Aquaculture Advisory Council

WORKING GROUP 2 «Shellfish» Meeting

Wednesday 10 June 2026 | 09.30 – 13.00
Copa-Cogeca – 61 rue de Trèves 1000 Brussels

Ocean acidification and shellfish

Sam Dupont

University of Gothenburg (Sweden)
Marine and Freshwater Research Institute (Iceland)

On the menu today

- Ocean acidification
- What drives biological impacts?
- Local adaptation
- Case study

On the menu today

- **Ocean acidification**
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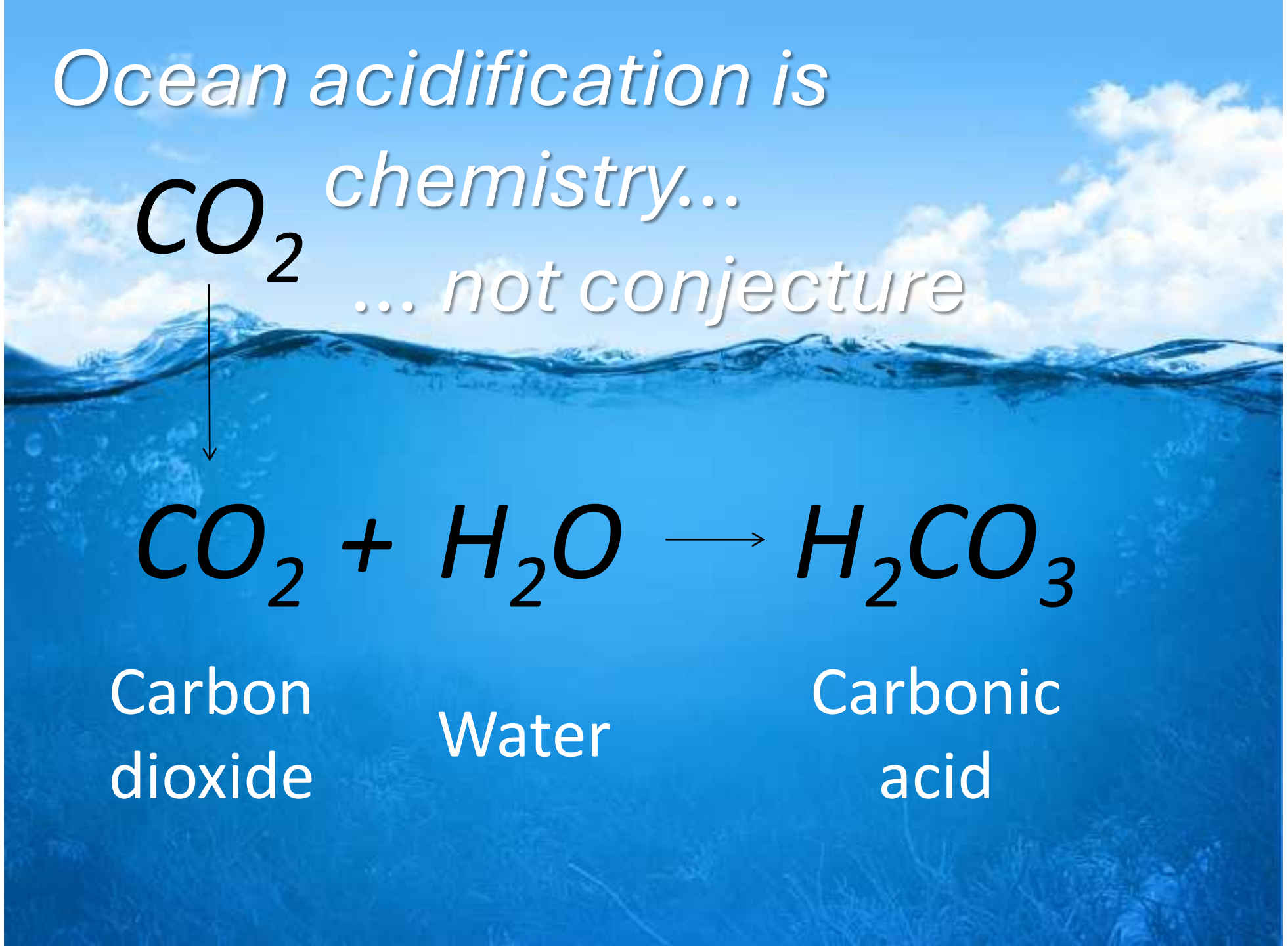
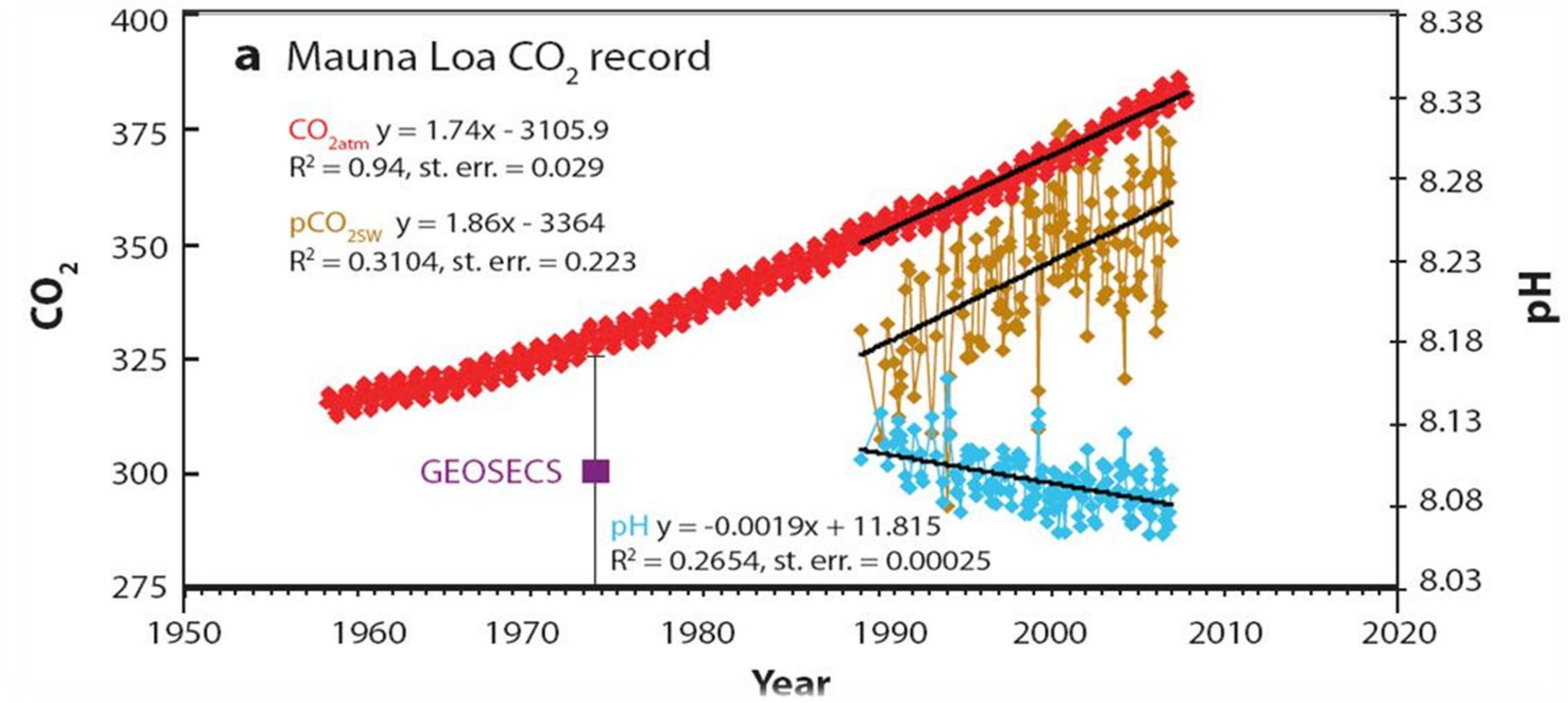

Ocean acidification is chemistry...
... not conjecture
CO_2
$CO_2 + H_2O \longrightarrow H_2CO_3$
Carbon dioxide
Water
Carbonic acid

Ocean acidification is happening now

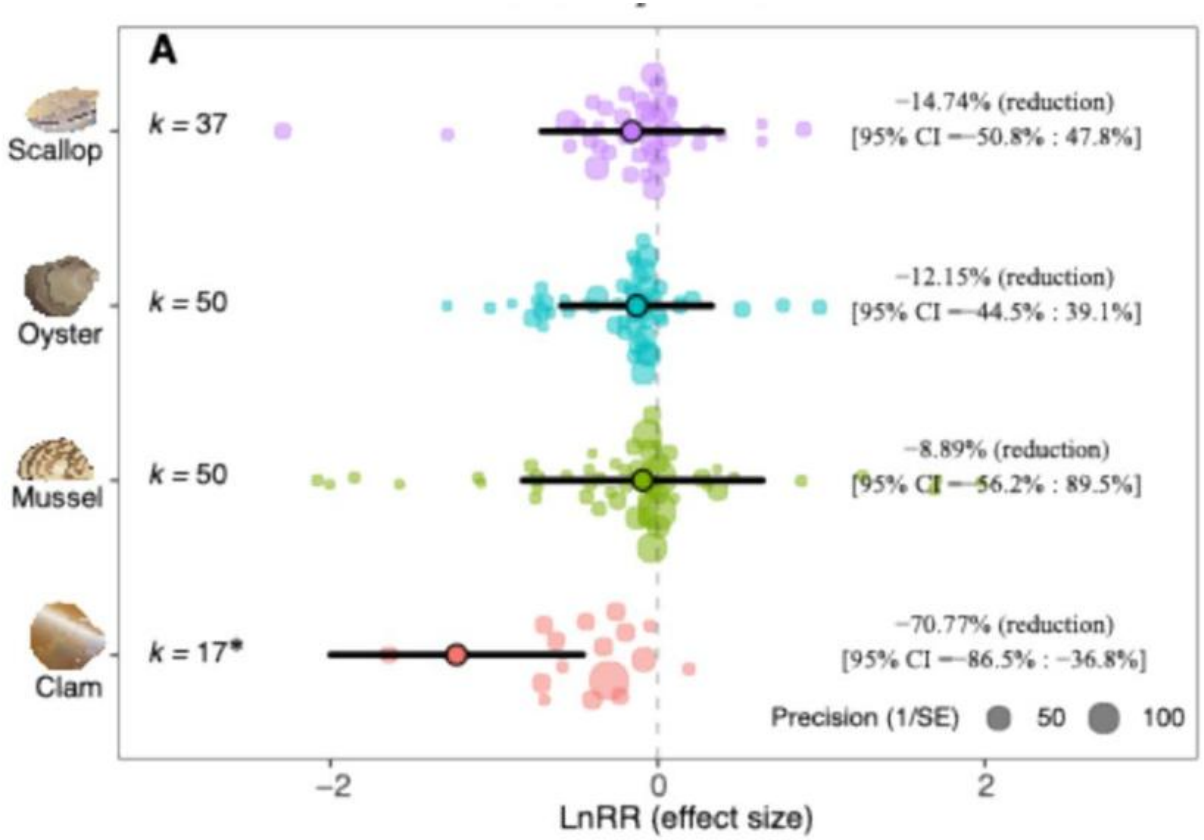


Doney et al. (2009)

Negative impact on marine life

50% of marine animals threaten by ocean acidification

Including shellfish



Rev Fish Biol Fisheries (2026) 36:10
https://doi.org/10.1007/s11160-025-10005-4

REVIEW

A global meta-analysis reveals consistently negative effects of ocean acidification on marine cultured bivalves: implications for future bivalve aquaculture

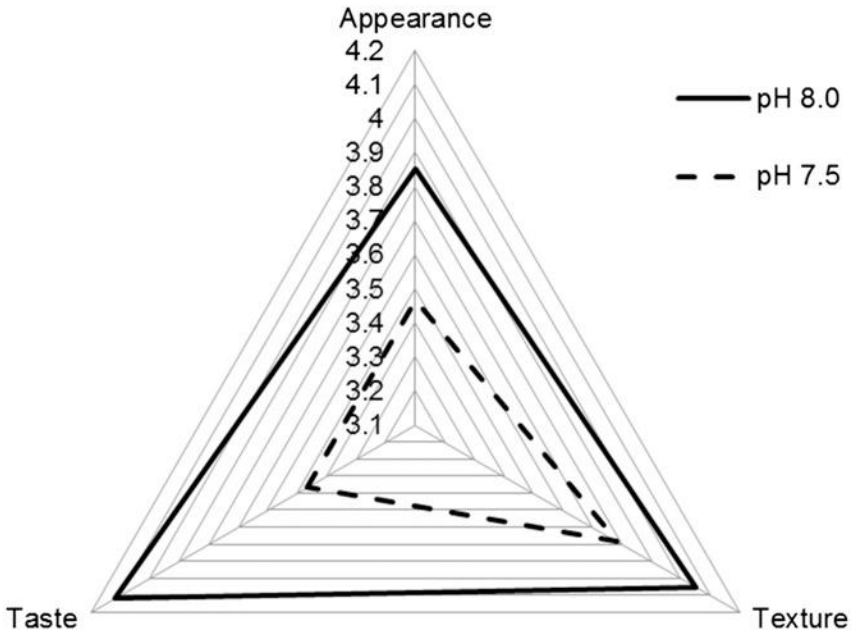
Nan Hu · Zhuonan Wang · Jiamin Sun

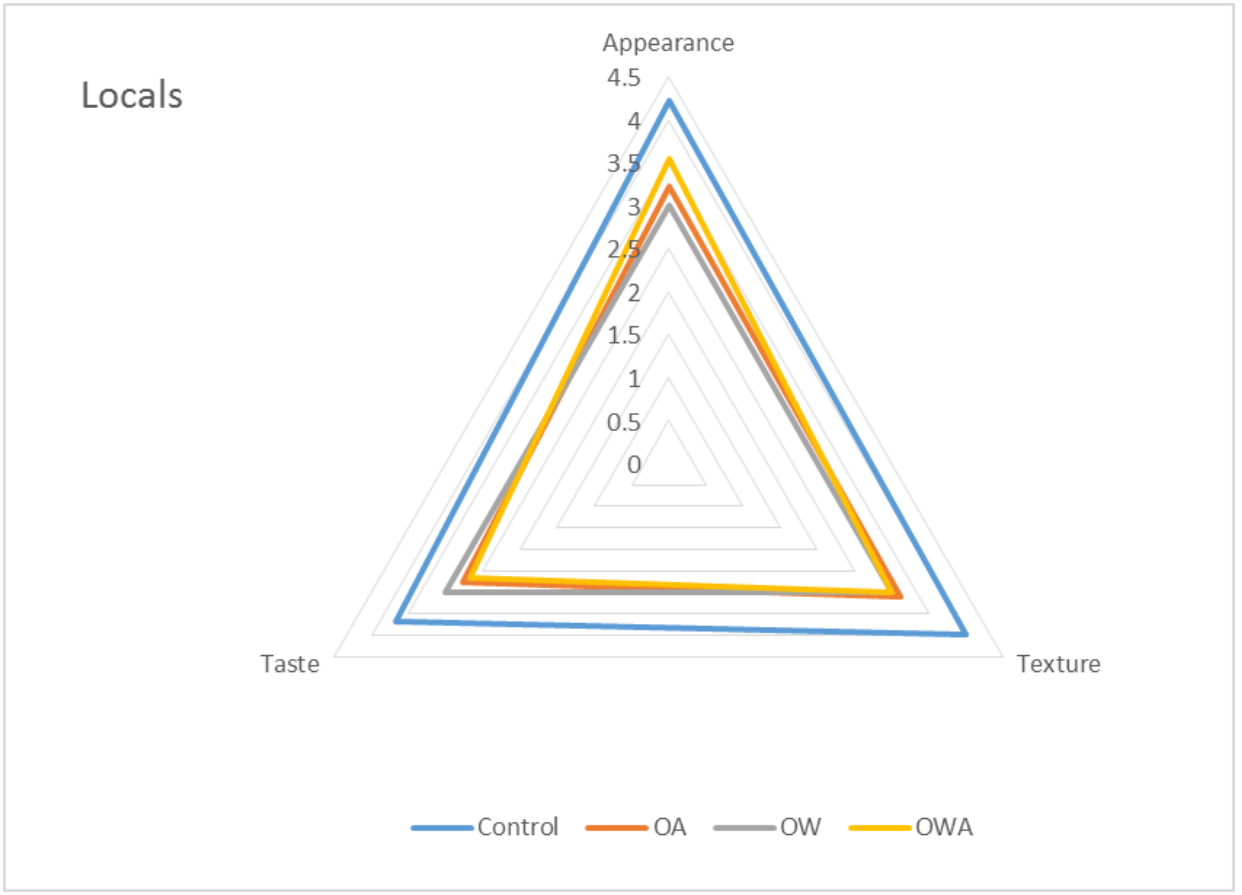
Quantity and quality – taste of shrimps and mussels

Journal of Shellfish Research, Vol. 33, No. 3, 857–861, 2014.

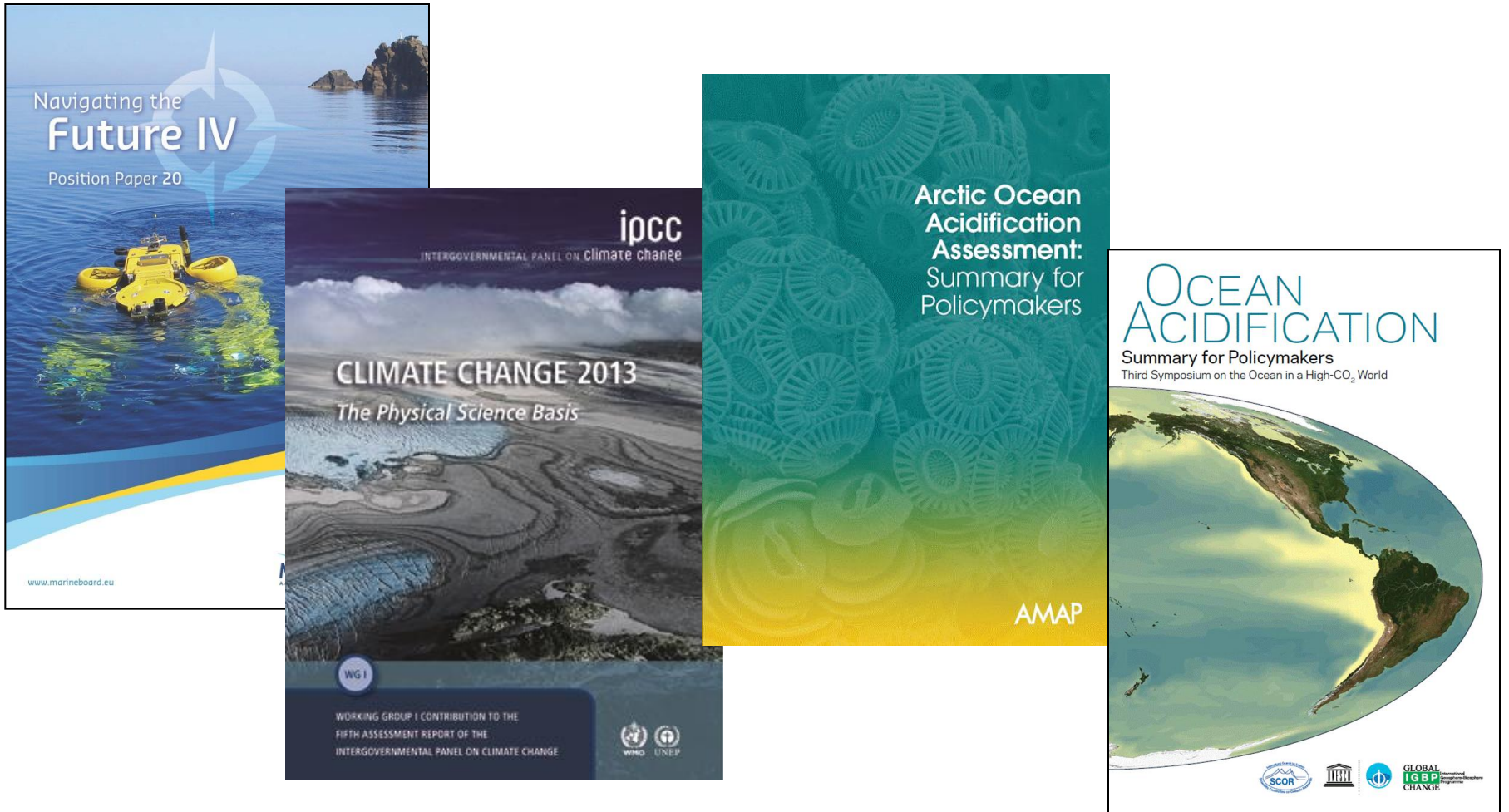
FIRST EVIDENCE OF ALTERED SENSORY QUALITY IN A SHELLFISH EXPOSED TO DECREASED pH RELEVANT TO OCEAN ACIDIFICATION

SAM DUPONT,[1]* EMILIE HALL,[2] PIERO CALOSI[2,3] AND BENGT LUNDVE[4]
[1]*Department of Biological and Environmental Sciences, University of Gothenburg, 566 Kristineberg, Fiskebäckskil 45178, Sweden;* [2]*School of Marine Science and Engineering, Plymouth University, Plymouth PL4 8AA, UK;* [3]*Département de Biologie, Chimie et Géographie, Université du Québec à Rimouski, Rimouski QC G5L 3A1, Canada;* [4]*The Sven Lovén Centre for Marine Sciences–Kristineberg, University of Gothenburg, 566 Kristineberg, Fiskebäckskil 45178, Sweden*





High evidence – "*virtually certain*"



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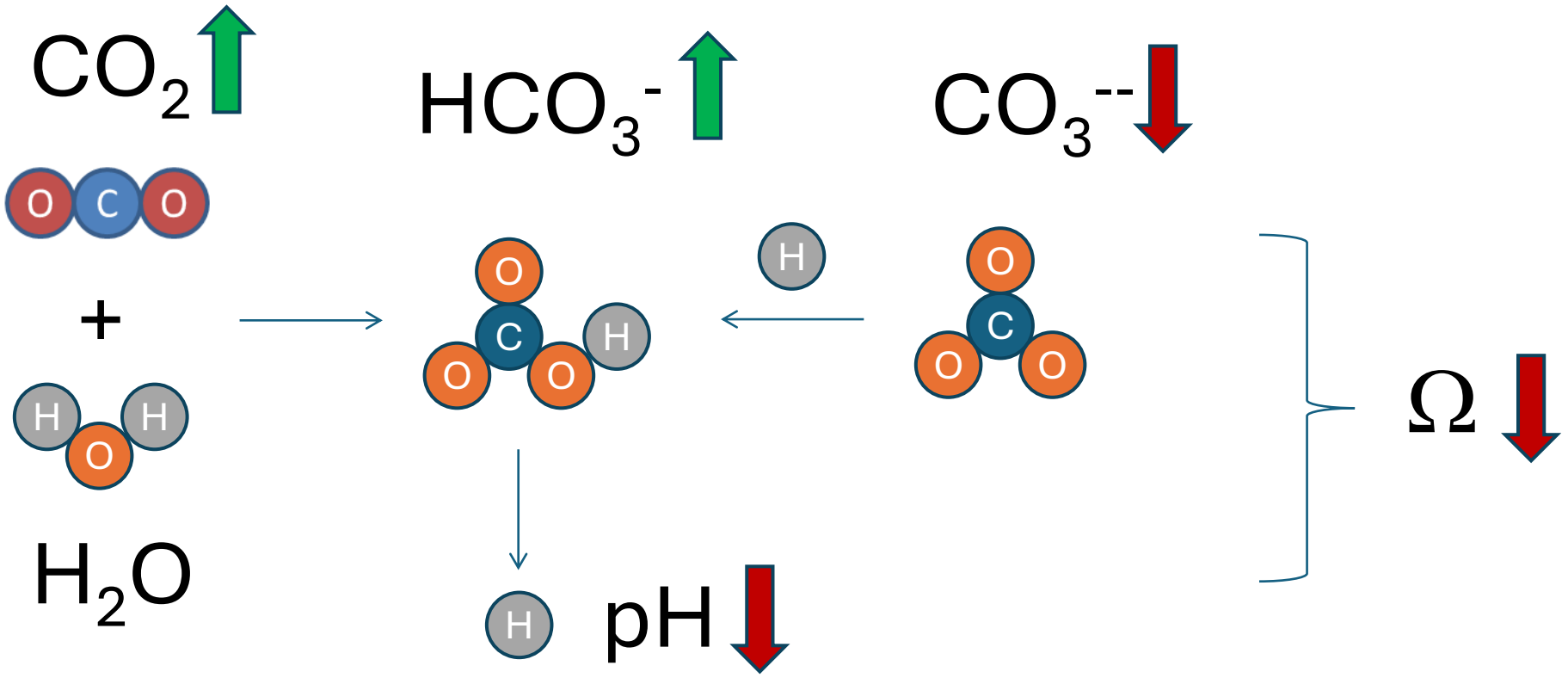
From chemistry to biology



Paradigm #1: Ω

nature climate change

PERSPECTIVE

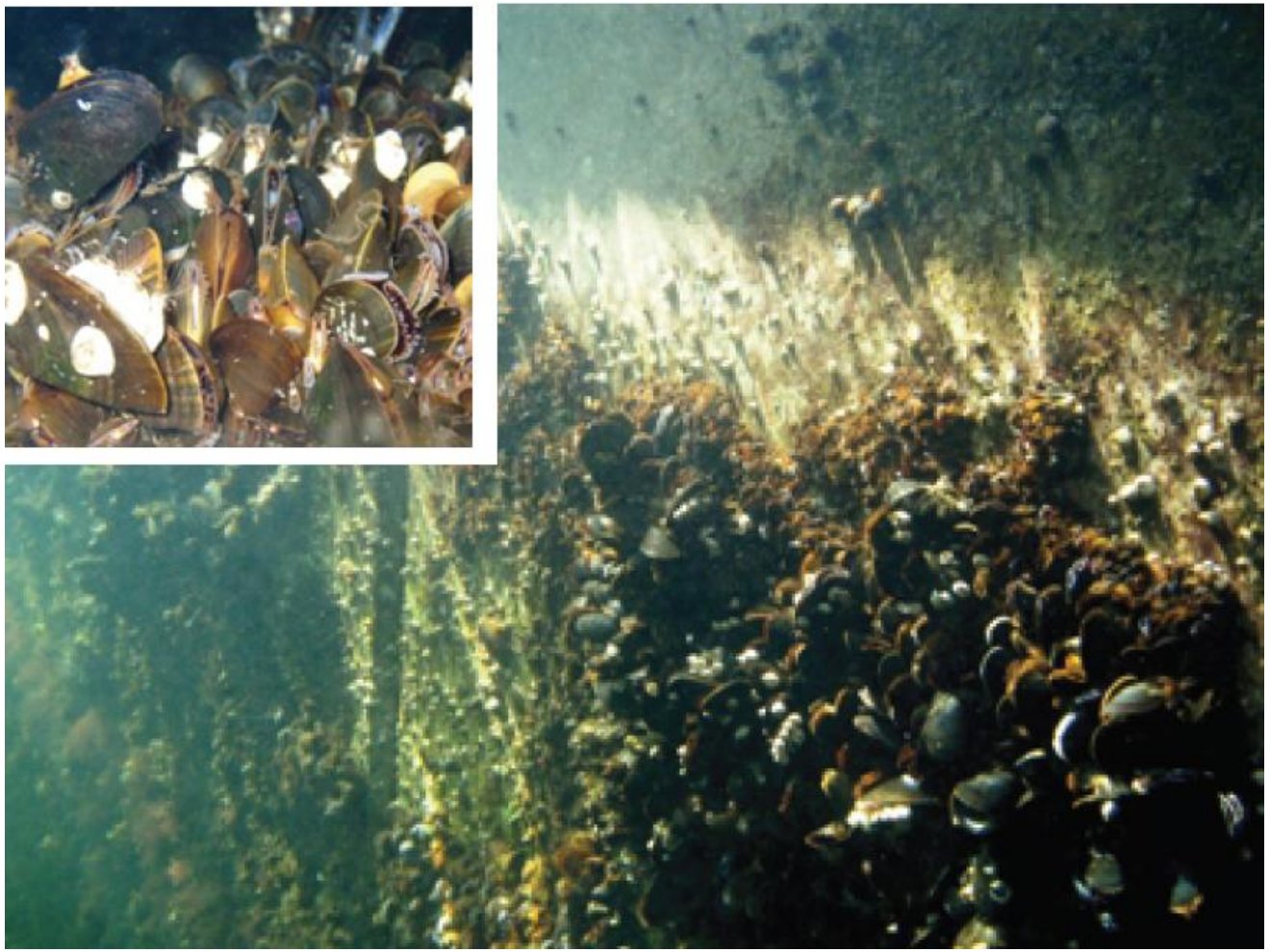
PUBLISHED ONLINE: 23 FEBRUARY 2015 | DOI: 10.1038/NCLIMATE2508

Vulnerability and adaptation of US shellfisheries to ocean acidification

Julia A. Ekstrom[1*†], Lisa Suatoni[2], Sarah R. Cooley[3], Linwood H. Pendleton[4,5], George G. Waldbusser[6], Josh E. Cinner[7], Jessica Ritter[8], Chris Langdon[9], Ruben van Hooidonk[10], Dwight Gledhill[11], Katharine Wellman[12], Michael W. Beck[13], Luke M. Brander[14], Dan Rittschof[8], Carolyn Doherty[8], Peter E. T. Edwards[15,16] and Rosimeiry Portela[17]

e.g. Threshold: $\Omega < 1.5$ for calcifiers

Shellfish are not pieces of calcium carbonate



pH 7.5, Ωara=0.35

(Thomsen et al. 2010)

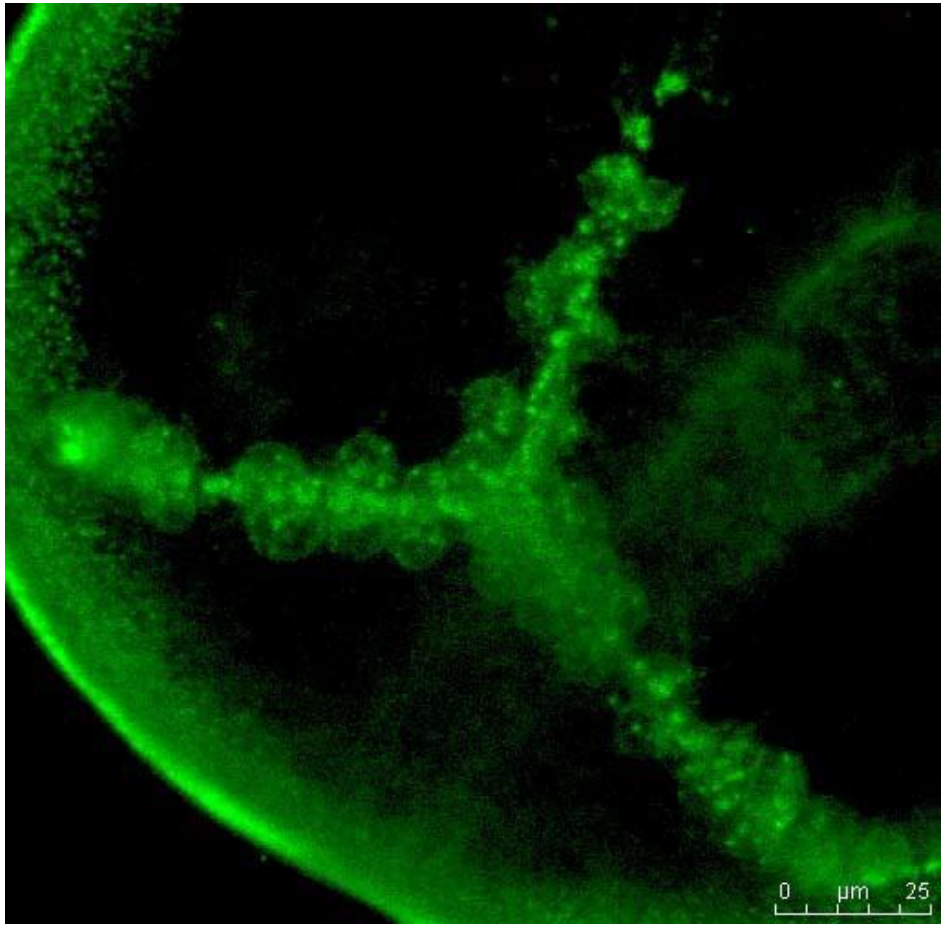
Threshold for ice = 0°C

How do you make ice when temperature is >0 °C

A freezer

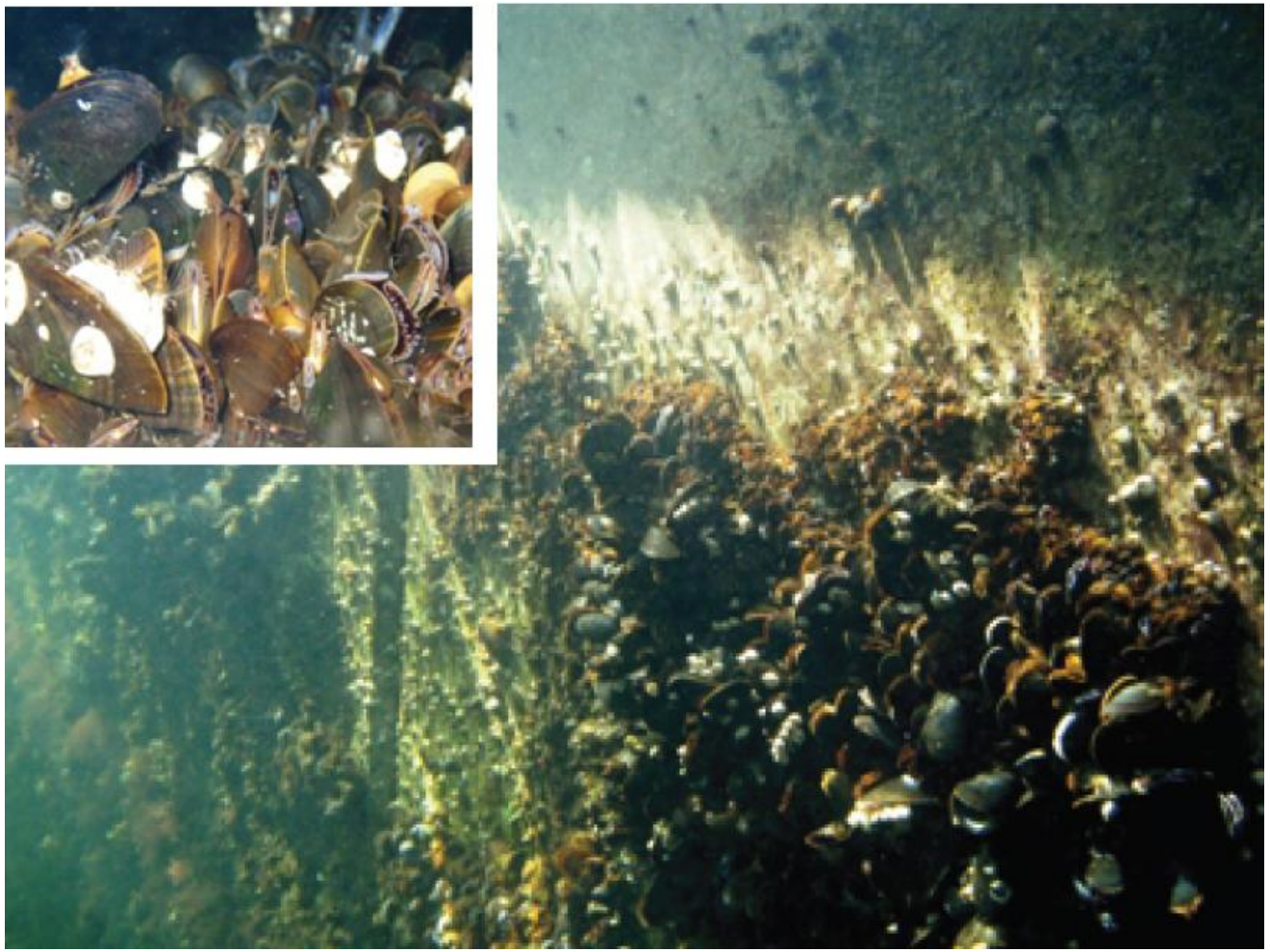
Energy cost

Acid-base regulation + energy



How to make $CaCO_3$ at $\Omega<1$?
$\Omega>1$ at the calcification site

Shellfish are not pieces of calcium carbonate



pH 7.5, Ωara=0.35

(Thomsen et al. 2010)

Acid-base regulatory mechanisms

+

Food

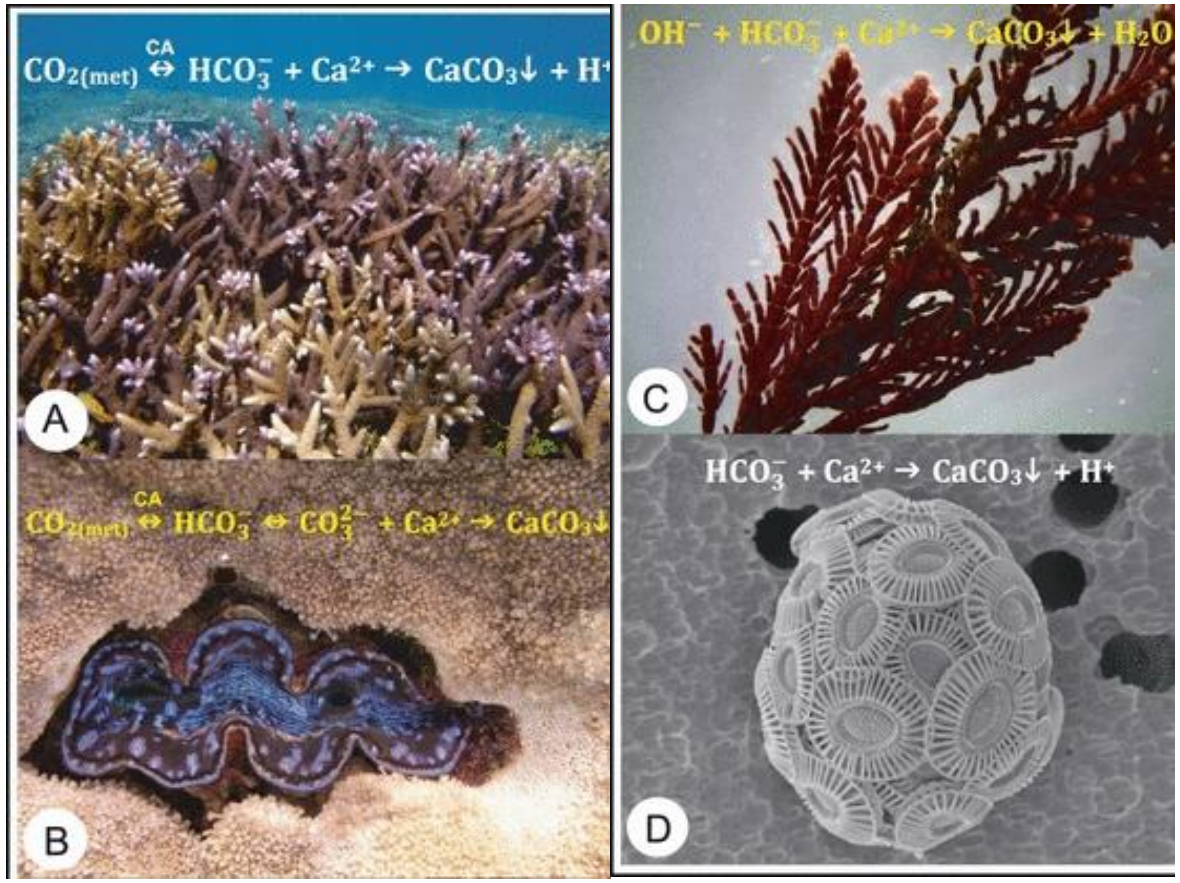
Paradigm #2: CO_3^{2-}

Calcification:

~~$Ca^{++} + CO_3^{--} \rightarrow CaCO_3$~~

$Ca^{++} + 2HCO_3^{-} \rightarrow CaCO_3 + H_2O + \mathbf{CO_2}$

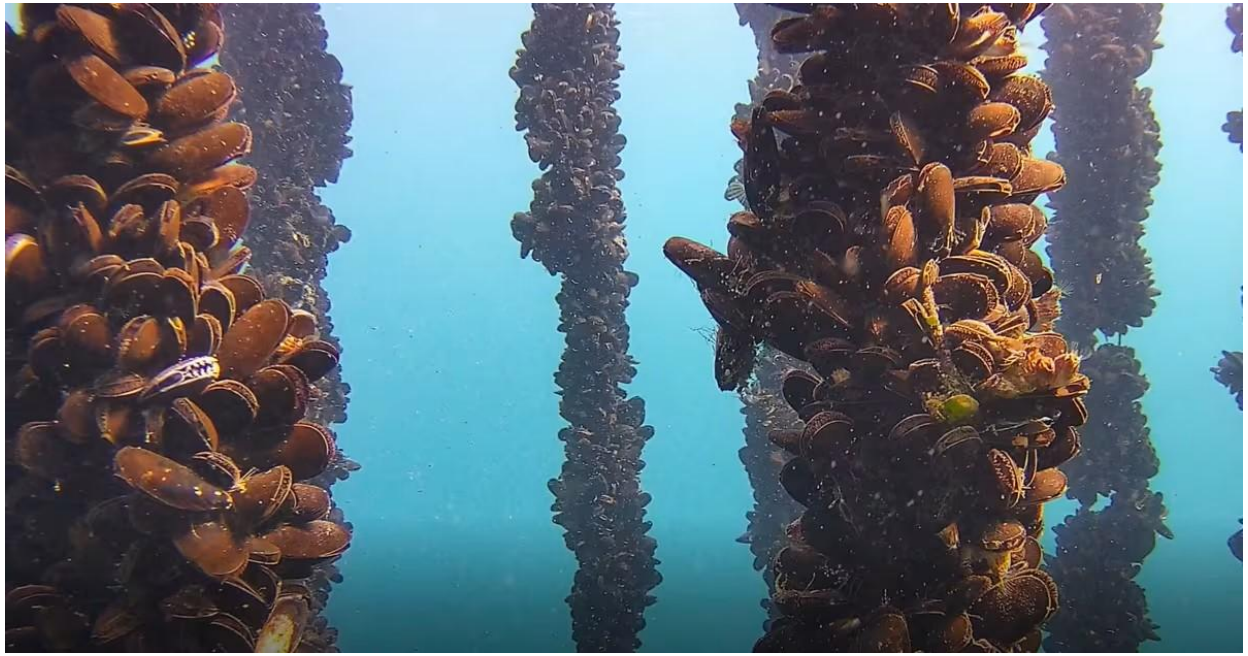
CO_3^{2-} not the calcification bricks



HCO_3^- and/or
CO_{2met}

Roleda et al. 2012

Side note: bivalve cultures are not CO_2 sink



Received: 14 March 2024 | Revised: 10 July 2024 | Accepted: 11 July 2024
DOI: 10.1111/raq.12954

REVIEW

Cracking the myth: Bivalve farming is not a CO_2 sink

Fabrice Pernet[1] | Sam Dupont[2,3] | Jean-Pierre Gattuso[4,5] | Marc Metian[3] | Frédéric Gazeau[4]

Reviews in Aquaculture

LETTER OPEN ACCESS

Bivalve Farming Is Not a CO_2 Sink: From Myth to Legend, Where Is Science?

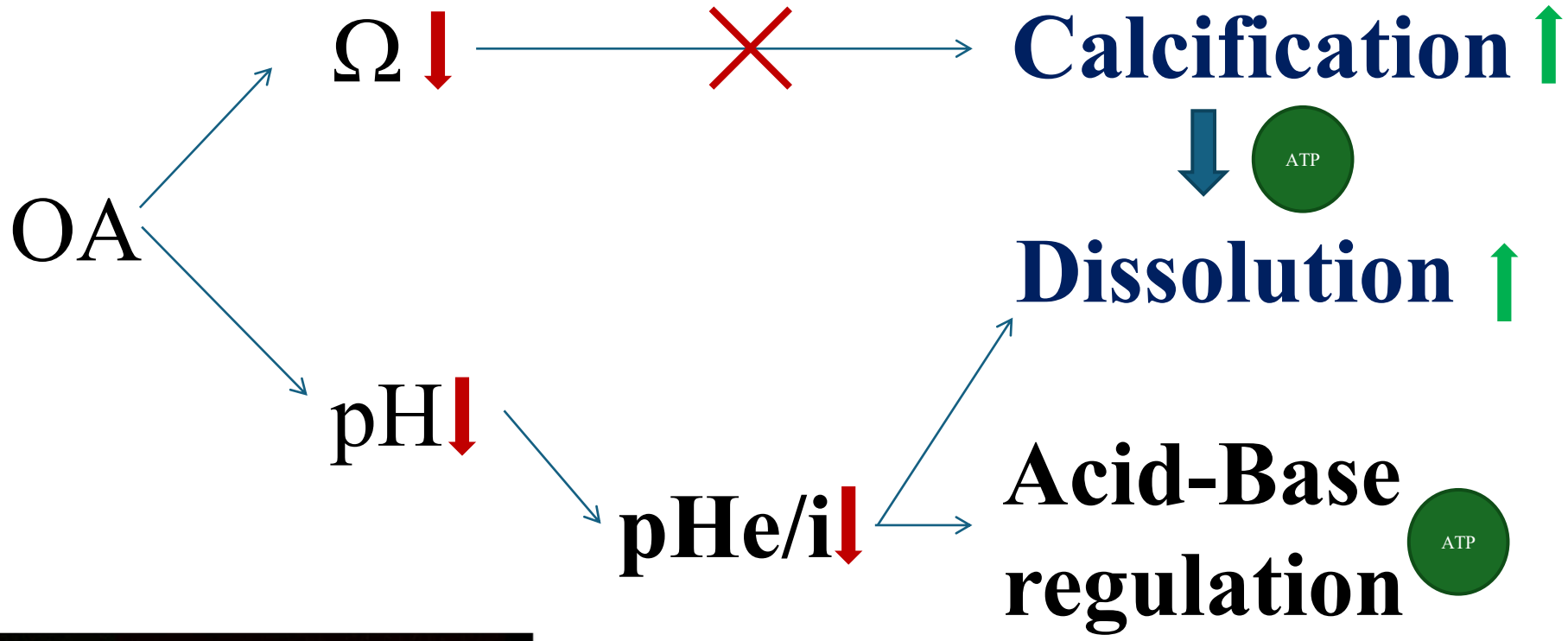
Fabrice Pernet[1] | Sam Dupont[2,3] | Jean-Pierre Gattuso[4,5] | Marc Metian[3] | Frédéric Gazeau[4]

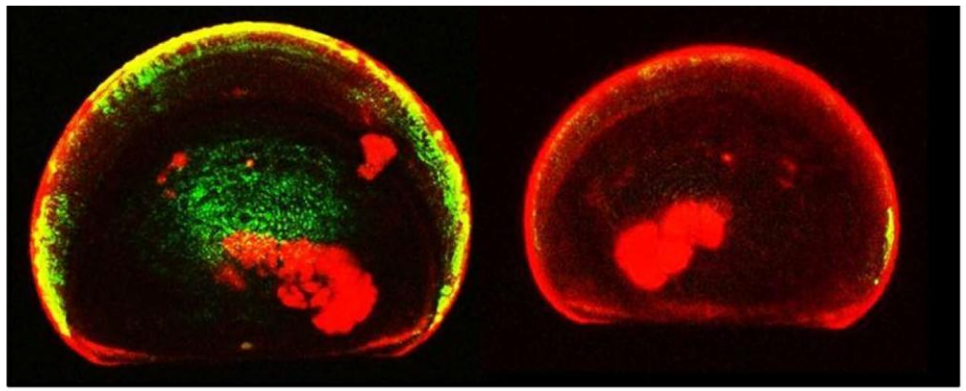
PNAS LETTER

Scientific evidence does not support oyster farming as a marine carbon dioxide removal strategy for climate mitigation

Fabrice Pernet[a,1], Philip W. Boyd[b], Sam Dupont[c], Jean-Pierre Gattuso[d,e], Frédéric Gazeau[d], Christopher J. Gobler[f], Marc Metian[g], Stephen Tomasetti[h], and Phillip Williamson[i]

Main driver: pH





On the menu today

- Ocean acidification
- What drives biological impacts?
- **Local adaptation**
- Case study

Thresholds

www.nature.com/scientificreports

SCIENTIFIC REPORTS

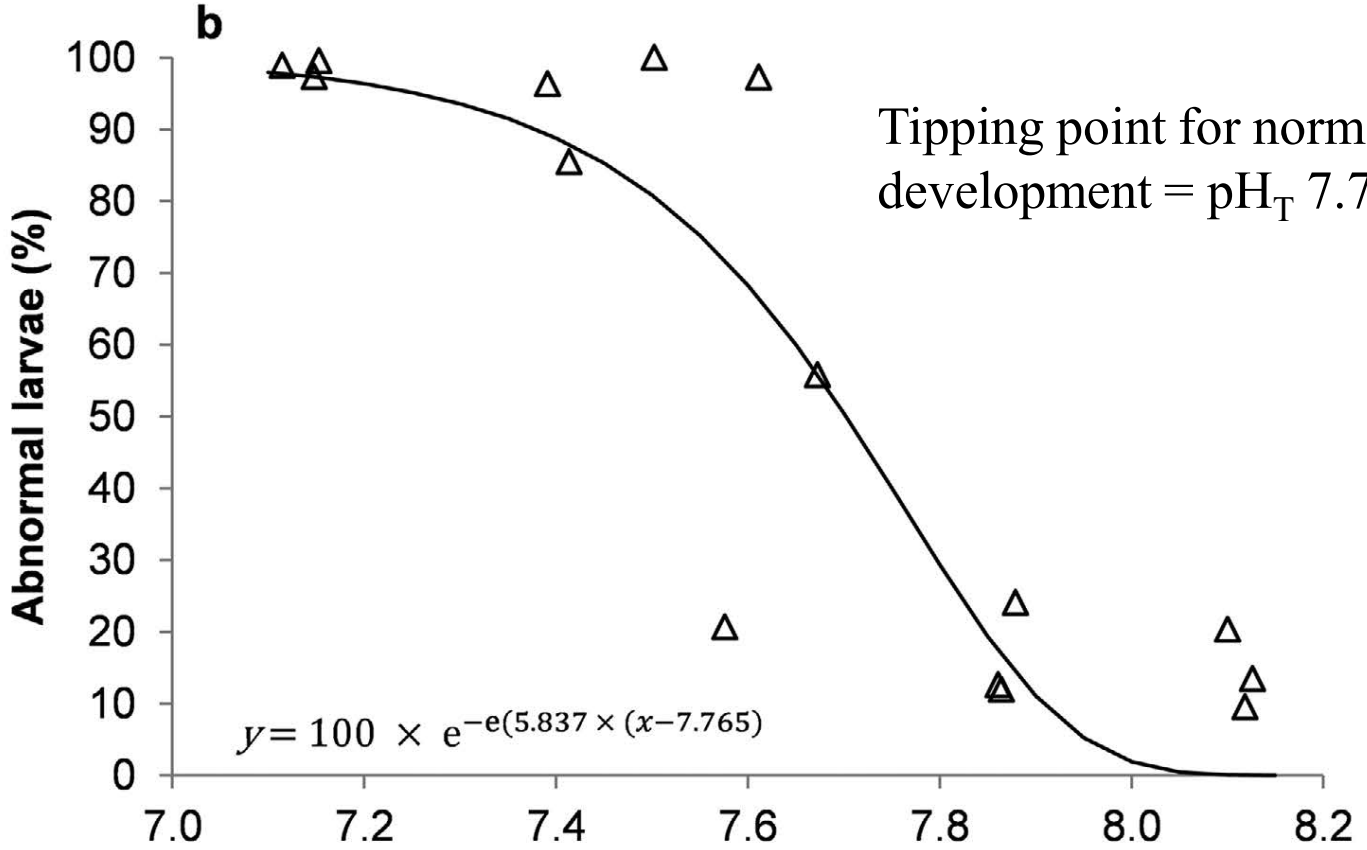
OPEN

Maintained larval growth in mussel larvae exposed to acidified under-saturated seawater

Received: 30 May 2015
Accepted: 03 March 2016
Published: 29 March 2016

Alexander Ventura, Sabrina Schulz & Sam Dupont

Ocean acidification (OA) is known to affect bivalve early life-stages. We tested responses of blue mussel larvae to a wide range of pH in order to identify their tolerance threshold. Our results confirmed that decreasing seawater pH and decreasing saturation state increases larval mortality rate and the percentage of abnormally developing larvae. Virtually no larvae reared at average pH_T 7.16 were able to feed or reach the D-shell stage and their development appeared to be arrested at the trochophore



Tipping point for normal development = pH_T 7.765.

Population-specific response

Population 1

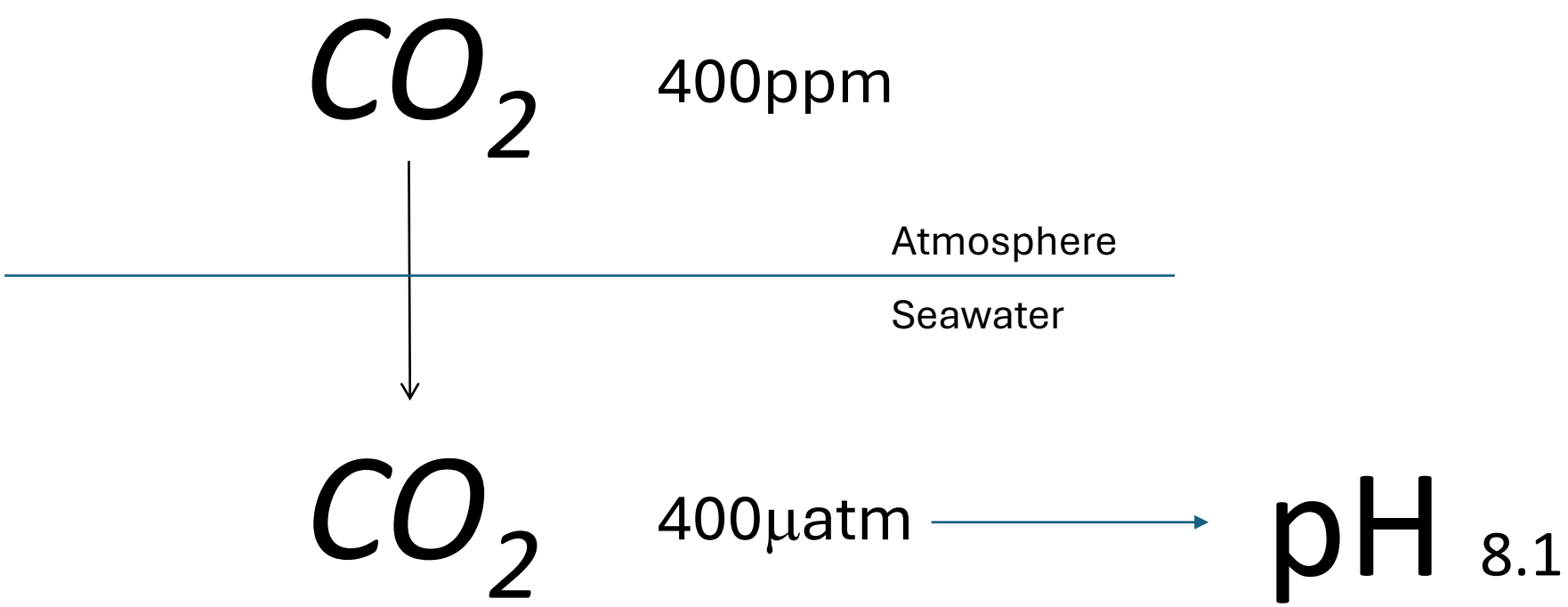
– – –

Population 2

=

Need to study all species and population in the world if we want to forecast biological impacts?

Open ocean: $P(CO_2)atm = p(CO_2)sw$



Equilibrium true for open ocean

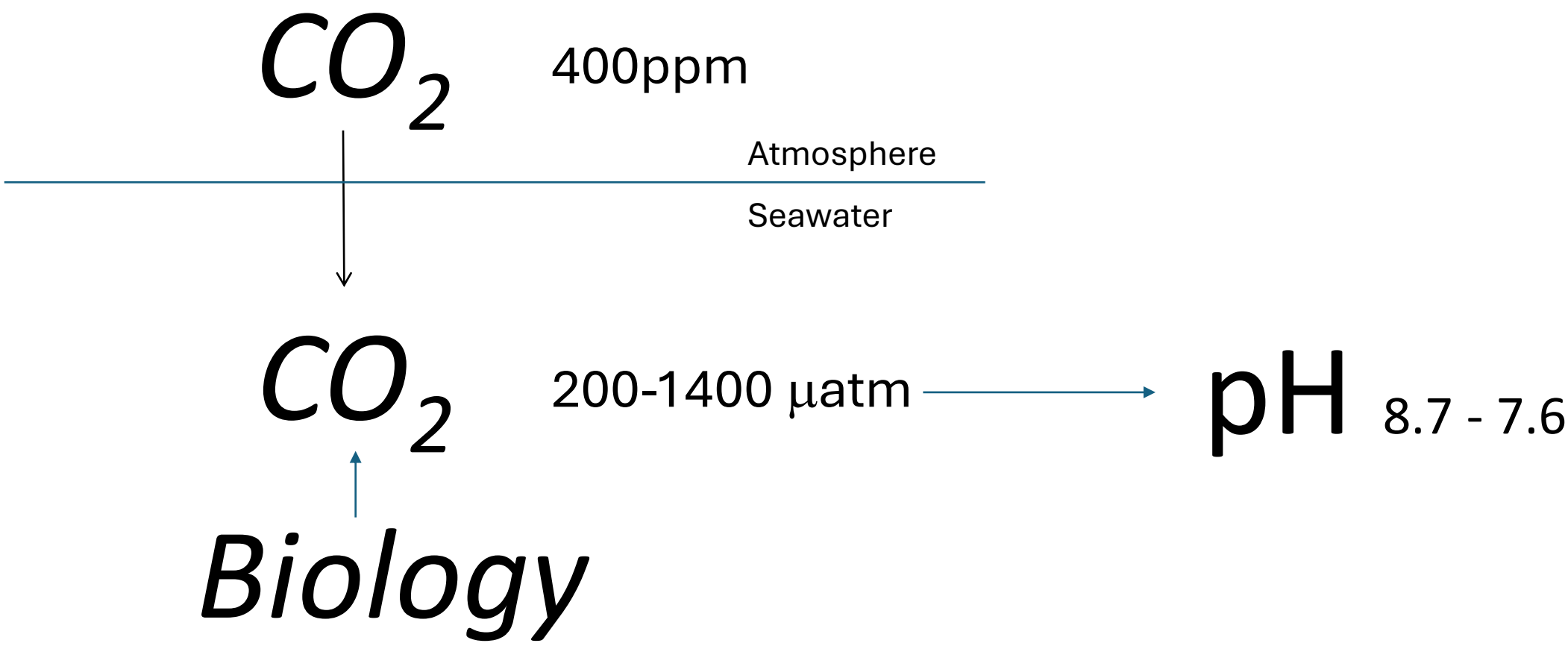
Present:	8.1
OA – 2100:	7.7 (ΔpH: 0.4)

Coastal zone

- ✓ Mixing/upwelling
- ✓ Interaction with other parameters (e.g. temperature, salinity)
- ✓ Other sources of acidification (nutrients, SOx/NOx)
- ✓ Biology (photosynthesis, respiration, calcification, etc.)

CO_2 ⬇ CO_2 ⬆ CO_2 ⬆

Costal zone: $P(CO_2)atm \neq p(CO_2)sw$



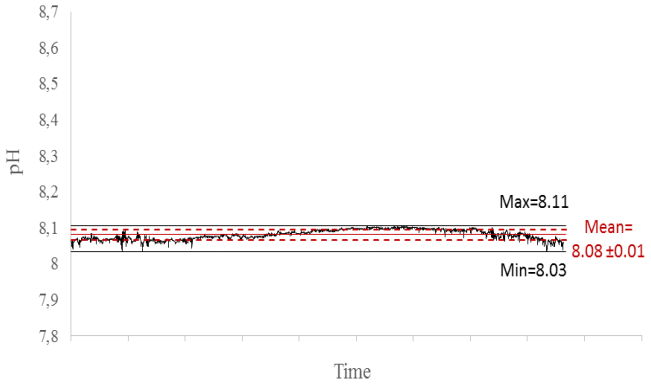
Not in equilibrium

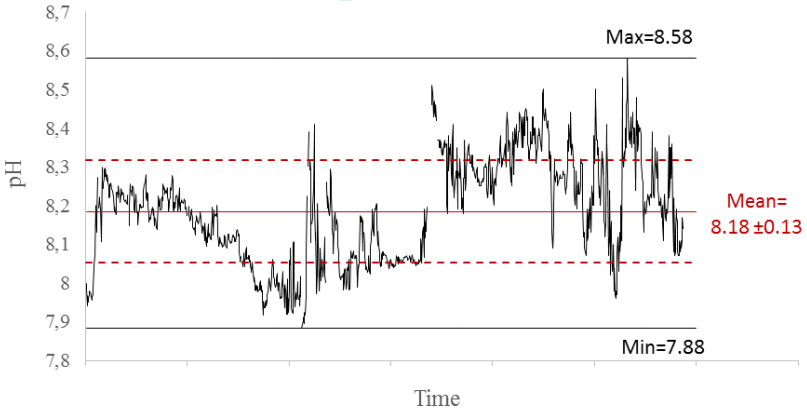
Present: 8.7-7.6
OA – 2100: 8.3-7.2 (ΔpH: 0.4)

Local adaptation

Population 1

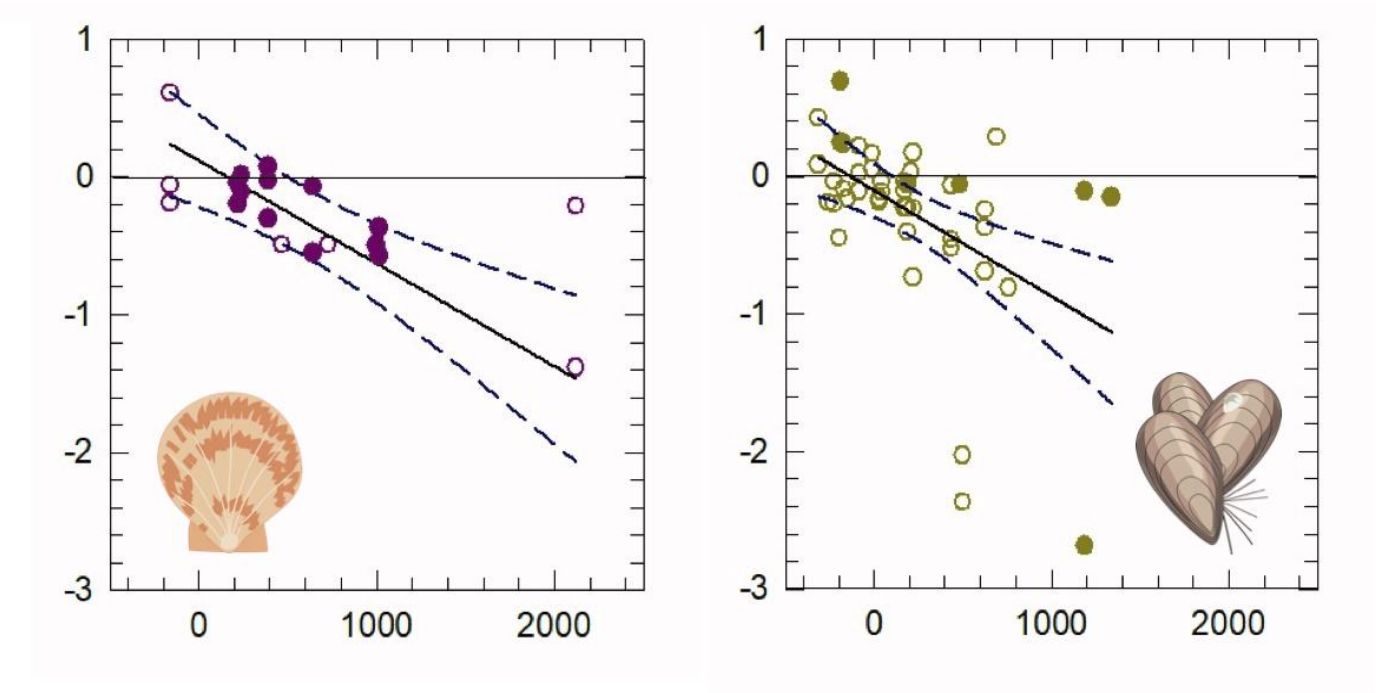
Population 2





Local adaptation

Local adaptation: importance of monitoring



$\Delta\ pCO_2$ (µatm)
(experimental – extreme environmental pCO_2)

ANALYSIS
https://doi.org/10.1038/s41558-021-01269-2
nature climate change
Check for updates

Upper environmental pCO_2 drives sensitivity to ocean acidification in marine invertebrates

Cristian A. Vargas[1,2,3], L. Antonio Cuevas[1,3], Bernardo R. Broitman[3,4], Valeska A. San Martin[3], Nelson A. Lagos[3,5], Juan Diego Gaitán-Espitia[6] and Sam Dupont[7,8]

On the menu today

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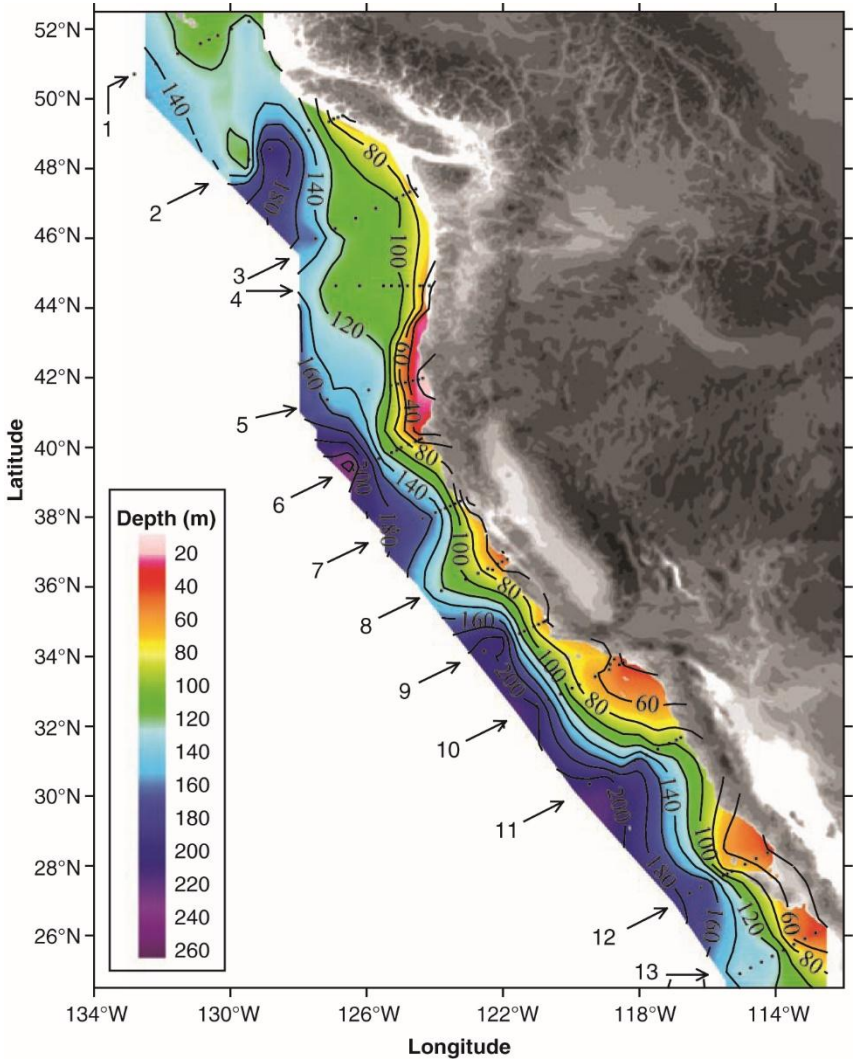
- **Case study**

2007 crash in US west coast aquaculture

Problem: Not possible to produce spats in hatcheries

-> No production, no money, no jobs

Diagnosis: ocean acidification (+ upwelling)



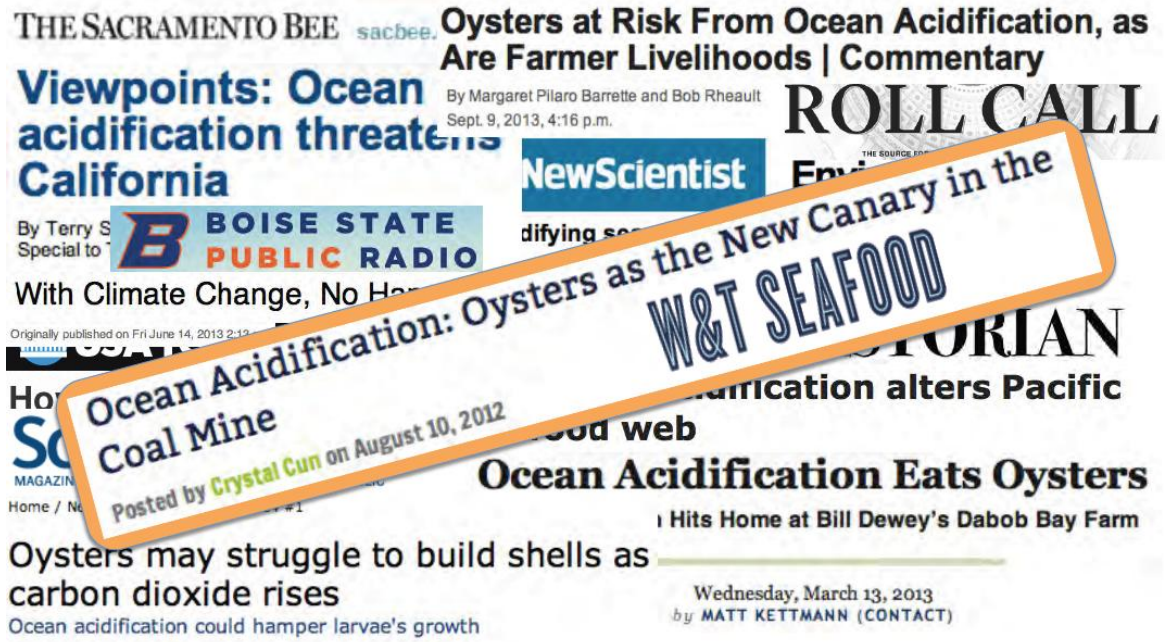
Feely et al. 2008

Solution #1 – CO_2 mitigation

Solution?: *Mitigation*

- ✓ Policy
- ✓ Change
- ✓ Acceptance

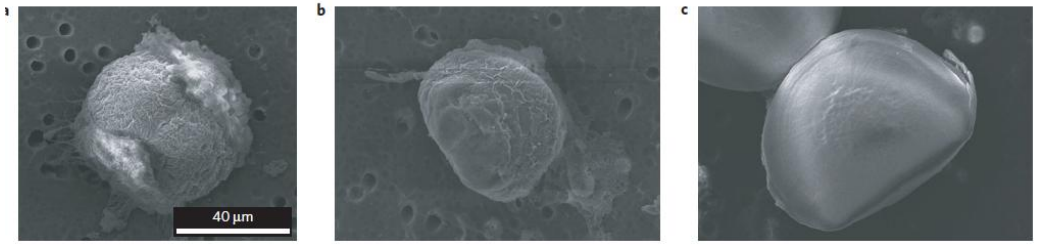
} Citizen



Inefficient: different times scales

Solution #2 – adaptation (change of practices)

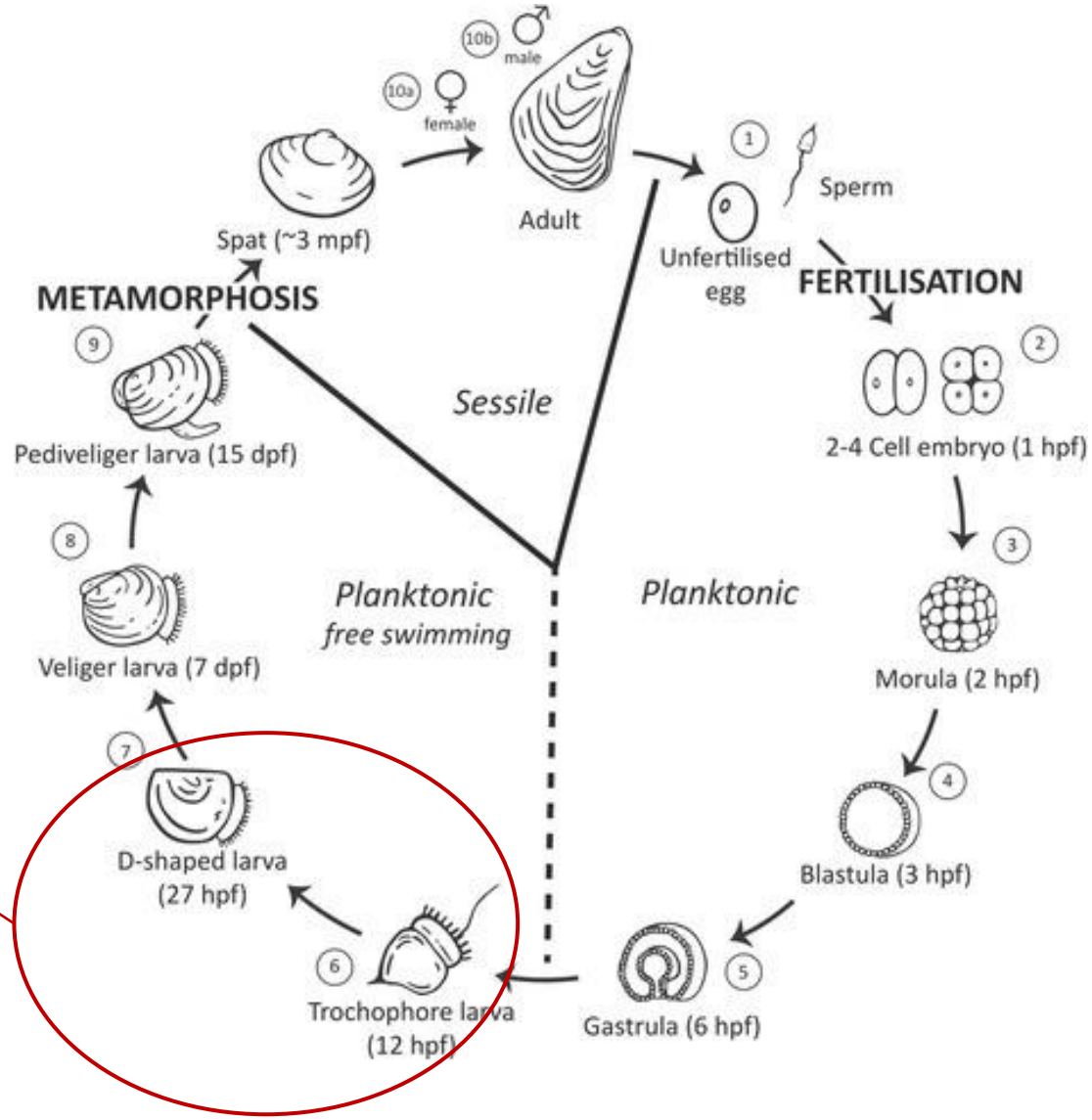
Window of opportunity



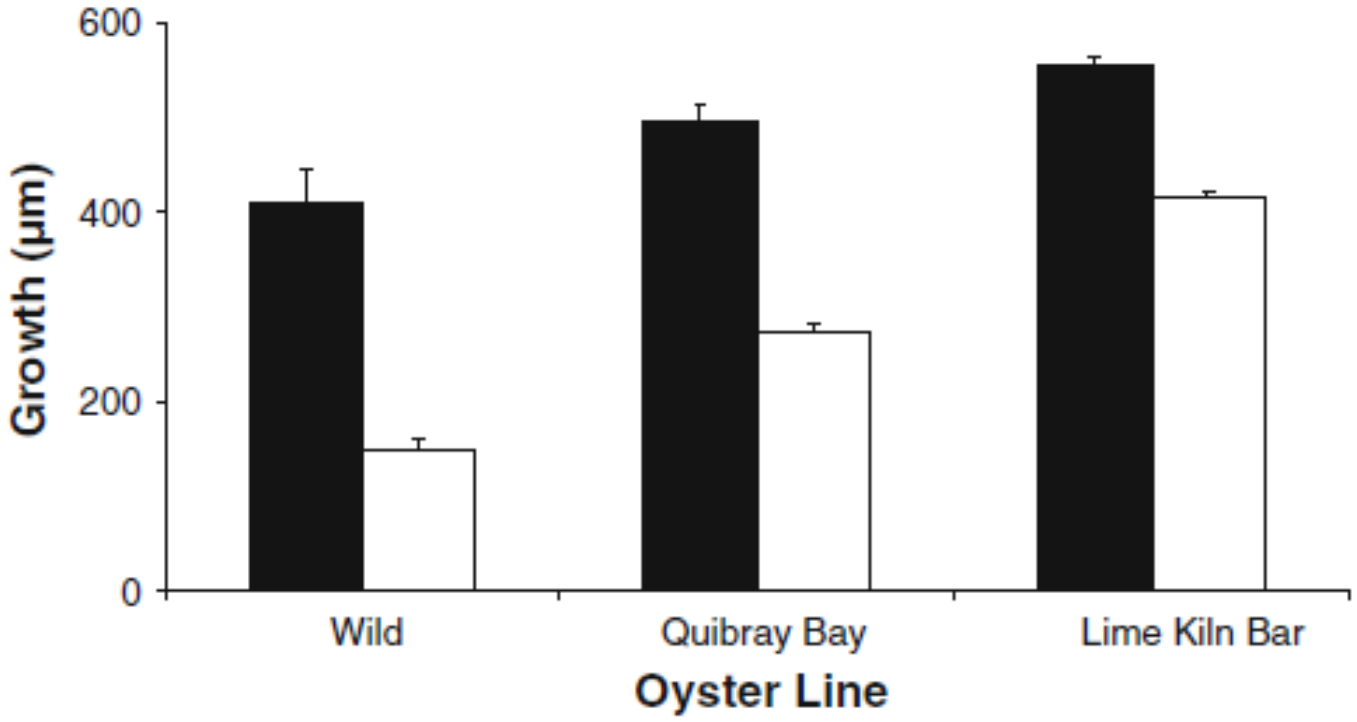
nature climate change
ARTICLES
PUBLISHED ONLINE: 15 DECEMBER 2014 | DOI: 10.1038/NCLIMATE2479

Saturation-state sensitivity of marine bivalve larvae to ocean acidification

George G. Waldbusser[1]*, Burke Hales[1], Chris J. Langdon[2], Brian A. Haley[1], Paul Schrader[2], Elizabeth L. Brunner[1], Matthew W. Gray[2], Cale A. Miller[3] and Iria Gimenez[1]



Solution #2 – adaptation (genetic strains)



Mar Biol
DOI 10.1007/s00227-010-1592-4

ORIGINAL PAPER

Populations of the Sydney rock oyster, *Saccostrea glomerata*, vary in response to ocean acidification

L. M. Parker · Pauline M. Ross · Wayne A. O'Connor

Solution #2 – adaptation (pre-acclimation)

OA

More relisient offsprings to OA

Global Change Biology

Global Change Biology (2012) **18**, 82–92, doi: 10.1111/j.1365-2486.2011.02520.x

Adult exposure influences offspring response to ocean acidification in oysters

LAURA M. PARKER*, PAULINE M. ROSS*, WAYNE A. O'CONNOR†, LARISSA BORYSKO*, DAVID A. RAFTOS‡ and HANS-OTTO PÖRTNER§

Conclusions

- **Ocean acidification is a direct consequence of CO_2 emission**
- **Shellfish are sensitive and impact driven by pH**
- **Local adaptation to present range of pH variability**
- **Aquaculture already impacted**
- **Mitigation is the solution but need to buy time**
- **Adaptation solutions exist**