Advances in OA Research
Where are we now...?

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Second U.S. Ocean Acidification PI Meeting
September 17-20, 2013
Gallaudet University’s Kellogg Conference Center
Washington, D.C.
Last time we met: “Skin in, Skin out”
Integrative Biology in OA Research

- Molecular
  - Proteomics
  - Gene Expression
  - Nano too

- Cellular
  - pH$_e$/ph$_i$
  - Calcification
  - Biochemical Enzymes
  - Photosynthesis
  - Oxidative stress

- Organism
  - Metabolic rate
  - Energetics
  - Acid/base phys.
  - Growth
  - Reproduction
  - Calcification
  - Development
  - Photosynthesis
  - Respiration
  - Biomaterials
  - ‘Hard parts’

- Population
  - Disease

- Community
  - Reef-wide calcification
  - Recruitment
  - Species Interactions (trophic)
  - Local Adaptation
  - Demographics

Symbiosis
Methodological Advances*

Highlight five developments:

1. Species interactions & ecosystem function
2. Experimental systems to support multistressors
3. Co-locating sensors with “Biology”
4. Use of next-generation sequencing (NGS)
5. Science Communications

*My humblest apologies for things I might have missed or not covered. Many thanks to those who shared data and images with me.
1. Species interactions

Ocean acidification causes ecosystem shifts via altered competitive interactions

Kristy J. Kroeker\textsuperscript{1*}, Fiorenza Micheli\textsuperscript{1} and Maria Cristina Gambi\textsuperscript{2}
2. New lab systems – support “multistressor” studies:

Apparatus to support independent regulation of CO₂ concentration, O₂ levels, and temperature in a controlled environment

2. Diatoms, multistressors & community composition

2. Experimental coral reefs

### Future reef decalcification under a business-as-usual CO₂ emission scenario

Sophie G. Dove\(^{a,b,c,1}\), David I. Kline\(^{a,b,2}\), Olga Pantos\(^{a,b}\), Florent E. Angly\(^d\), Gene W. Tyson\(^{d,e}\), and Ove Hoegh-Guldberg\(^{a,b,c}\)

\(^a\)Global Change Institute, \(^b\)School of Biological Sciences, \(^c\)Australian Research Council Centre for Excellence in Coral Reef Studies, \(^d\)Australian Centre for Ecogenomics, and \(^e\)Advanced Water Management Centre, University of Queensland, St. Lucia, QLD 4072, Australia

Edited by Paul G. Falkowski, Rutgers, The State University of New Jersey, New Brunswick, NJ, and approved August 6, 2013 (received for review February 16, 2013)

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3. Co-location of Sensors with Biology

SeaphHOxes and SeaFETs are paired with coral recruitment plates to relate development of early successional communities on reefs with environmental condition.

Price et al. 2012 *PLoS One*

Daily seawater pH seasonal low

Bioeroders and soft-bodied species

Calcifiers and reef builders
4. Next Generation Sequencing (NGS)

• Molecular genomic applications
  – NGS available to people who can do a “good experiment”, no longer the provenance of genomicists
Whole Transcriptome Analysis of *Acropora millepora* with Illumina RNAseq

Moya et al. (2012) *Molecular Ecology* 21: 2440-2454
4. Next Generation Sequencing (NGS)

• Genomic applications
  – NGS available to people who can do a good experiment, no longer the provenance of genomicists

• Examine capacity for adaptation or looking for polymorphisms in the DNA for genes – Single Nucleotide Polymorphisms (SNPs)
Summary schematic of predicted evolutionary forces and enrichment results (A) and observed protein function enrichment results for greater changes in allele frequency (B) between the four day and treatment combinations.
4. An approach to look at the genotype-phenotype connection: *Larvae reared under high CO₂ are smaller*...

Mytilus californianus

... but there is lots of variation!

Morgan Kelly, unpubl. results
RNA seq to identify differences among resistant vs. sensitive larvae

1) Gene expression:
   - What are the expression differences between high and low \( \text{pCO}_2 \)?
   - What are the expression differences in resistant vs. sensitive larvae?

2) SNPs:
   - Are there SNPs associated with larvae that are resistance to high \( \text{pCO}_2 \)?
4. Strategic approaches to measuring evolutionary approaches

- Munday et al. *Ecology Letters* (Accepted)

<table>
<thead>
<tr>
<th>Approach</th>
<th>Strengths</th>
<th>Limitations</th>
<th>Relevant organisms</th>
<th>Examples</th>
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<tr>
<td>Molecular / genomics</td>
<td>Can survey populations for molecular variation (i.e., among individual alleles)</td>
<td>Genotype-phenotype map often poorly resolved: difficult to link allelic variation to heritable phenotypic variation in quantitative traits that are likely to be most relevant in adaptive evolution</td>
<td>All organisms, especially large, long-lived or rare species that are not amendable to laboratory breeding experiments or experimental evolution</td>
<td>Barshis et al 2013 Pespeni et al 2013</td>
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<td>Can give insight into mechanisms of gene expression</td>
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<td>Can be applied to natural populations</td>
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CLEAR AND “SIMPLE!”

MORE NUANCED, CONFLICTING RESULTS

INCREASINGLY ROBUST AND PREDICTABLE

CONFIDENCE

TIME

COMPASS
5. Science Communication

- Three OA trainings:
  - Monterey, here in DC, and next one in Hawaii
- Profiles in OA Courage!
The Elevator Speech
The Radio Interview

Jeff Runge
*Univ. of Maine (L)*

&

Jon Hamilton (R)
*Science Desk, NPR news*
Summary OAPI 2013

• Advances in understanding species interaction – more on ecosystem function to come
• OA occurs with other abiotic factors
• Observing linked to “Biology” is powerful
• Next generation sequencing, an emerging tool to study evolutionary potential
• By February 2014, 60 people in our community will have advanced training to communicate their OA science