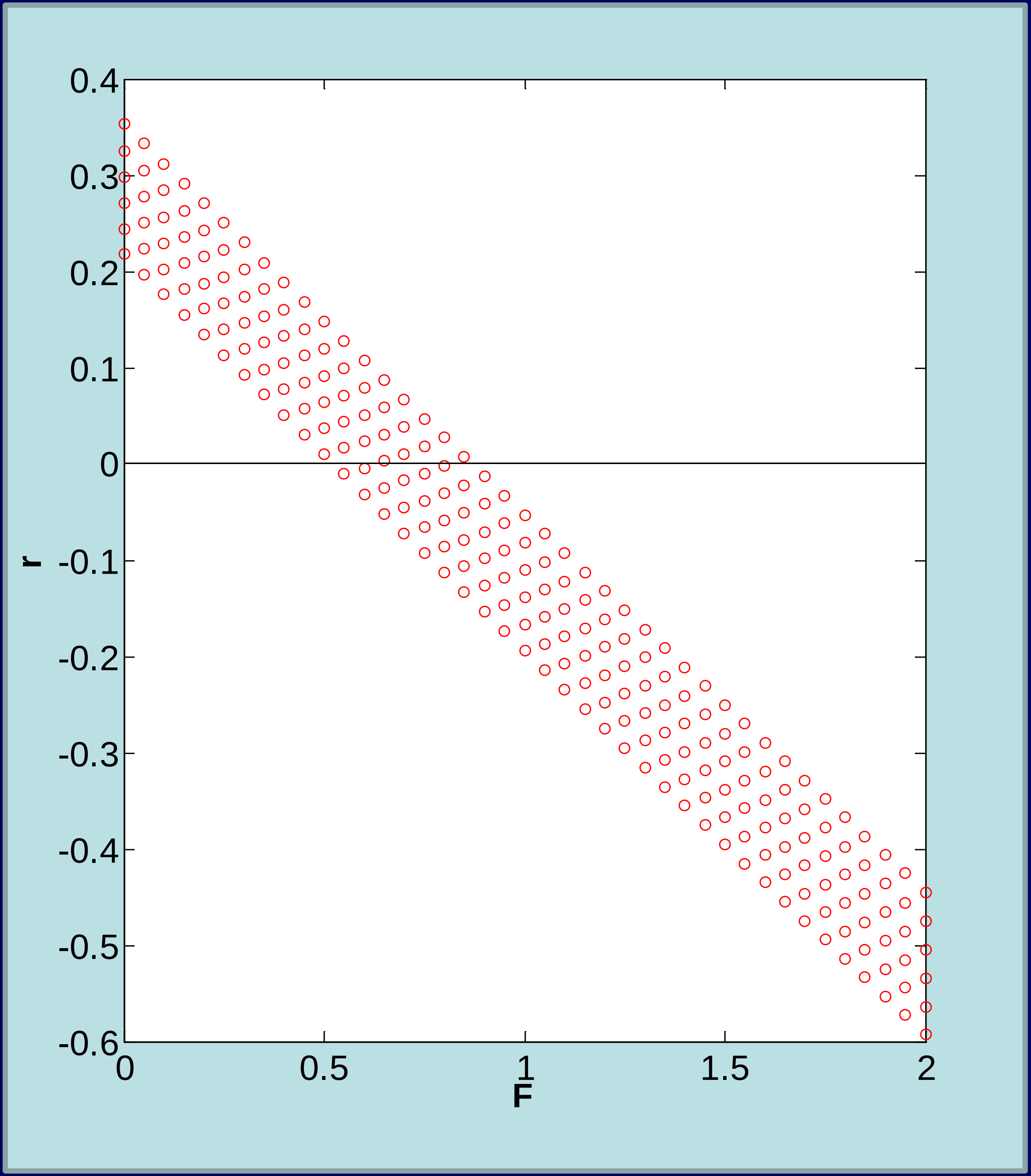
Changing conditions

- r=0 occurs at F_{crit}=0.55
- If increasing "growth" rate decreases time to maturity
  - then increasing growth shifts the isoclines, more than doubling F_{crit}



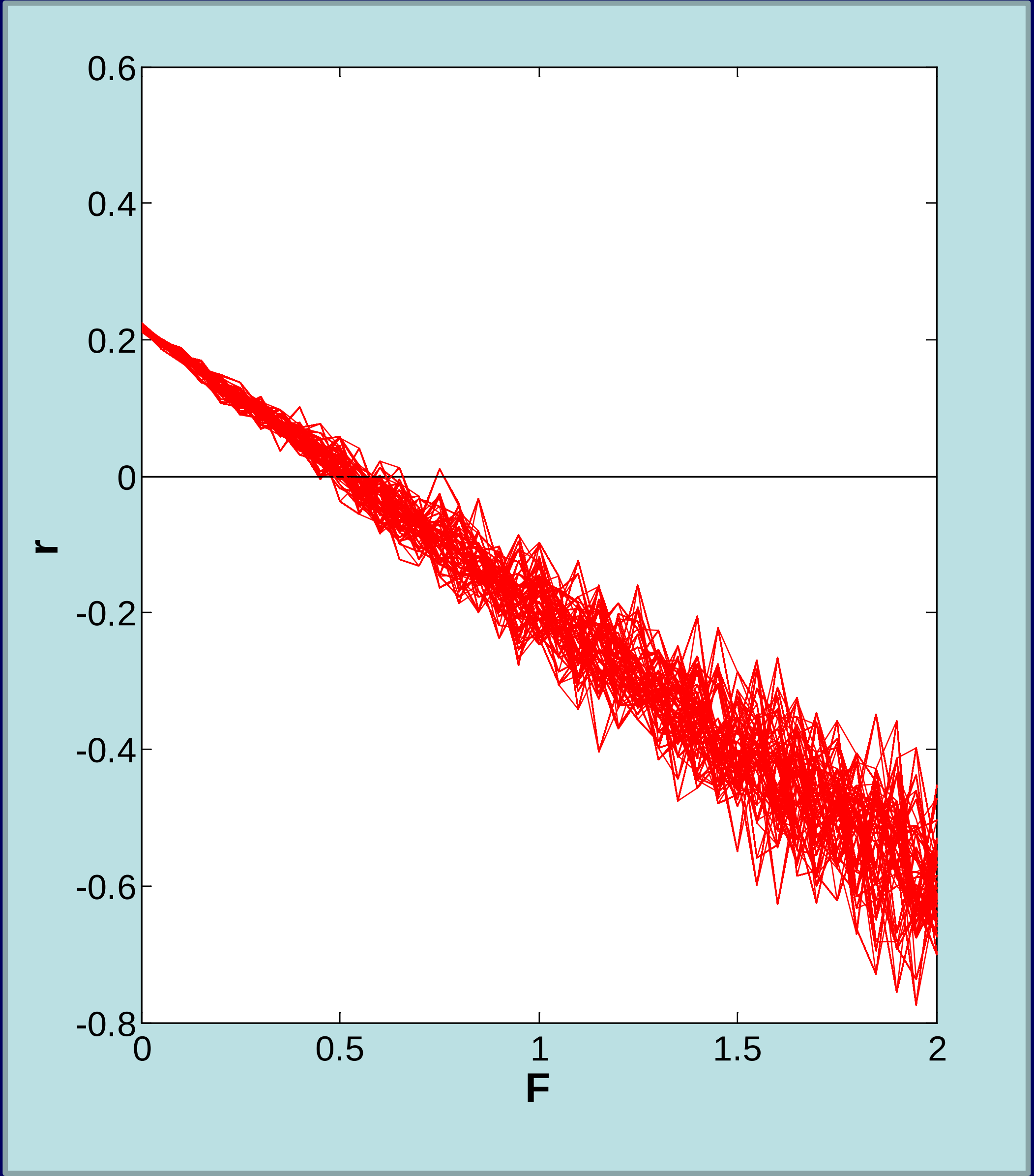
Changing conditions

- r=0 occurs at F_{crit}=0.55
- Decreasing winter mortality increasing productivity of the stock, almost doubling the F_{crit} value.
- But this “benefit” only accrues provided the winter remains a “closed” period



Stochasticity

- Detection of patterns revealed in deterministic projections may be masked by stochasticity.



Conclusions

- Growth and mortality are strongly temperature dependent
- Population dynamics are highly variable, and show latitundinal patterns
- Climate change has potential to dramatically change timing of key life history transitions
- Ocean acidification imposes energetic costs on blue crab – consequences remain to be quantified
- Population dynamics of blue crab will change dramatically in next 30-50 yrs, presenting opportunities and challenges

http://hjort.cbl.umces.edu