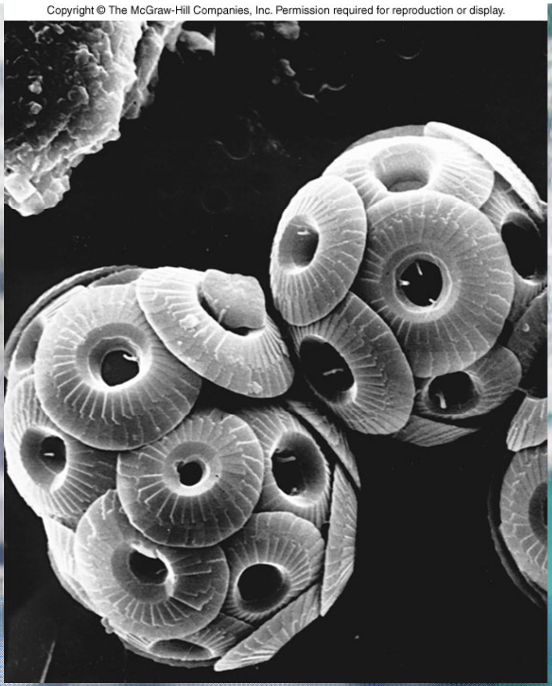


ECCO

Evolution and Climate Change in the Oceans

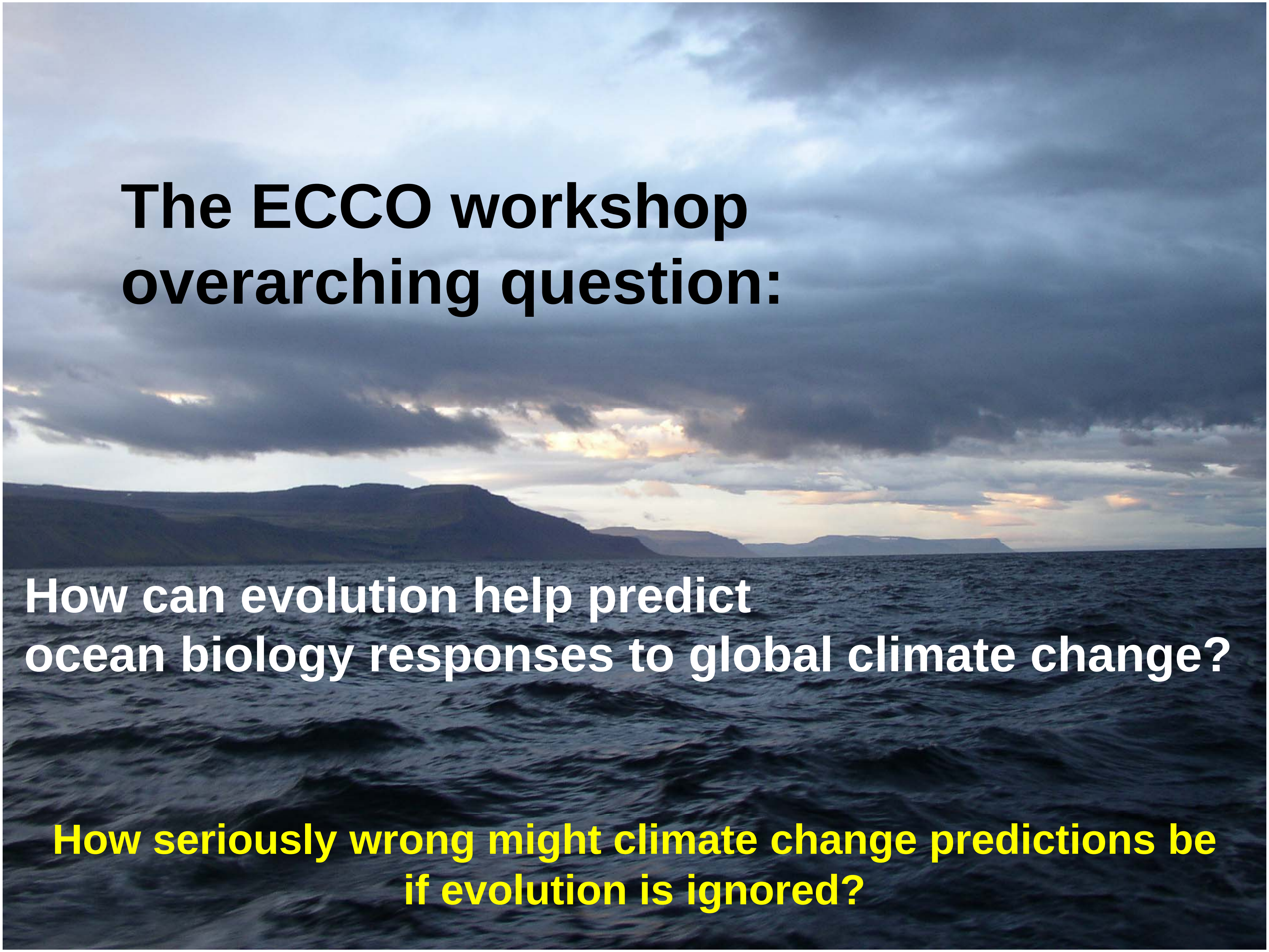
An NSF OCE Biological Oceanography-sponsored workshop

May 7-9, 2010

Wrigley Institute of Environmental Sciences, Catalina Island

University of Southern California

http://hofmannlab.msi.ucsb.edu/ecco/


The ECCO workshop overarching question:
How can evolution help predict ocean biology responses to global climate change?
How seriously wrong might climate change predictions be if evolution is ignored?

ECCO catalytic workshop Steering Committee

National Evolutionary Synthesis Center (NESCent), Durham, North Carolina (October 1-2, 2009).

- Ginger Armbrust (University of Washington)
- Mike Behrenfeld (Oregon State University)
- Sinead Collins (University of Edinburgh)
- Brian Helmuth (University of South Carolina)
- Gretchen Hofmann (UC Santa Barbara)
- David Hutchins (University of Southern California)
- Joel Kingsolver (University of North Carolina)
- David Kirchman (University of Delaware)
- Carol Lee (University of Wisconsin)
- Amy Moran (Clemson University)
- Alison Murray (University of Reno-Nevada)
- Steve Palumbi (Stanford University)
- Robin Waples (National Marine Fisheries Service)

ECCO Catalina workshop Organizing Committee

- David Hutchins (University of Southern California)
- Gretchen Hofmann (UC Santa Barbara)
- Brian Helmuth (University of South Carolina)
- Amy Moran (Clemson University)

Steering committee science questions

1. How does evolution help predict how ocean biology will react to global climate change? [How seriously wrong might climate change predictions be if evolution is ignored?]
2. What are the critical rates of environmental change for different taxa and different environments? How do spatial and temporal scales map onto physiological and evolutionary responses?
3. What are the limits to phenotypic plasticity? How can the paleontological and empirical records help us understand this? Are there tipping points or guardrails?
4. What is the relationship between short-term plasticity and long-term evolution? How do evolutionary biologists and oceanographers think about plasticity?
5. How do complex, co-occurring environmental factors that will typify climate change in the oceans interact to determine fitness?
6. How can we interpret marine genomes in light of evolutionary theories with regard to climate change?
7. Can we use evolutionary theory to predict consequences for complex, dynamic systems? Can existing ecological theory explain how multiple factors might interact in a climate change scenario in marine ecosystems? (e.g. antagonistic and synergistic interactions of temperature and acidification)
8. What buffers ecosystem responses to environmental changes? Does evolution contribute? How do evolutionary processes impact resilience of ecosystem properties?
9. If interested in changing properties of the whole community, how can one partition between evolution within lineages, interactions between lineages, and physiological acclimation?
10. How do we test our hypotheses/validate our predictions? (e.g., how can we make them more information-rich)?

ECCO Catalina workshop participants

Ginger Armbrust	Elena Litchman
Farooq Azam	Charles R. Lovell
Philip Boyd	Craig McClain
Robert C. Carpenter	Amy Moran
Emily Carrington	Margie Mulholland
Matthew Church	Stephen Palumbi
Sinead Collins	Uta Passow
David Conover	Cathy Pfister
Suzanne Edmands	David Reznick
David Garrison (NSF)	Kaustuv Roy
Christopher Gobler	Tatiana Rynearson
John Heidelberg	Mak Saito
Brian Helmuth	Eric Sanford
Gretchen Hofmann	Paul Schmidt
Raymond B. Huey	Patricia Schulte
Pete Jumars	Deborah Steinberg
Michael Kearney	Philip Taylor (NSF)
Raphael Kudela	John Wares
Carol Lee	

ECCO workshop, May 7-10, 2010
Wrigley Institute for Environmental Studies

Disciplinary breakout groups

Biogeochemistry and biological oceanography
Ecology and physiology
Genetics and genomics

Organismal breakout groups

Algae and microbes
Invertebrates
Vertebrates

Mixed breakout groups

Consensus and implementation

Common barriers

-Language (jargon)

-Cultural divides – training, and natural tendency to specialize

-Thinking and working at different scales in different fields– spatial, temporal, shaped in part by scaling associated with organisms and systems

-C*entral* questions to each field are often different – people may have to work outside of central areas in their own fields to come up with transformational questions at interdisciplinary interface

Common solutions

Identify and prioritize what each field needs from, and has to offer to, the others

Facilitate communications via meetings and workshops, special journal issues, presentations/lecture series

Establishment of accessible, cross-referenced databases and archival sample collections that would be useful to both communities

Recognizing need for more data – matched physical and biological

Crossdisciplinary graduate and postdoctoral training

1. Marine communities are composed of multiple ecotypes and species. **An important question is the extent to which responses to climate change will be based on species adaptation, versus changes in community composition, or both.**

2. Marine communities are composed of diverse organisms, both taxonomically and functionally. For example, kingdoms differ in how they generate heritable genetic variance (e.g. the relative importance of horizontal gene transfer, point mutations, recombination) and this may alter their evolutionary responses to environmental change. This in turn may drive changes in ecological structure and biogeochemical cycles. **We need to support the evolutionary study of diverse taxa with a range of functional roles.**

3. Behavior, physiology, life history, and genetics can all mediate fitness responses to climate change. **The relative contributions of these responses need to be considered and resolved.**

4. Model systems have proven to be a valuable way to gain insight into evolutionary processes and dynamics. However, the applicability of existing model systems to climate change in marine ecosystems may be limited. **We thus encourage the evaluation of potential marine model species that are tractable, ecologically important and relevant to marine climate change.**

5. Marine ecosystems have historical data, both via long-term sampling programs and via the fossil and sedimentary record. **We encourage the use of cross-referenced historical and archival data in making inferences about climate change. We also encourage programs that leverage or enhance existing time-series to improve our ability to detect and predict evolutionary responses.**

6. Climate and biological systems are highly nonlinear, and thus small changes in drivers can result in large changes in community structure (“tipping points”). **Understanding how evolution influences physiological, genetic and ecological mechanisms underlying these thresholds is therefore key.**

7. Extrapolating from laboratory experiments to ocean processes is challenging due to large differences in scale, complexity and rates of change. **Investigations that test the validity of these extrapolations across scales are needed.**

8. The application of laboratory experiments to inform current and future conditions in nature requires that we place these experiments within appropriate ecological and environmental contexts. **We therefore encourage interdisciplinary studies in which controlled laboratory experiments are coupled with models and field measurements of the stressors under consideration.**

9. Multiple anthropogenic stressors will interact with climate change to shape the evolutionary responses of marine organisms. **Studies of evolution and climate change need to consider other aspects of the changing ocean.**

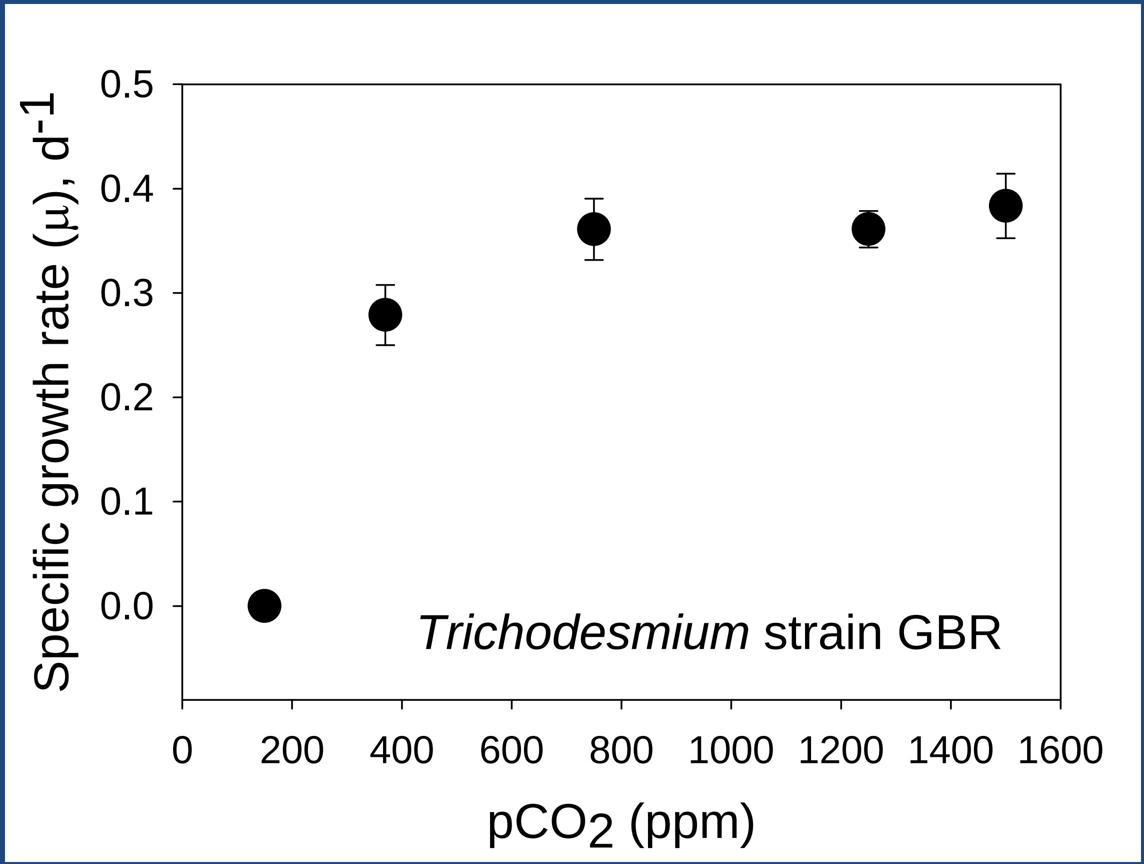
ECCO products and outcomes

- Workshop report (currently being written)
- Website **http://hofmannlab.msi.ucsb.edu/ecco/**
- Oral report for NSF personnel
- Input to upcoming meeting and workshop efforts (2012 Oceans in a High CO_2 World)
- Interdisciplinary collaborations between participants

Evolutionary fitness response curves: Phytoplankton growth rates as a function of temperature (or pCO_2, etc)

Cross-disciplinary collaboration

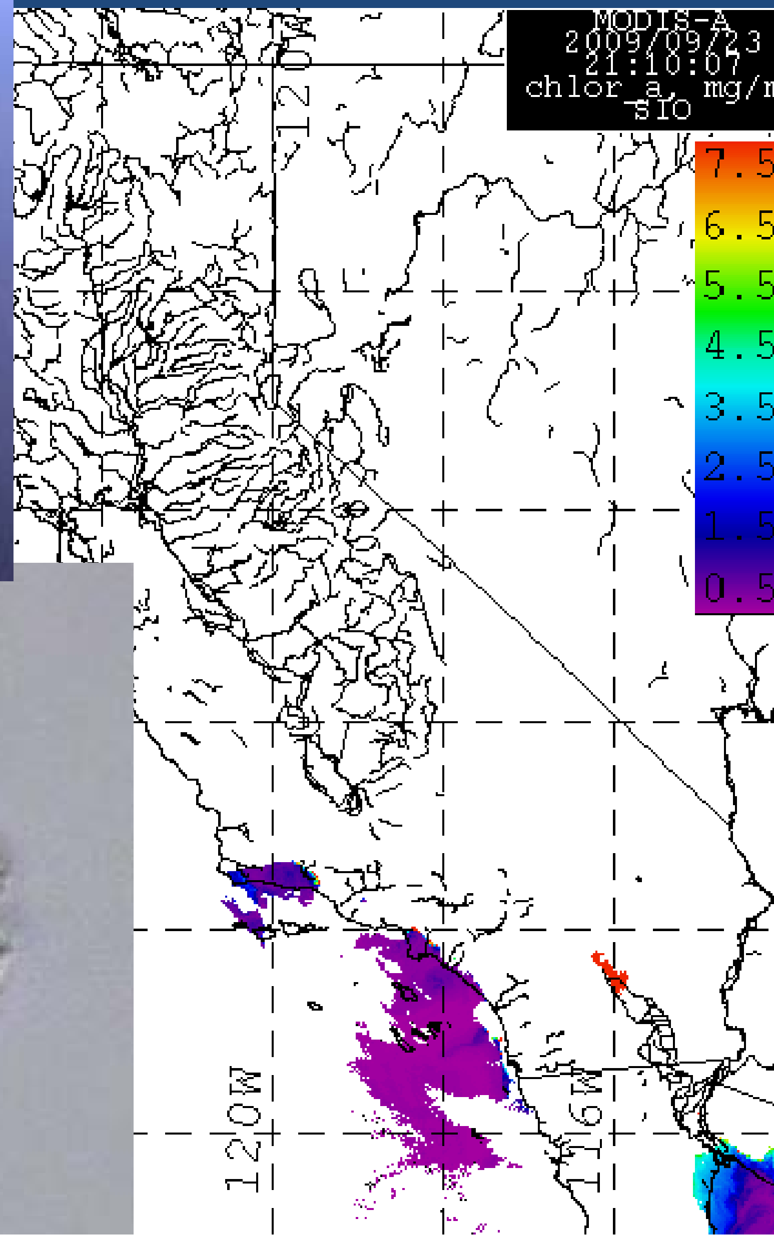
P. Boyd, D. Hutchins, R. Kudela, M. Mulholland, U. Passow, S. Collins



How predictive are short term natural community manipulation experiments of future long-term changes?

How can we evaluate the potential for acclimation and adaptation to global change?

Southern California *Lingulodinium polyedrum* bloom, September 2009

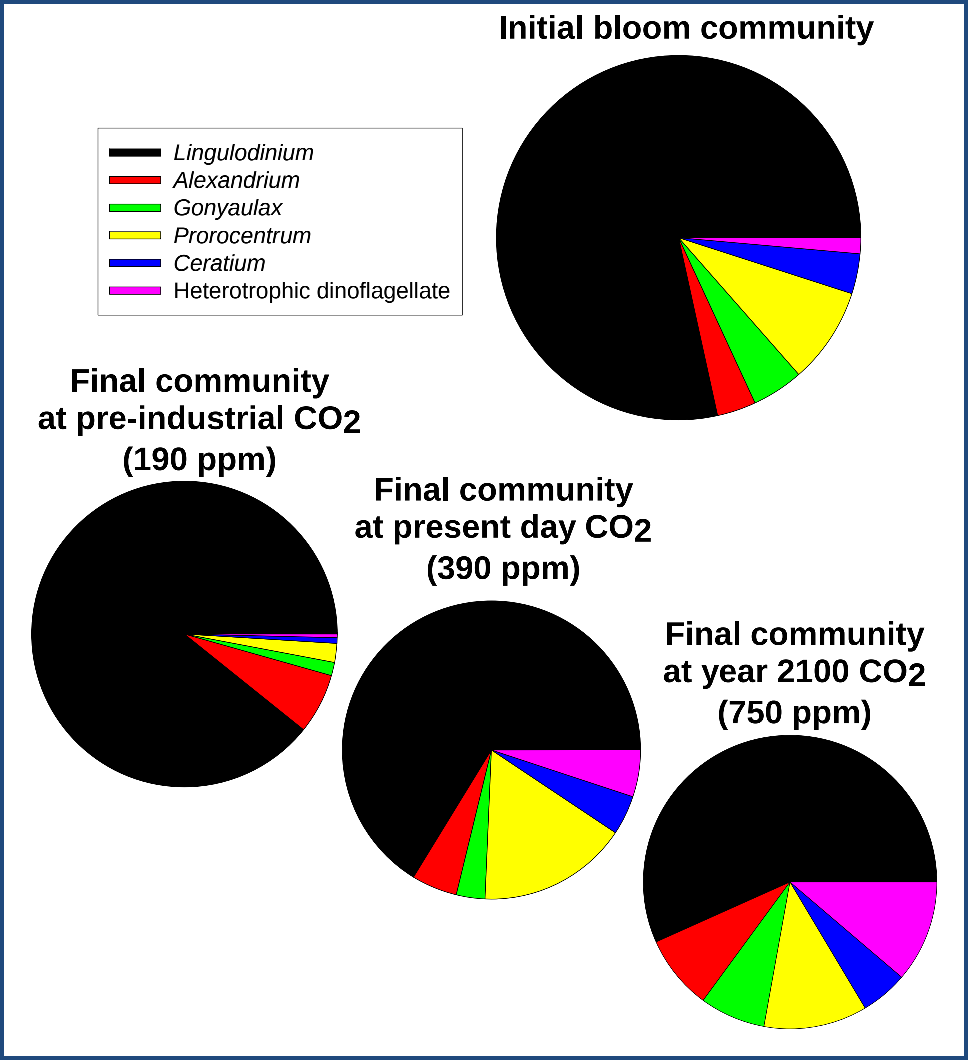


blocs.xtec.cat/.../42-els-dinoflagel·lats/

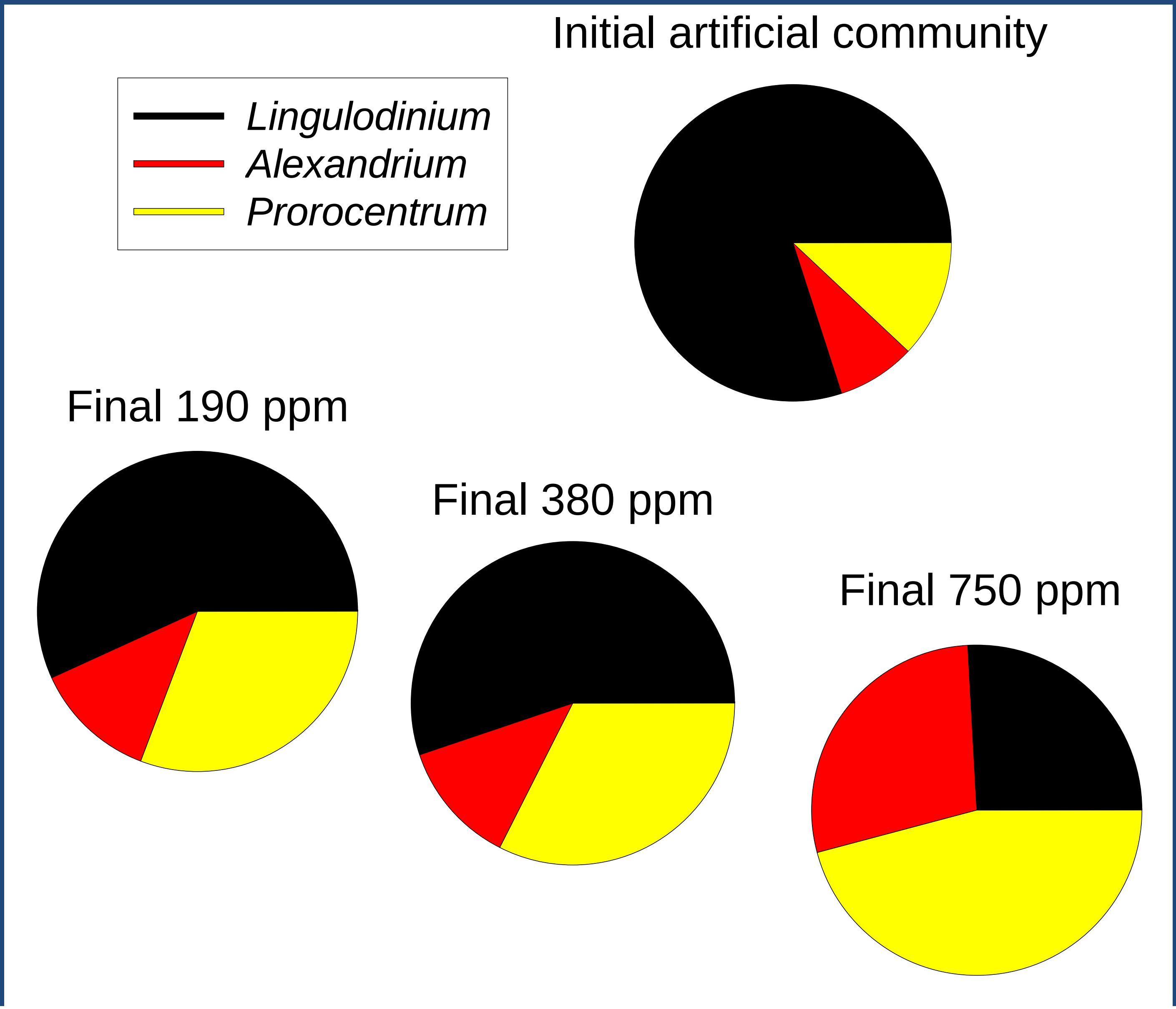
Acclimation experimental design

- Dinoflagellate bloom collected, and dominant members isolated into unialgal cultures
- Bloom incubated at 3 pCO_2 levels (190, 380 and 750 ppm) for ~2 weeks
- Final community composition determined in all three treatments
- Isolated cultures maintained at all 3 pCO_2 levels for ~ 2 months
- Acclimated cultures mixed together again in artificial communities at all 3 pCO_2 levels, and allowed to compete for 2 weeks

Dinoflagellate bloom community experiment



Artificial community experiment following ~2 months acclimation time: competitive outcomes



Conclusions

- The trends in outcome of inter-specific competition using long-term acclimated cultures is in some cases similar (750 ppm) and in some cases different (190 ppm) from the trends in the original short-term manipulative experiment using the natural dinoflagellate bloom.

Acknowledgements

Collaborators and coauthors

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Students and postdocs

Avery Tatters, Nathan Garcia, Cynthia Breene, Andrew King, Yuanyuan Feng

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