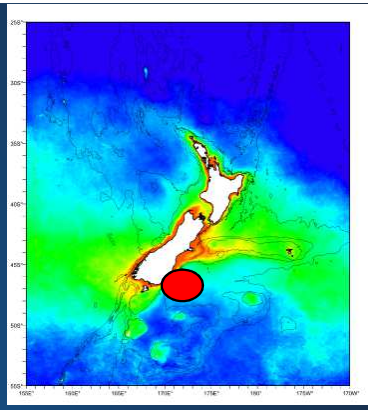
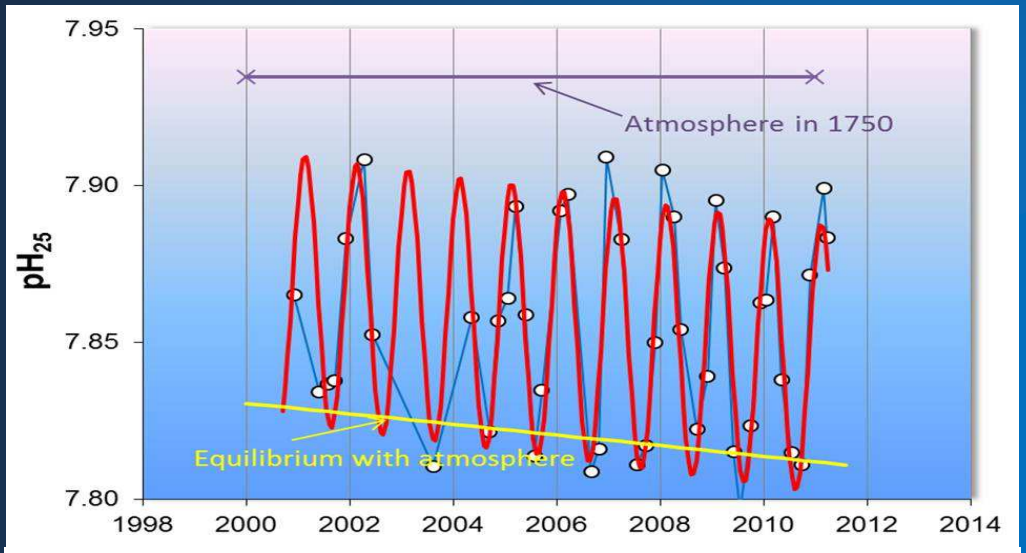
OA in the Pacific: NZ Perspectives

Cliff Law
NIWA/University of Otago

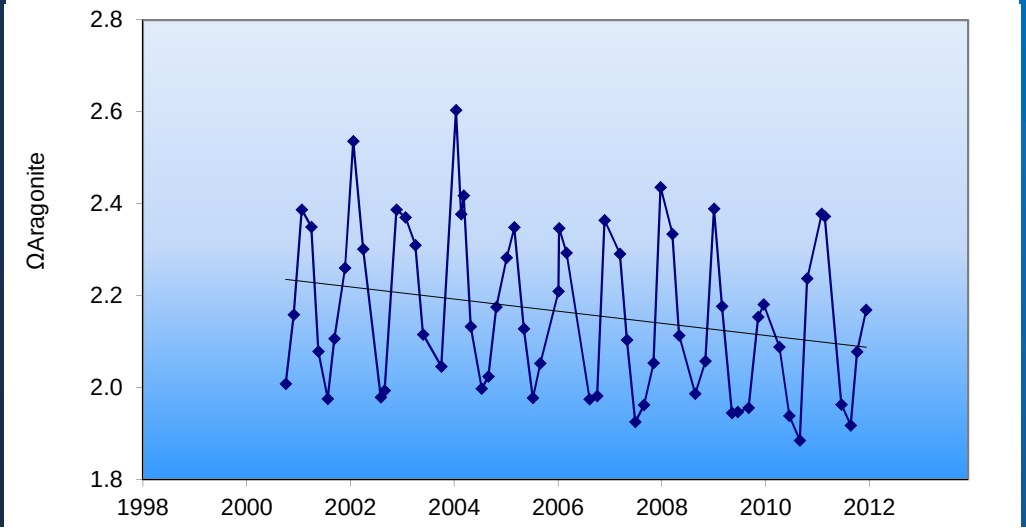
Current acidification of South Pacific waters





Surface pH

- decline in pH consistent with atmospheric CO_2 trend
- Similar pattern in North Pacific

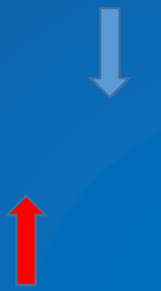


Surface carbonate saturation

K. Hunter, M. Reid & K. Currie

Projected change in surface pH in South Pacific waters

10- 50^{o}S



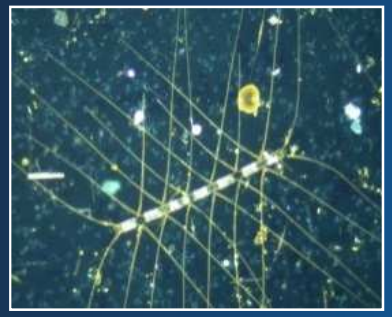
Current pH range
In NZ waters

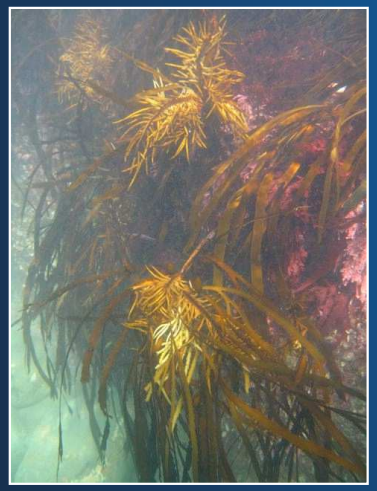
Lowest pH & fastest pH
rate change for 50M years

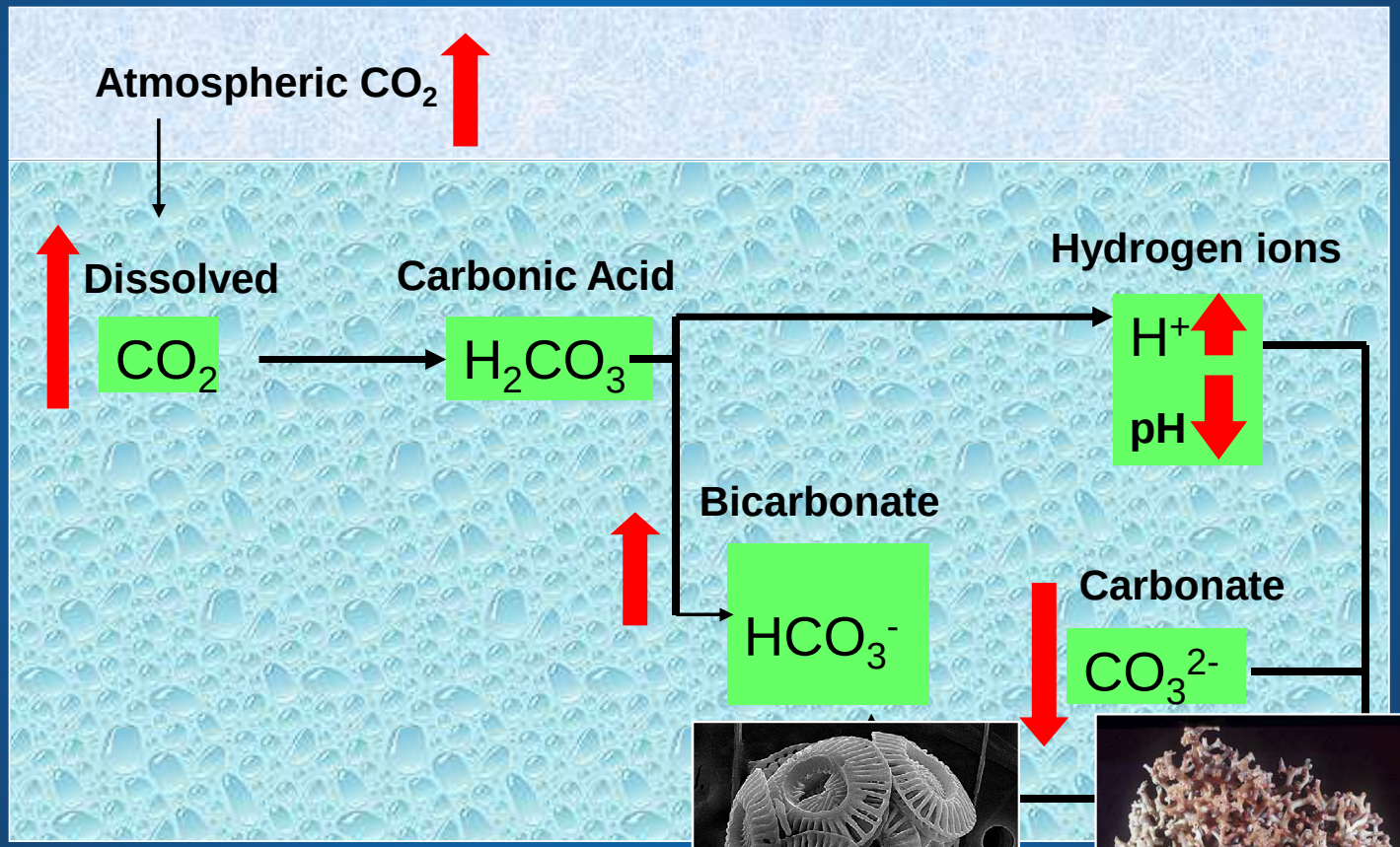
S. Mikaloff-Fletcher, NIWA

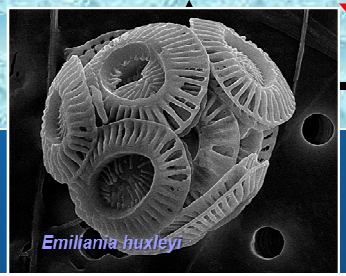
Ocean Acidification is not just change in pH

Winners and losers



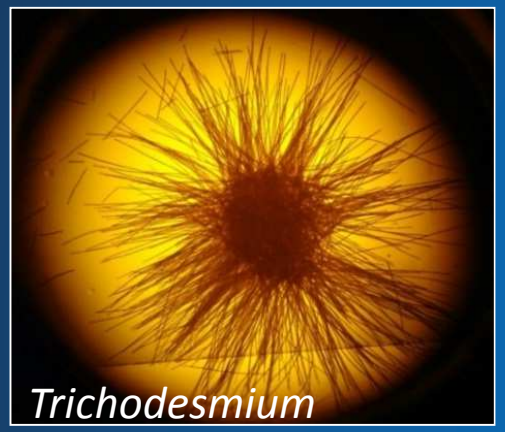






Are phytoplankton OA “winners” ?

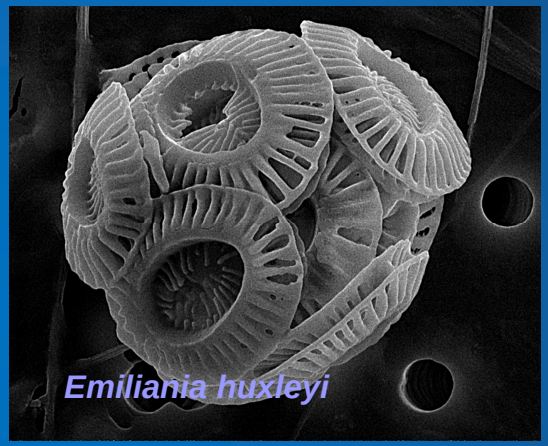
Nitrogen fixers



Nitrogen fixation may increase by 30-120% under low pH…

…but south of 30°S N fixation is not affected

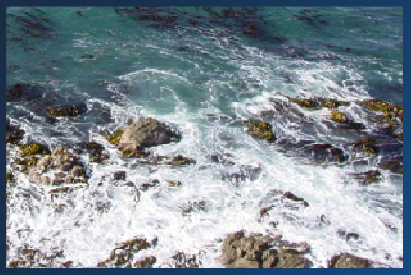
Calcifying phytoplankton



Reduction in carbonate production in coccolithophores under low pH…….

….but currently increasing in NZ waters

Hutchins et al, 2009; Law et al, 2012



Shifts in NZ coastal macroalgae communities under declining pH

2100

Crustose corallines
uses carbonate

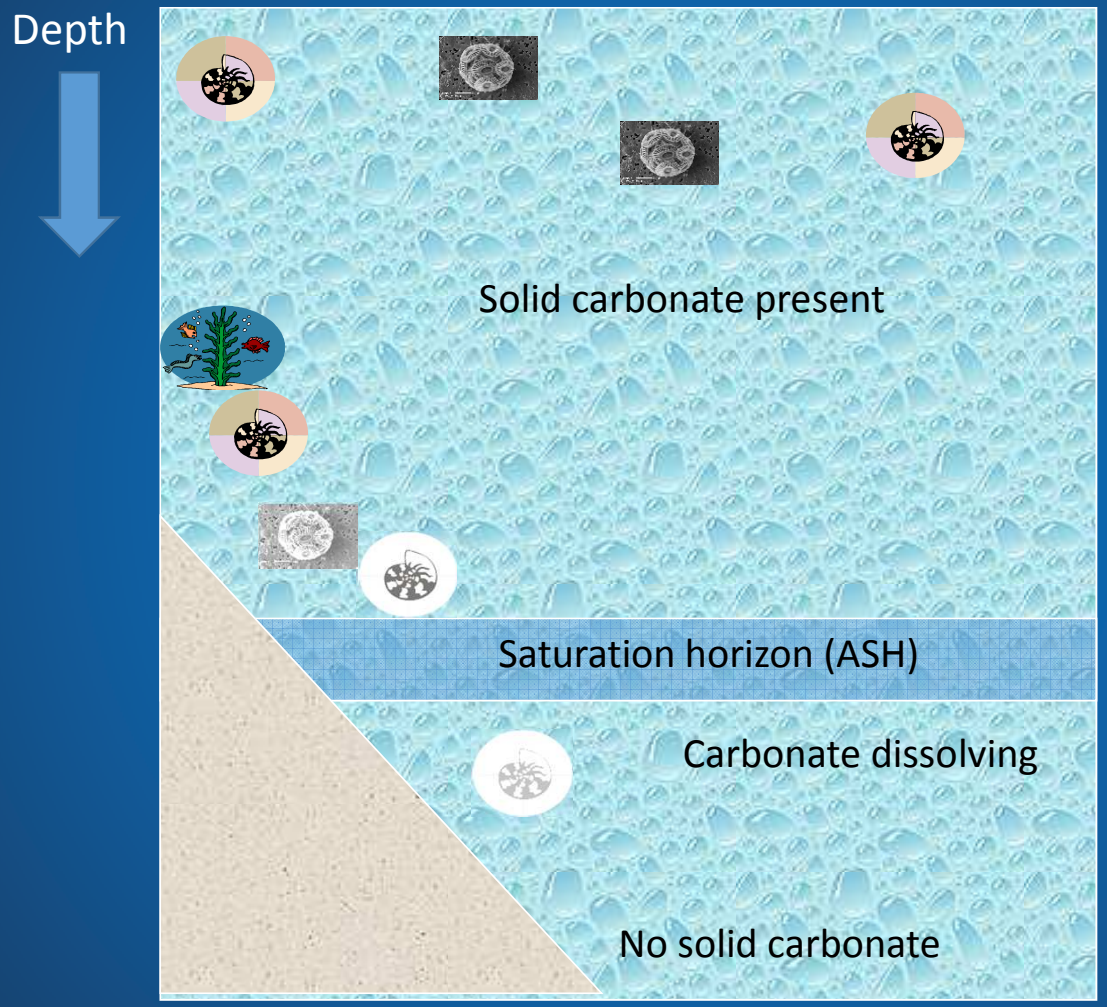
Kelp
uses Bicarbonate & CO_2

Red algae
uses CO_2

Different physiology has implications for future ecosystem structure

Hepburn et al, 2011

Carbonate in the deep ocean

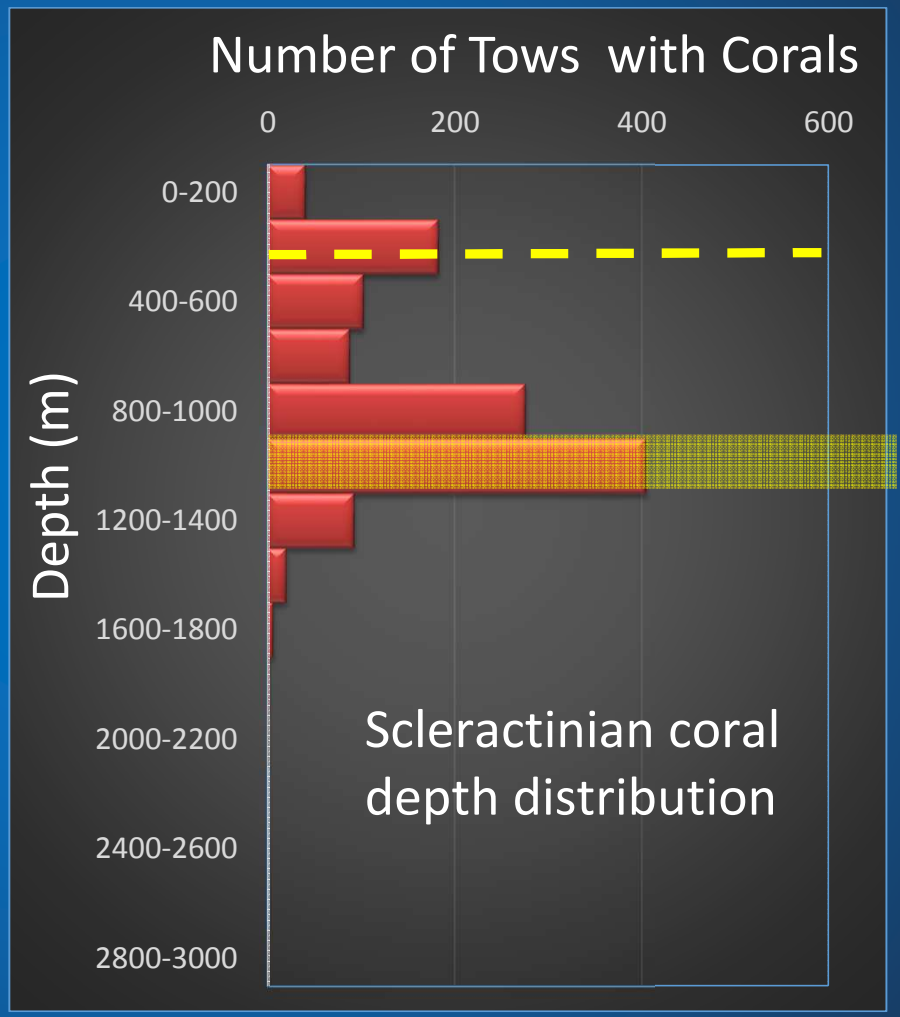


Impact on NZ Cold Water Corals

Important habitat
CWCs require carbonate

<25% of current coral locations will be above the ASH in 2100

implications for deep-sea habitat and biodiversity



IPCC-S650 scenario; Orr et al (2005); Bostock et al (2013); Tracey et al (2011)

Ocean acidification impacts on NZ coastal ecosystems

NZ Sea Urchin

NZ abalone (Paua)

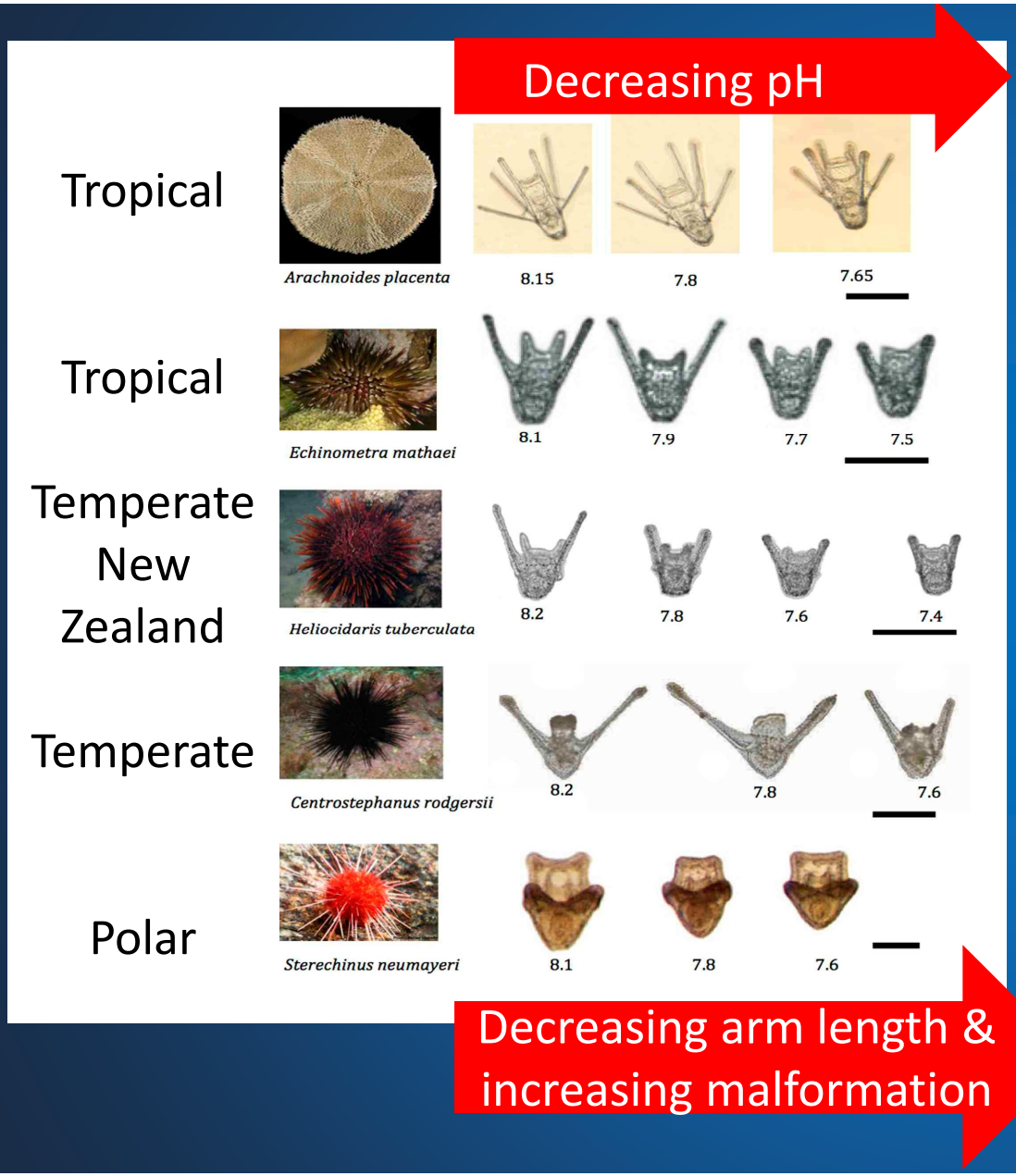
- Echinoderms and molluscs are keystone species in coastal marine ecosystems
- New Zealand asset/export values $460M/$260M
- Customary and recreational importance
- Vulnerable to decreasing carbonate resulting from ocean acidification

Green-lipped mussels

Flat oysters

Cockles

www.fish.govt.nz; Cooley et al, 2012



Sensitivity in echinoderm larvae

At lower pH:

Smaller larvae with malformation

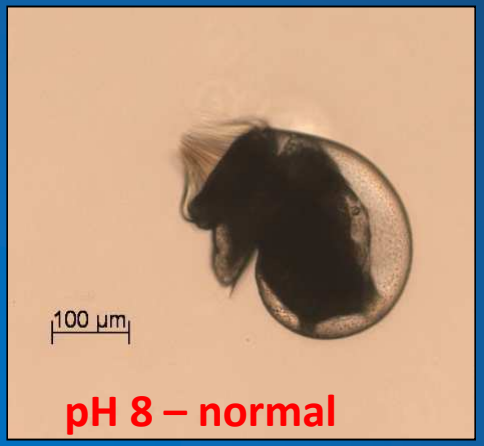
Genes for energy metabolism & mineralization down-regulated

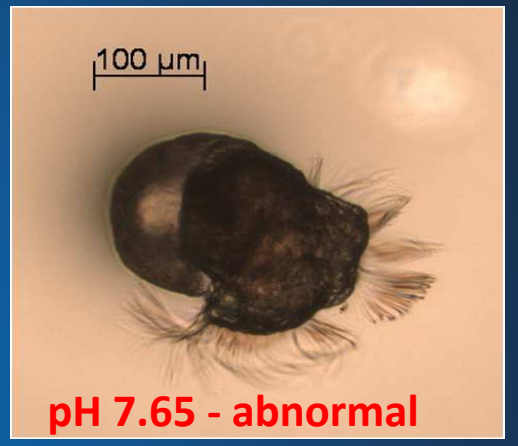
Decreased feeding efficiency
= increased planktonic phase
= reduced survival

Byrne et al (2013); O'Donnell et al (2010)

Influence of Ocean Acidification on Paua life stages

Malformed Paua larvae at low pH





Erosion of empty Paua shells at low pH;
not observed in live juveniles

- indicates additional metabolic energy cost for shell maintenance

Early life stages may be bottlenecks for population success

V. Cummings, N.Z. Ministry for Primary Industries

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

CARIM
Coastal Acidification: Rate, Impacts & Management

4-year multi-disciplinary project starting October 2015

THE UNIVERSITY OF AUCKLAND
Te Whare Wananga o Tamaki Makaurau
NEW ZEALAND

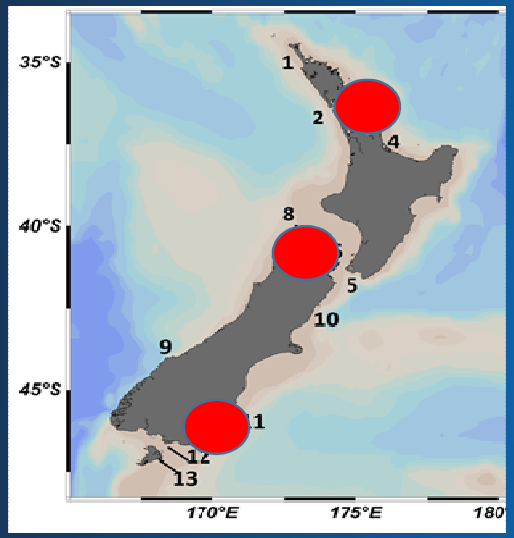
NIWA
Taihoro Nukurangi

CAWTHRON INSTITUTE

UNIVERSITY of OTAGO
SAPERE AUDE
Te Whare Wānanga o Otāgo

RA1. Variability of coastal pH and the carbonate system

3 Sentinel sites



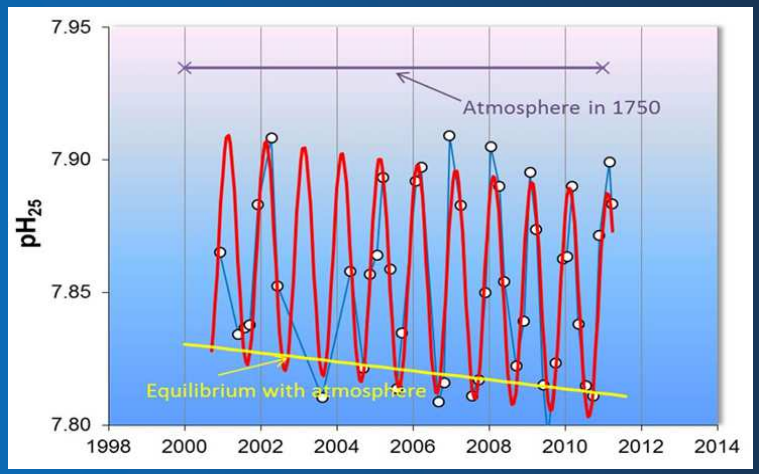
Firth of Thames

Nelson Bays

Karitane

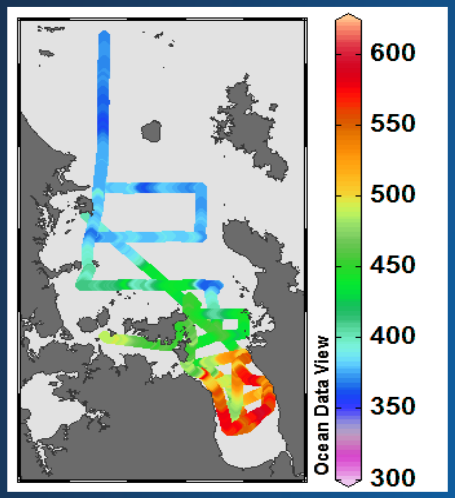
Autonomous pH sensors (SeaFET™)

High resolution pH time-series data

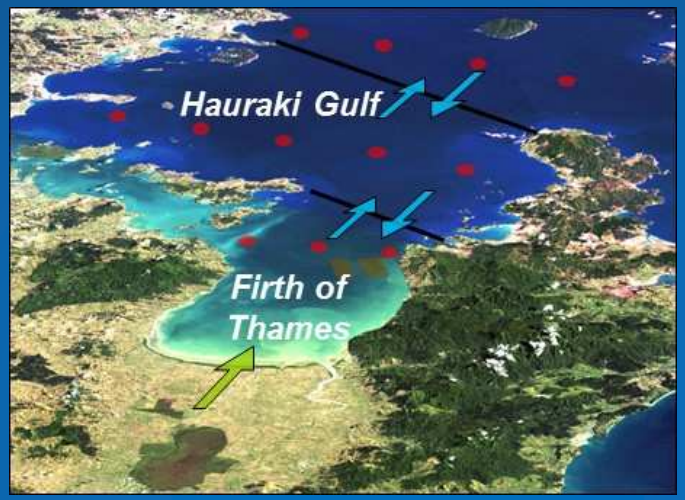


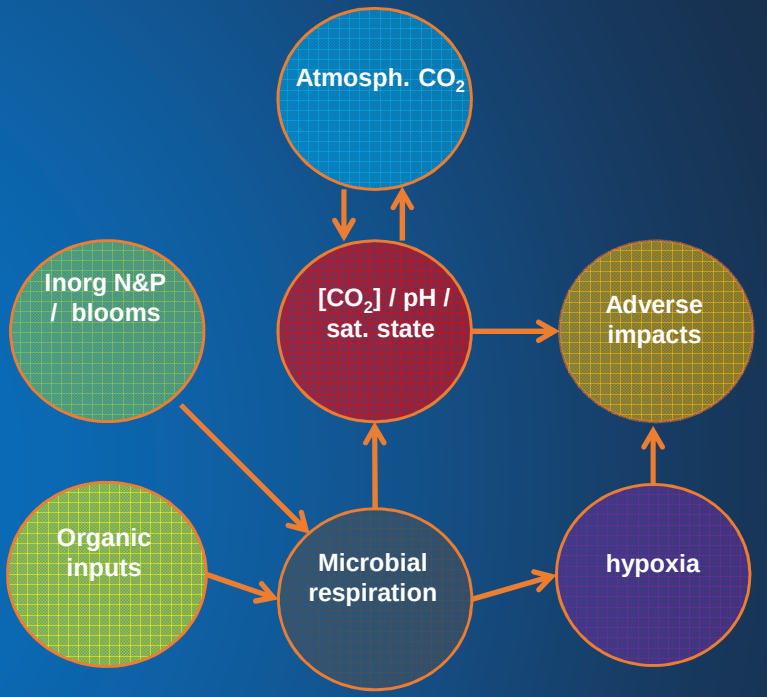
- pH variability and magnitude to guide impact manipulation experiments and future projections
- pH data to national OA network (NZOA-ON) & GOA-ON; publicly available

RA2. Sources and seasonality of low pH and carbonate in the Hauraki Gulf



pCO_2 (µatm)



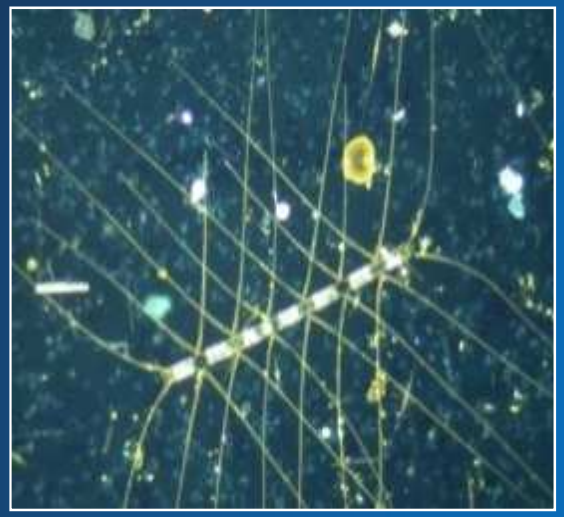


Atmospheric CO_2 is not the only cause of coastal acidification

Budgets, dynamic models & seasonal carbonate maps will support mitigation and adaptation measures

Adapted from Sunda and Cai (2012)

RA3. Impacts of reduced pH on primary producers & ecosystem interactions



- Manipulation experiments in mesocosms with automated pH, T and light regulation
- Plankton – primary production, composition, food quality and trophic interaction
- Calcifying Coralline algae - mineralogy and growth rates; habitat for Paua settlement

RA4. Determine the acclimation potential of iconic species to future coastal acidification

Paua –
All life stages

Snapper
larvae
behaviour

Greenshell Mussel
– All life stages

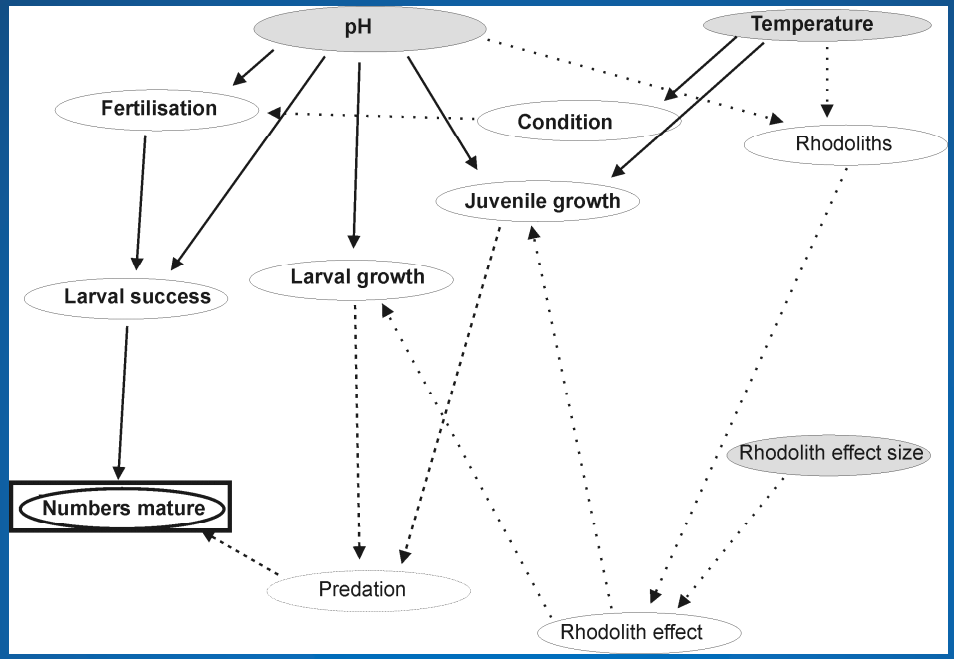
Multi-stressor manipulation facility

Assess effect on egg/sperm quality, survival, growth, physiology, energetic costs and fitness, gene & protein expression

RA5: Selection in coastal species for resilience to low pH

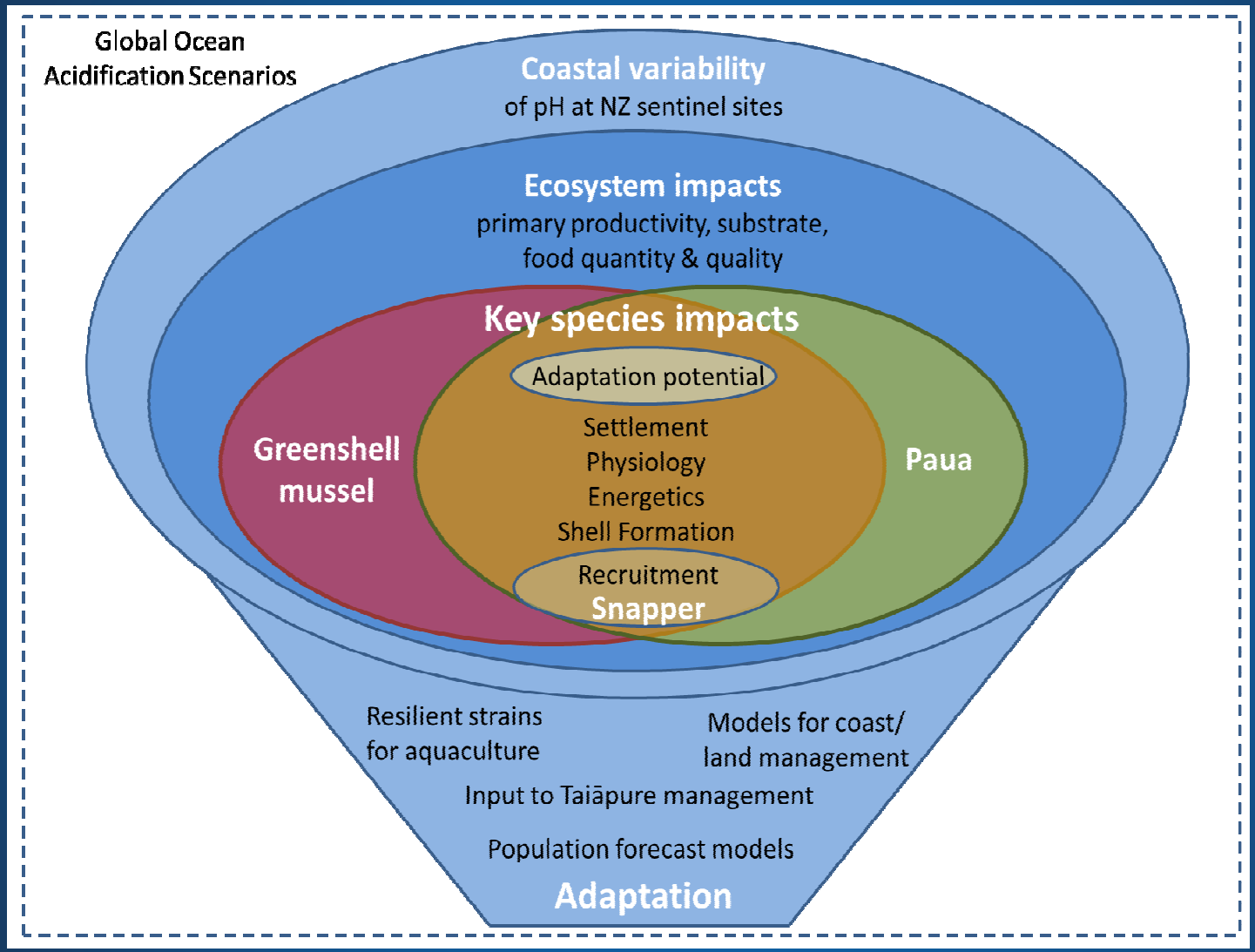
- Assess larvae performance from pedigreed Paua & Greenshell Mussel families (NZ selective breeding programmes) under low pH
- Identify most vulnerable or resilient families reared to juvenile stage
- Examine the mechanisms that account for differences between families

RA6. Consequences of coastal acidification for key species



- Phytoplankton & productivity projections, and implications for coastal foodwebs
- Paua population forecast models (above)
- Greenshell Mussel - Dynamic Energy Budget
- Snapper - ecosystem effects population model

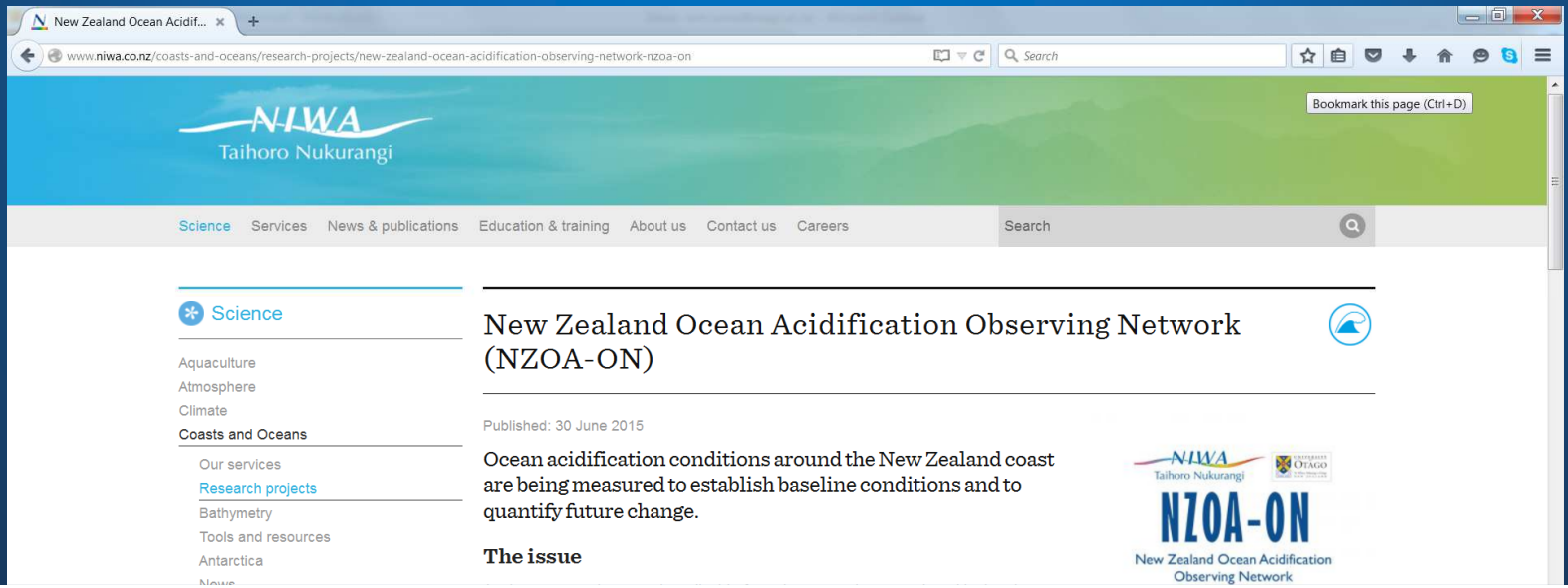
CARIM (Coastal Acidification: Rate, Impacts & Management)



A way forward for addressing Ocean Acidification in the Pacific Islands?

RA7. Communication and Outreach

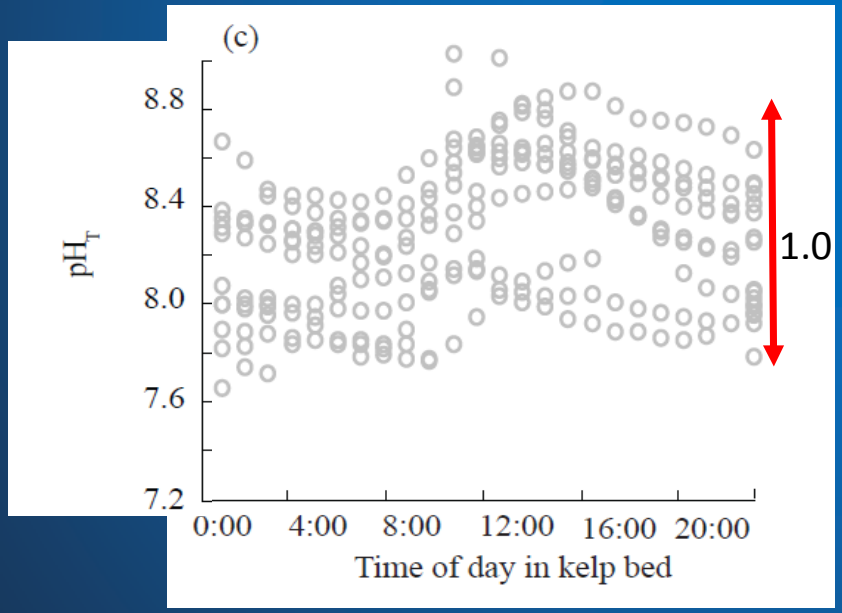
- Annual Stakeholder Group meetings, & regular engagement with Iwi
- Media – website, newsletters, Twitter & Facebook
- “Oceans Guardians” participatory science component for schools
- Science publications
- National OA workshops & international conferences;
- Final research synthesis report, and stakeholder workshop

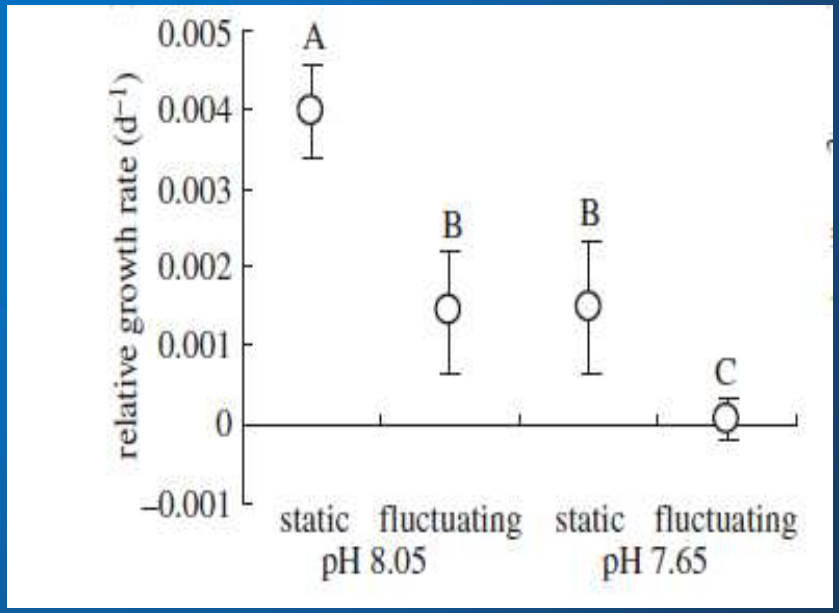


Confounding Factors - pH variability in coastal waters

Daily pH fluctuation may exceed range of future change

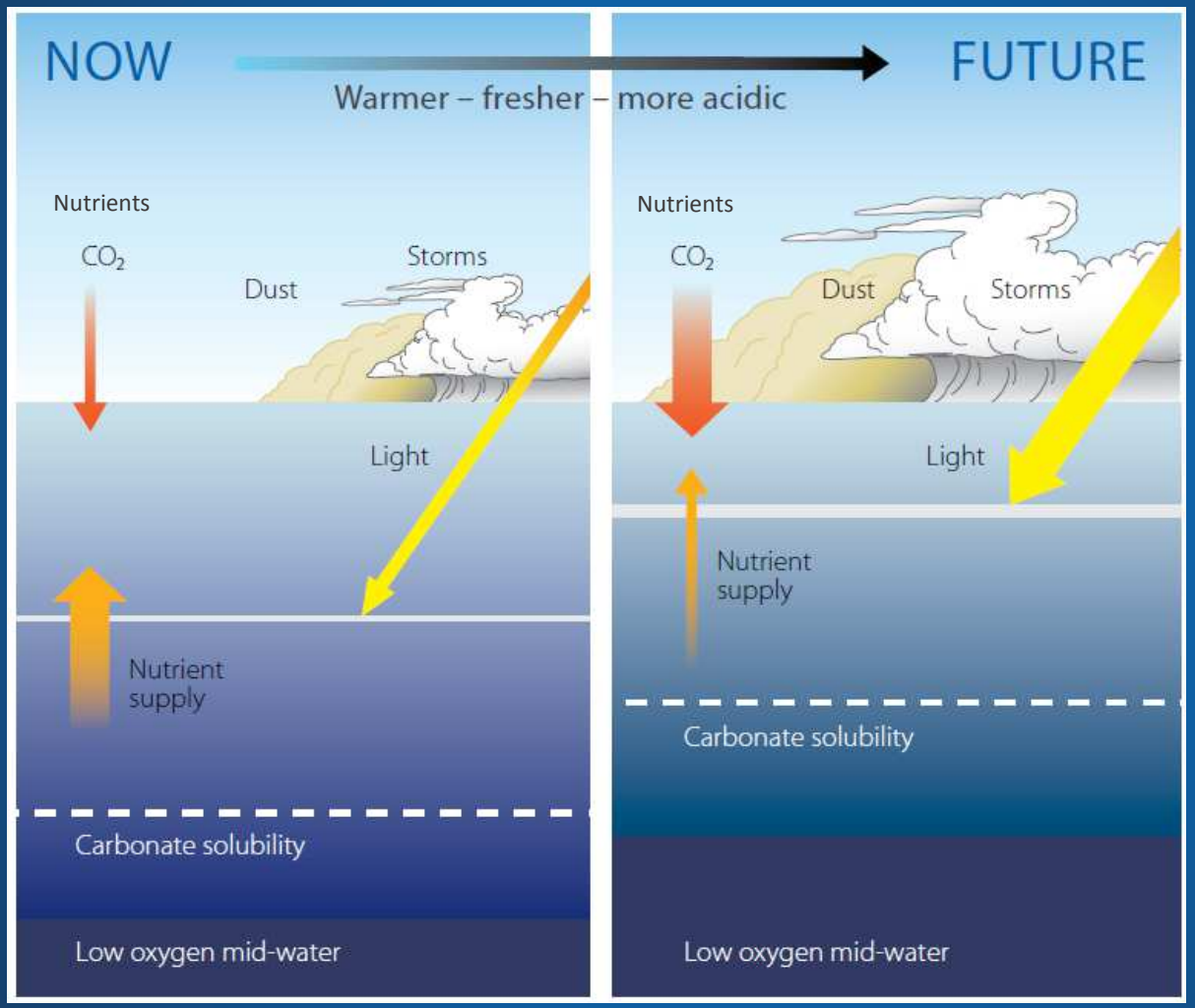
Consider natural short term fluctuations in organism response





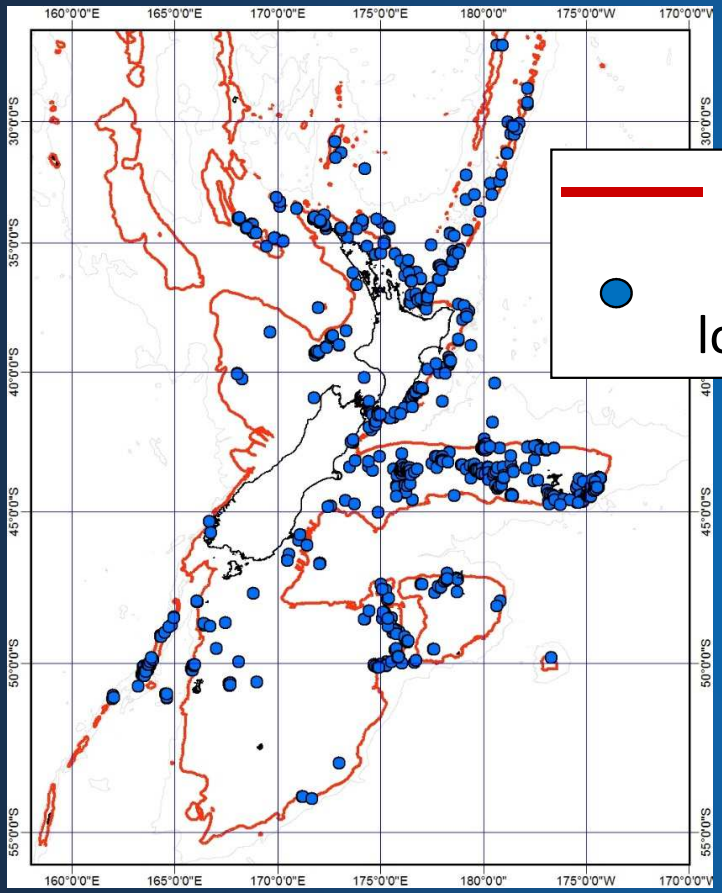
Cornwall et al., 2013

Prediction of the impacts of OA is complicated by other changes

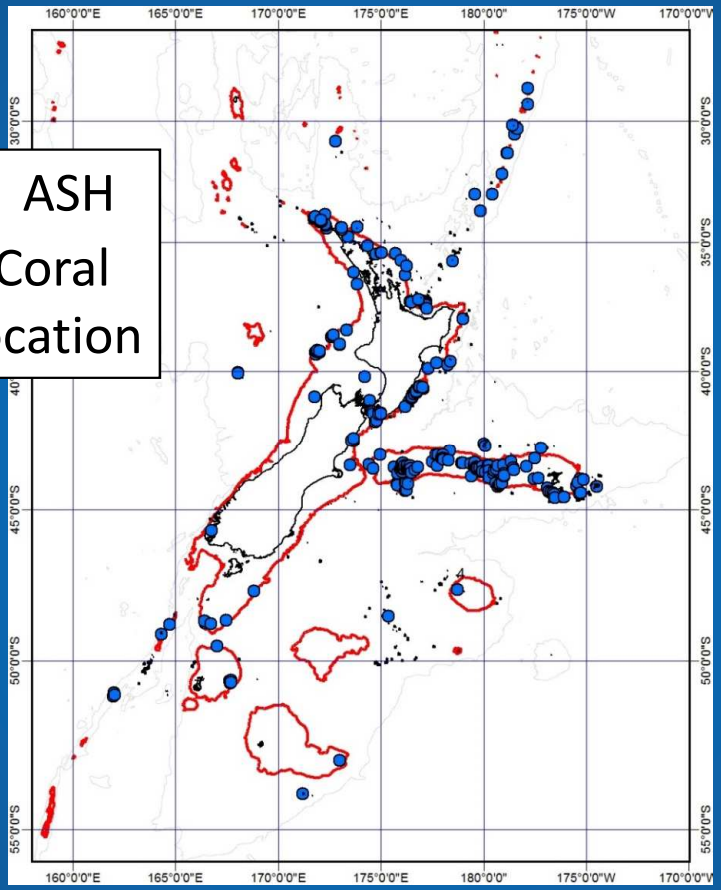


N.Z. Climate Change Atlas, Boyd & Law (2011)

Future distribution of habitat-forming Cold Water Corals in N.Z. waters



Present day



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Topographical features, may be refugia for cold water corals

Orr et al (2005); Bostock et al (2013); Tracey et al (2011); Tittensor et al (2009)