Studying ocean acidification at an LTER: a coral reef example from Moorea

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Context for, and advantages of, OA research at an LTER site
Moorea Coral Reef LTER – sampling design

- Fringing reef
- Back reef
- Outer reef (10 + 17 m)
MCR research themes

1. Resilience of contemporary reefs

From: http://oceantippingpoints.org

2. Coral reefs of the future

OA research
Physical measurements of pH

Upstream/downstream

Fringing reef

Offshore (2005-present)
- 7 km and outer reef
- TA = 2345 ± 3 µmol/kg
- pH = 8.071 ± 0.003

Comeau et al. (2014) MEPS 501: 99-
Summary: Over the first decade, major changes driven by pulse disturbances (COT and cyclone)
Development of OA research theme

- Cells
- Organisms
- Populations
- Communities
- Ecosystem
- Winners & Losers

Ecologically relevant chemical and physical conditions

Revised ecological scenarios

Revised physical sampling

Revised ecological Sampling?

Time series
Organism scale effects
Long-term change on the N shore

Winners in Moorea
Porites
Pocillopora
Losers in Moorea
Acropora
Montipora

Variety of species contrasts differ in their response to OA, and show no tipping point against pCO$_2$

Solid lines, P < 0.05, dashed P > 0.05

Organism scale effects – functional groups

Do coral reef calcifiers differ among functional groups in response to OA?
• fast vs slow

Summary: Functional groups differ, fast are more sensitive than slow calcifiers

Comeau et al. (2014) L&O 59, 1081-
Community scale effects – flume experiments

Back reef
Community scale effects – back reef

Summary: community calcification reduced 59% at high pCO2, with 50% of this due to sediment dissolution; corals and calcified algae reduced 29%

Comeau et al. (2015) Biogeosciences 12: 365-
Community-scale effects – 17 m, outer reef

Summary: $pCO_2$ (1200 µatm) depressed Community calcification 45% when Integrated over 24 h, largely due to pavement dissolution

Comeau et al. (2015) GCB (in press)
Scaling-up OA effects

Modeling approaches:
- Dynamic energy budgets (DEB)
- Integral projection models (IPM)
- Metabolic theory of ecology (MTE)

Edmunds (+ 15 others) BioSciences (in prep.)
Integral projection models – *Pocillopora verrucosa* example

**Factorial experiment**
(Trial 1, 2014; Trial 2, 2015)

ANCOVA: Temp x pCO2 x Size, P = 0.009

- **Low Temp**
  - Ambient, $r^2 = 0.769$
  - High, $r^2 = 0.889$

- **High Temp**
  - High, $r^2 = 0.784$
  - Ambient, $r^2 = 0.589$

**Integral projection model (IPM)**

Summary: Preliminary work reveals complex ways by which OA translates to population growth
Future OA plans in Moorea

1. In situ flume work to better match to conditions affecting reefs in the LTER

2. Extend duration of experiments to 12 months

3. Common gardens to explore within- and among- genotype capacity to respond to OA
Summary points

1. MCR-LTER supplies information infrastructure for contextualizing OA research and for providing added value to this research.

2. Long-term (decades+) aspect of LTER is critical to providing:
   (a) a means to evaluate effects of press disturbances (like OA)
   (b) test hypotheses emerging from OA research
   (c) framework for year+ OA experiments

3. Intellectual, data, and technology infrastructure is well suited to one of the next major challenges: integrating effects across scales.
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Population/community scale effects – ecological processes

Competitive encounters among corals
Montipora vs Porites

Summary: Growth depressed by OA, but competitive encounters reduced negative effects

Evensen, Edmunds, Sakai. MEPS (in review)