Present and Future Natural pCO_2 Variability on a Coral Reef Flat

Emily Shaw, Ben McNeil, Bronte Tilbrook, Richard Matear

Climate Change Research Centre, The University of New South Wales
CSIRO Marine and Atmospheric Research

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA

National Research FLAGSHIPS Wealth from Oceans

CSIRO

Open Ocean

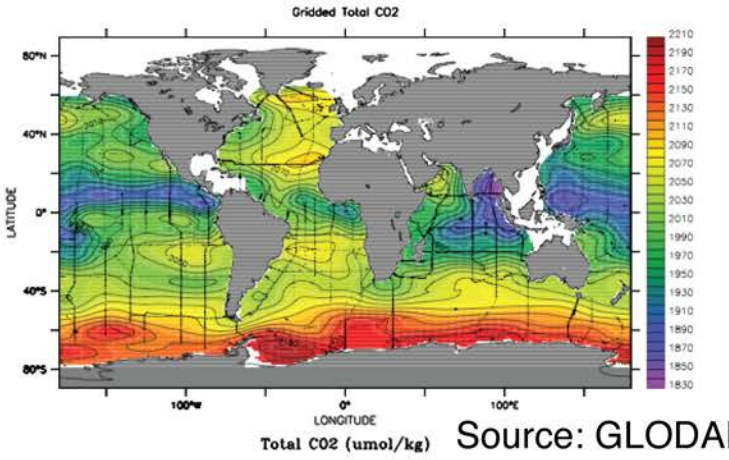
Open ocean measurements (e.g. WOCE)

↓

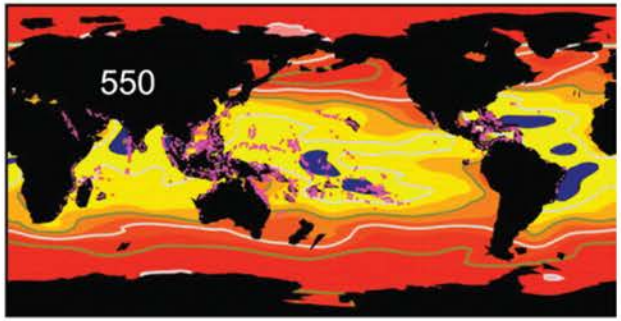
Global-scale predictions

↓

Lab/mesocosm perturbation experiments



Source: GLODAP



Source: Hoegh-Guldberg *et al.* 2007 *Science*

Open Ocean

In situ measurements (e.g. WOCE)

Global-scale predictions

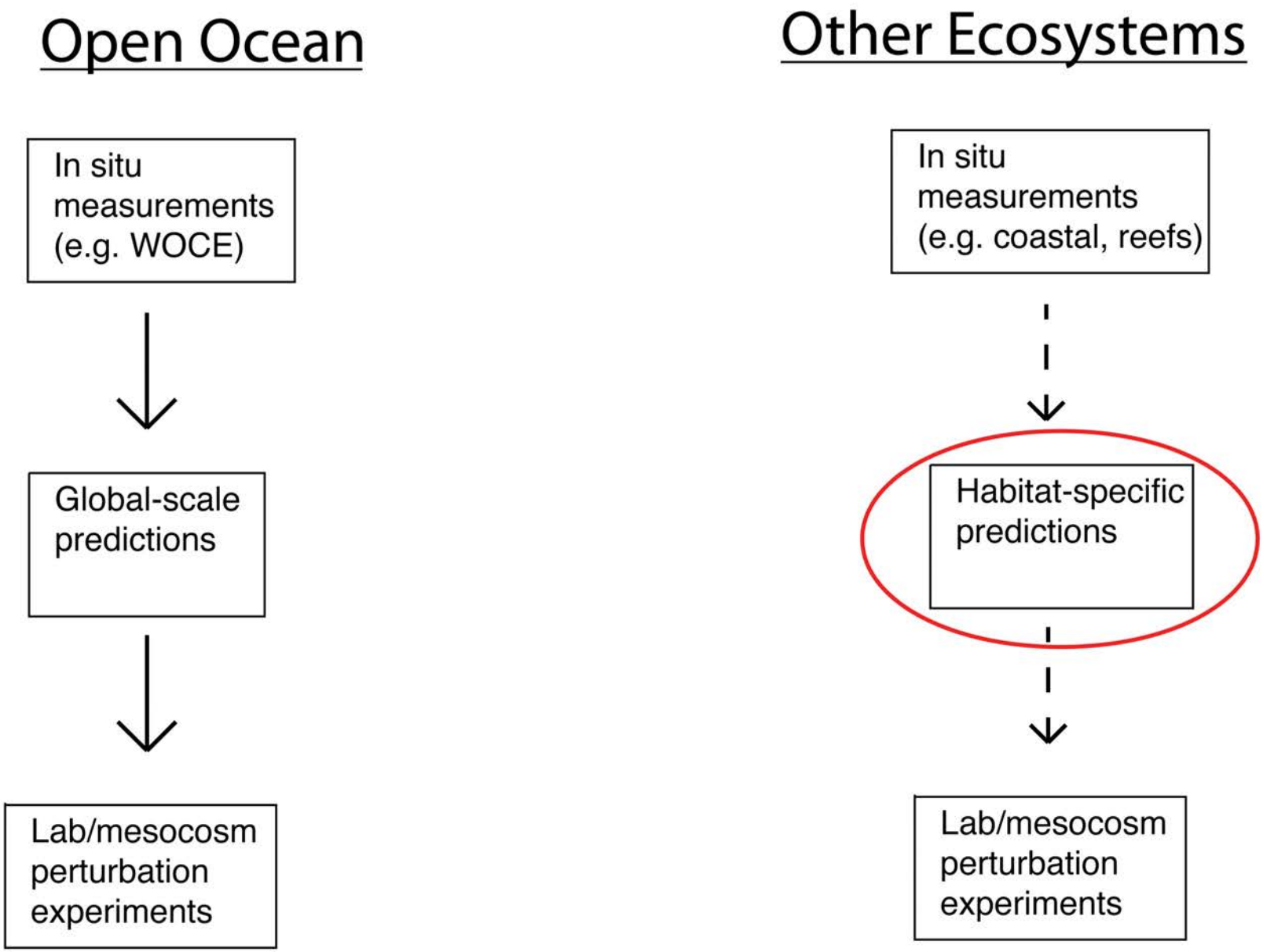
Lab/mesocosm perturbation experiments

Other Ecosystems

In situ measurements (e.g. coastal, reefs)

Habitat-specific predictions

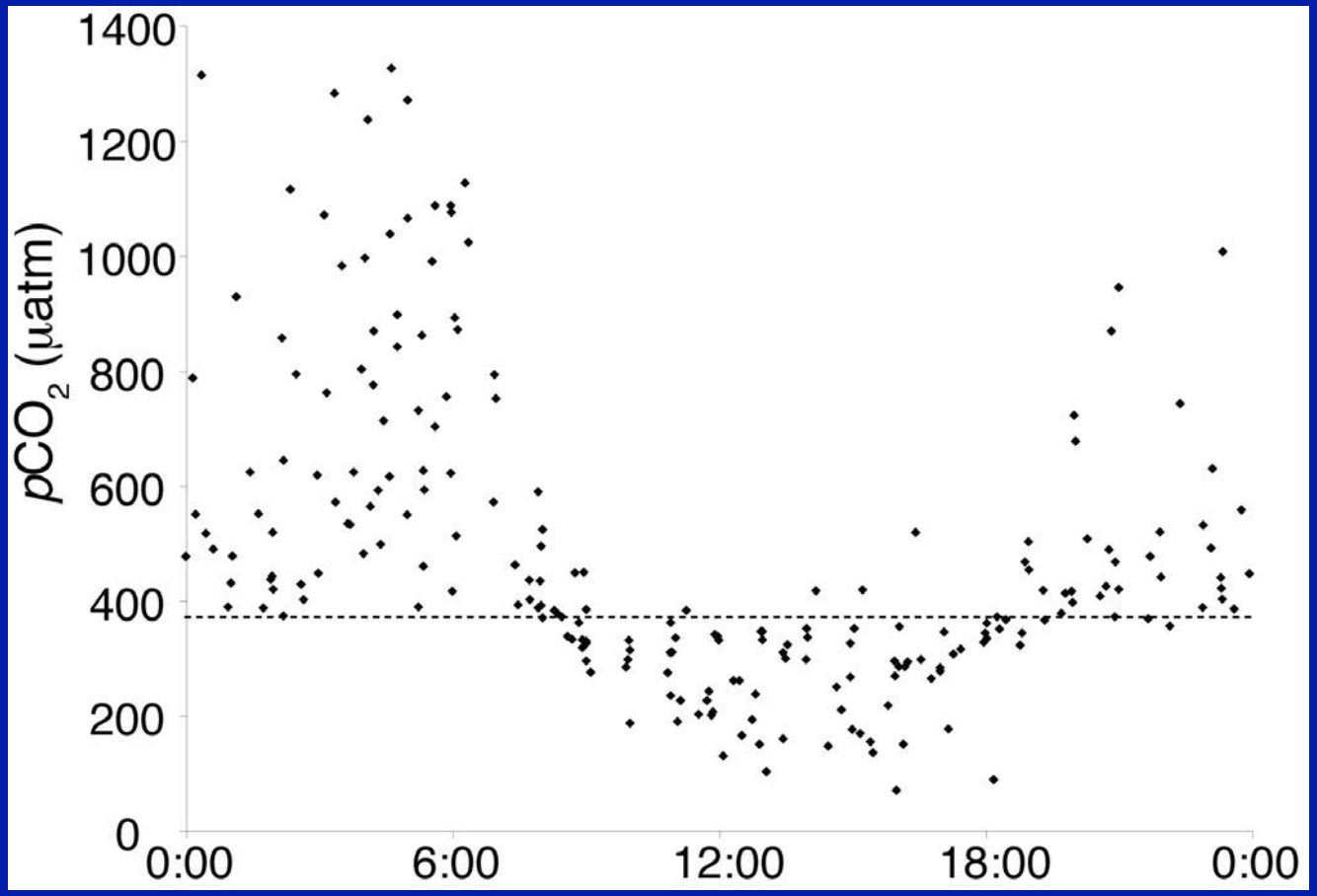
Lab/mesocosm perturbation experiments


Open Ocean
In situ measurements (e.g. WOCE)
Global-scale predictions
Lab/mesocosm perturbation experiments
Other Ecosystems
In situ measurements (e.g. coastal, reefs)
Habitat-specific predictions
Lab/mesocosm perturbation experiments

Study Site - Lady Elliot Is., GBR

- Semi-diurnal tides
- Reef flat depth ~40-180 cm

Observed pCO_2 Variability

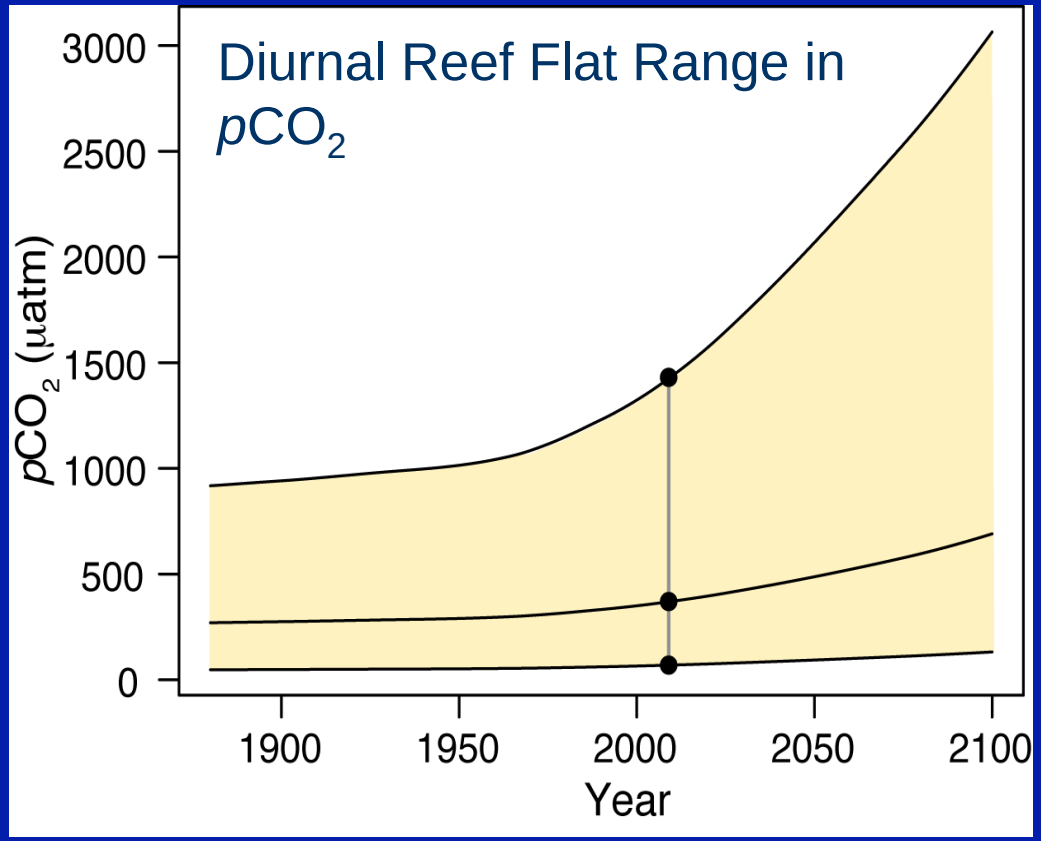


Shaw *et al*. (2012, *JGR*)

- Diurnal variability driven by reef metabolism
- High tide conditions approximate offshore values

Reef flat pCO_2 projections

- Effect of declining buffer capacity only (temperature and biological processes remain constant)
- Using BAU emissions
- Mean (high tide) value is equal to offshore value and tracks the atmospheric CO_2 concentration
- Variability of reef flat pCO2 increases due to declining buffer capacity



End-century reef flat pCO_2 projections

	Min pCO_2 (µatm)	Max pCO_2 (µatm)
Buffer capacity only	130	2960
+ Calcification	120	2760

- Calcification change according to:

  $G_{net} = 2.14\Omega_{arag} - 1.59$ (Shaw et al. 2012, *JGR*)

Implications of natural variability for resilience to OA

- Mesocosm experiments from the GBR have shown species found at LEI to be sensitive to pCO_2 levels within the natural in situ range.

  - e.g. Reduced calcification in CCA (Anothony et al. 2008, *PNAS*)

  - e.g. Impaired sensory and behavioral responses in fish (e.g. Cripps et al. 2011, *Plos One*; Devine et al. 2012, *Oecologia*)

Natural variability & resilience

- Intraspecies variability – populations that inhabit more variable environments are tolerant to those conditions and may be more resilient to high CO_2 conditions
- But pCO_2 amplification implies that these species will be exposed to conditions well outside of the current range of natural variability
- Exposure time – may not be great enough to induce negative effects on time scales of natural variability
- In the future there will be a long-term increase in pCO_2, along with short-term natural variability

Conclusions

- The combination of community metabolism and non-linear carbonate chemistry associated with the Revelle factor amplify future pCO_2 variability.
- This process will occur in all productive coastal systems with increasing CO_2 emissions.
- The biological effects of short-term exposure to largely amplified CO_2 conditions is currently unknown.
- To accurately predict the effects of OA it is important to determine the present and future natural variability that organisms are/will be exposed to & design experiments accordingly.

Thanks!

National Research
FLAGSHIPS
Wealth from Oceans

CSIRO

Lady Elliot Island
GREAT BARRIER REEF

NCCARF
National
Climate Change Adaptation
Research Facility
Adaptation Research Network
MARINE BIODIVERSITY AND RESOURCES