Ocean Acidification International Coordination Centre

IAEA OA-ICC

UNIVERSITY OF GOTHENBURG

KUNGL. VETENSKAPS-AKADEMIEN

THE ROYAL SWEDISH ACADEMY OF SCIENCES

Basic training course on ocean acidification

EVT1804704

14-19 March 2022

From Chemistry to Biology

Take home messages

- ✓ Chemistry influences Biology

Ocean acidification is a multi-driver change in the carbonate system and key chemical parameter(s) influencing biology depend on organisms/ecosystems

- ✓ Biology influences the Chemistry

It is then critical to design a system that maintain the target carbonate chemistry and water quality throughout the experiment

- ✓ You need to document the water quality and chemistry in each experiment

Adapt the frequency and quality to the design

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Ocean acidification is chemistry…

CO_2

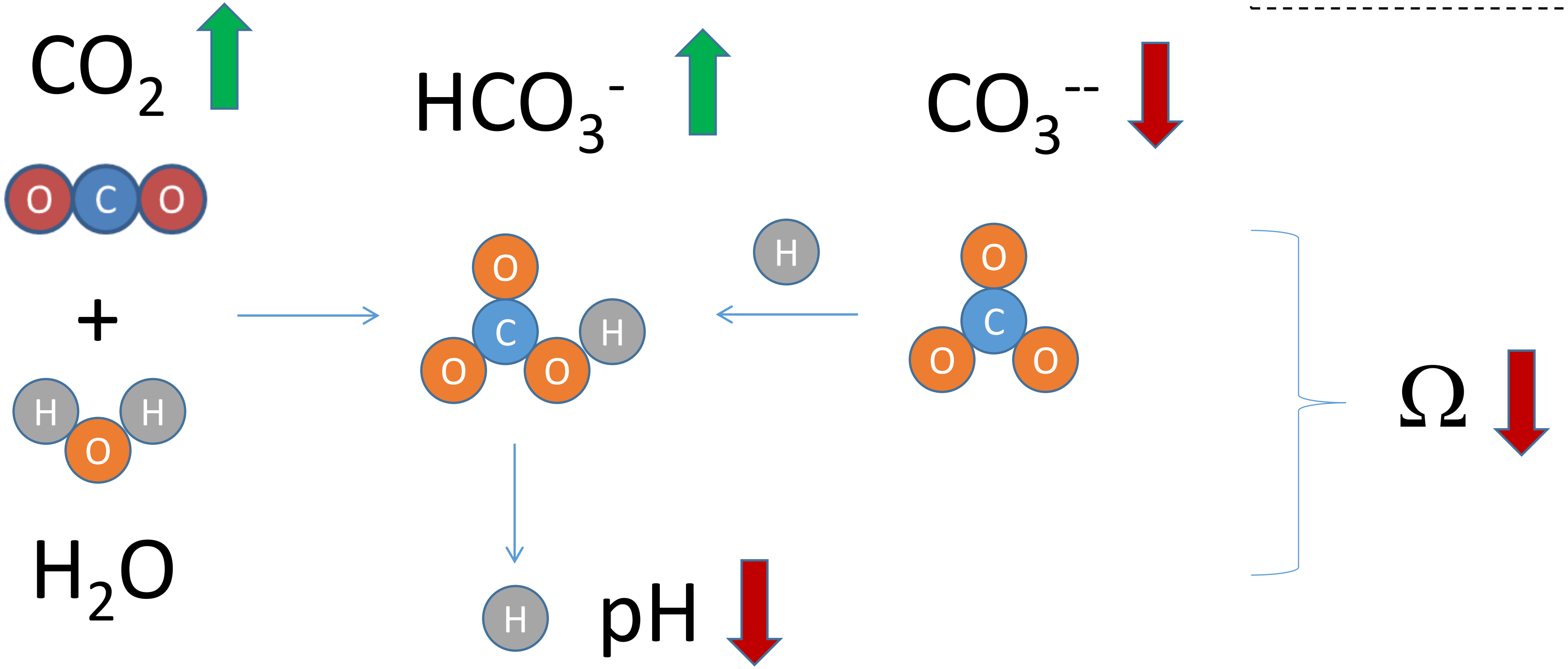
$$CO_2 + H_2O \longrightarrow H_2CO_3$$

Carbon dioxide

Water

Carbonic acid

Ocean acidification in a nutshell



What is driving biological changes?

Is it Ω?

nature climate change

PERSPECTIVE

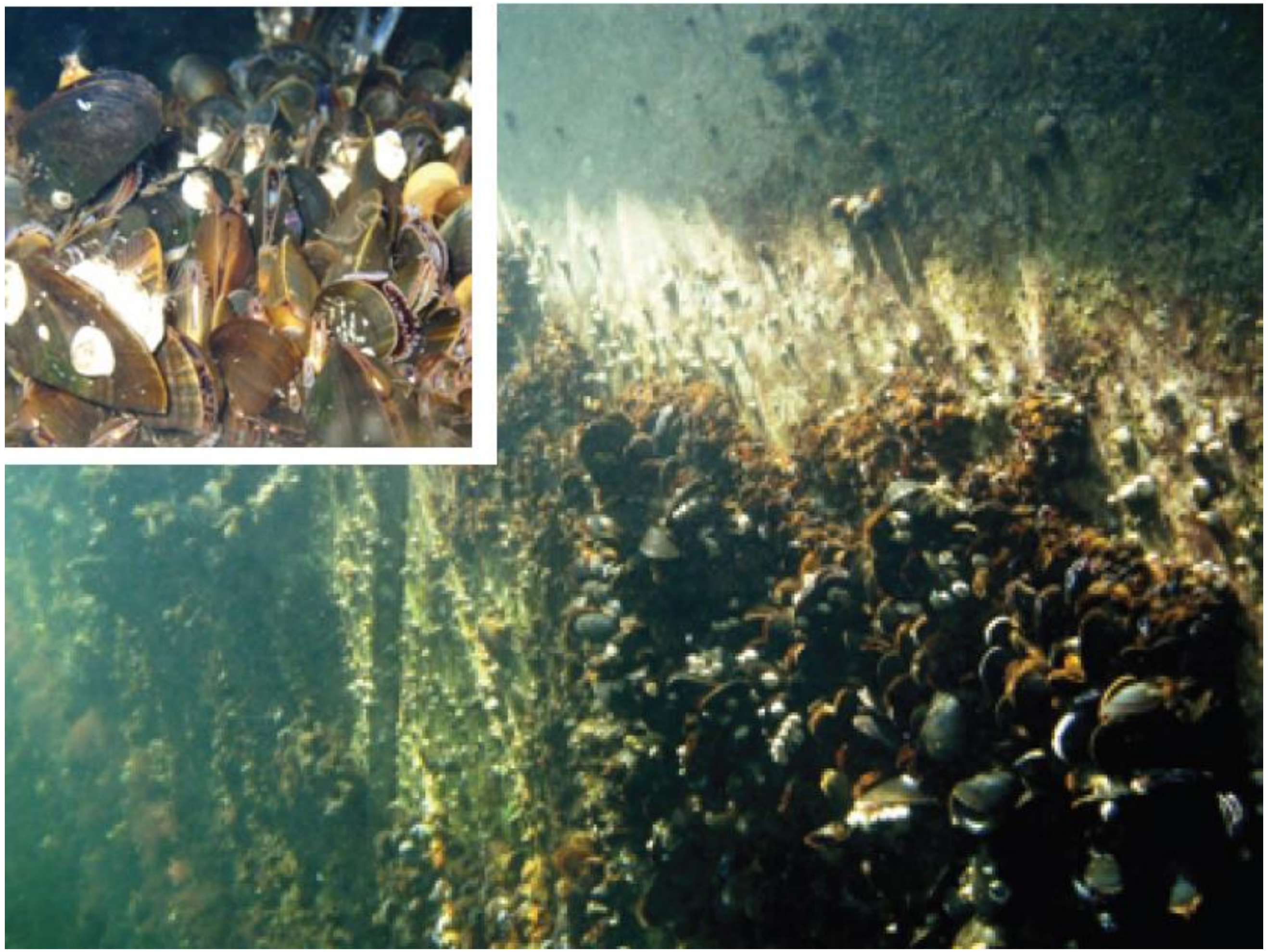
PUBLISHED ONLINE: 23 FEBRUARY 2015 | DOI: 10.1038/NCLIMATE2508

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

Organisms are not pieces of calcium carbonate



pH 7.5, Ωara=0.35

(Thomsen et al. 2010)

Acid-base regulatory mechanisms

Omega myth…

ICES Journal of
Marine Science

ICES
CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science (2016), 73(3), 558–562. doi:10.1093/icesjms/fsv075

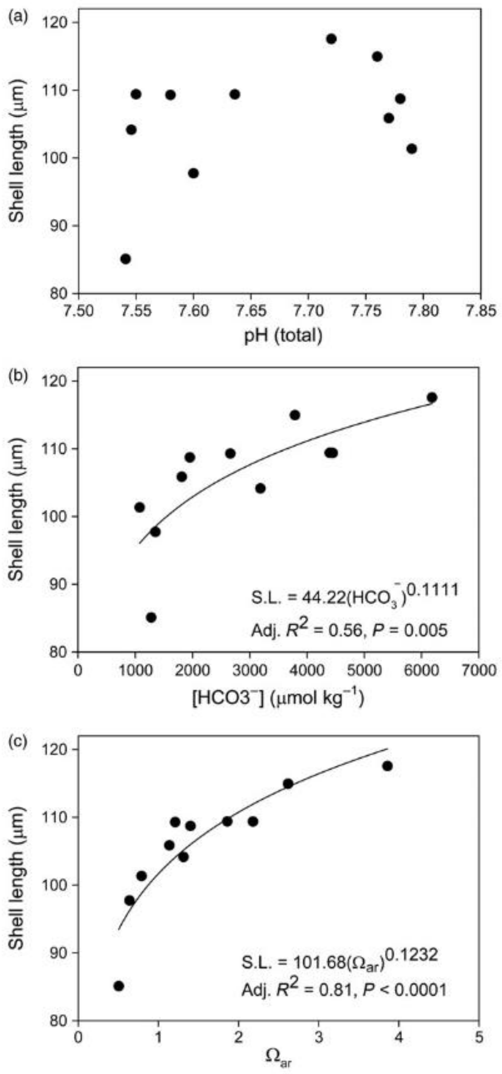
Contribution to Special Issue: 'Towards a Broader Perspective on Ocean Acidification Research'

Food for Thought

The Omega myth: what really drives lower calcification rates in an acidifying ocean

Tyler Cyronak[1]*, Kai G. Schulz[2], and Paul L. Jokiel[3]

Omega myth… but…



ICES Journal of Marine Science

ICES CIEM International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science (2016), 73(3), 563–568. doi:10.1093/icesjms/fsv174

Contribution to Special Issue: 'Towards a Broader Perspective on Ocean Acidification Research'

Comment

Calcium carbonate saturation state: on myths and this or that stories

George G. Waldbusser*, Burke Hales, and Brian A. Haley

Ω can be important for organisms with:

- Exposed skeletal structure (dissolution) e.g. corals
- Periods of fast calcification (kinetic constrains) e.g. larval bivalves

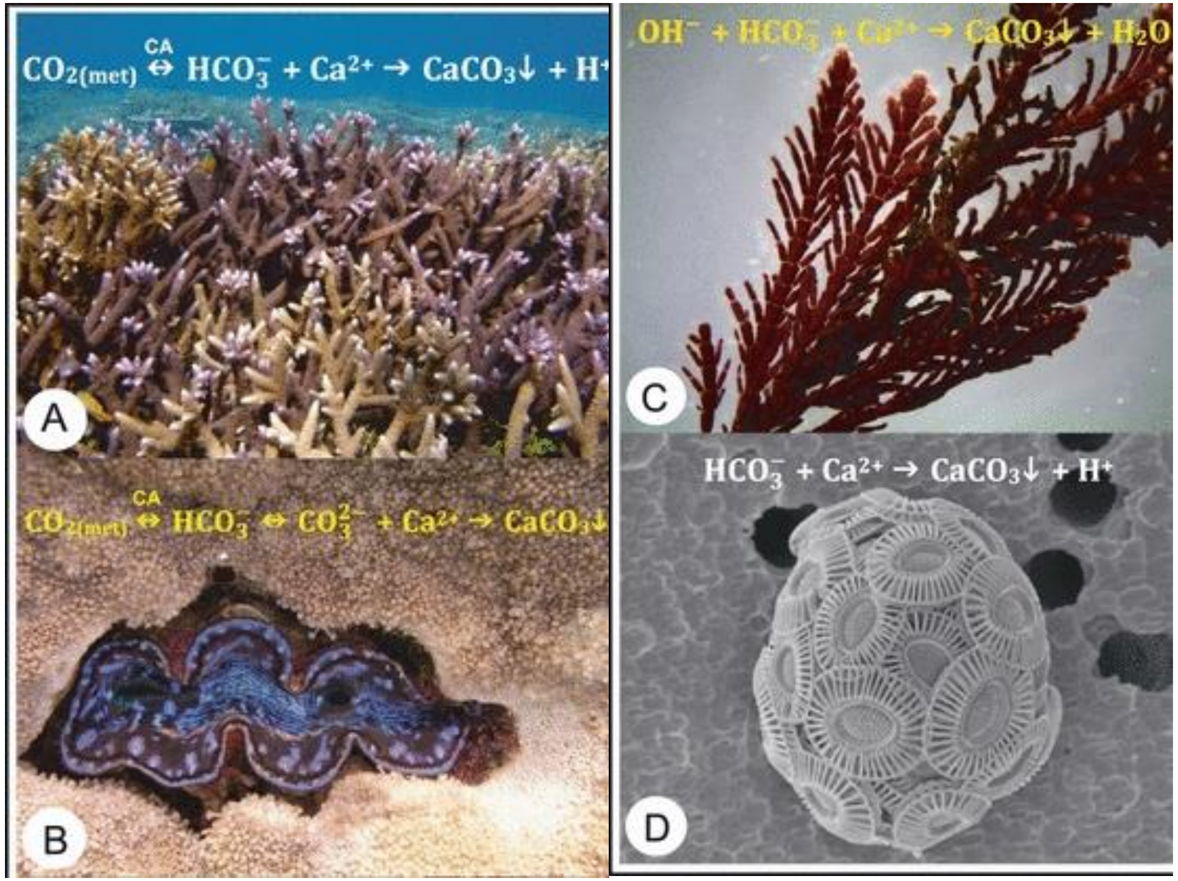
Is it CO_3^{2-}?

Calcification:

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

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

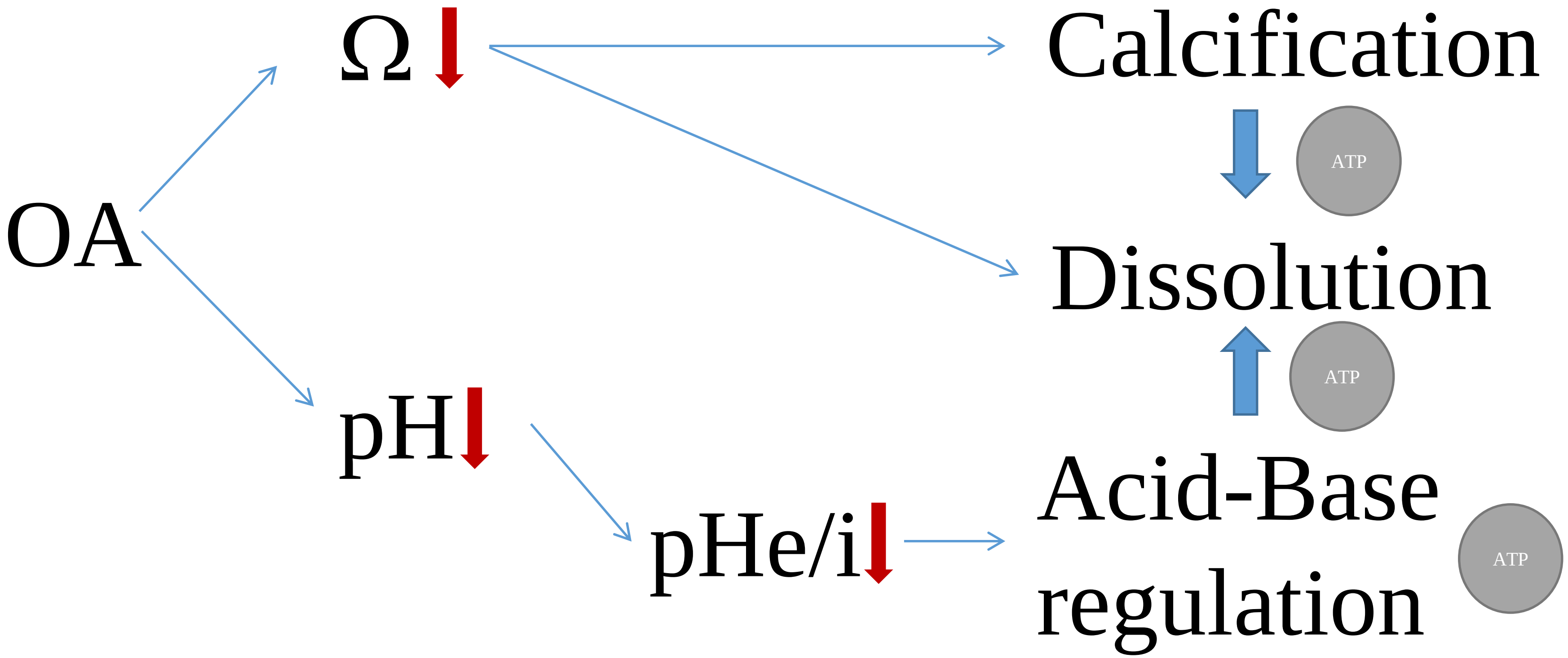
Is it CO_3^{2-}?



Seawater CO_3^{2-} not main bricks for calcification

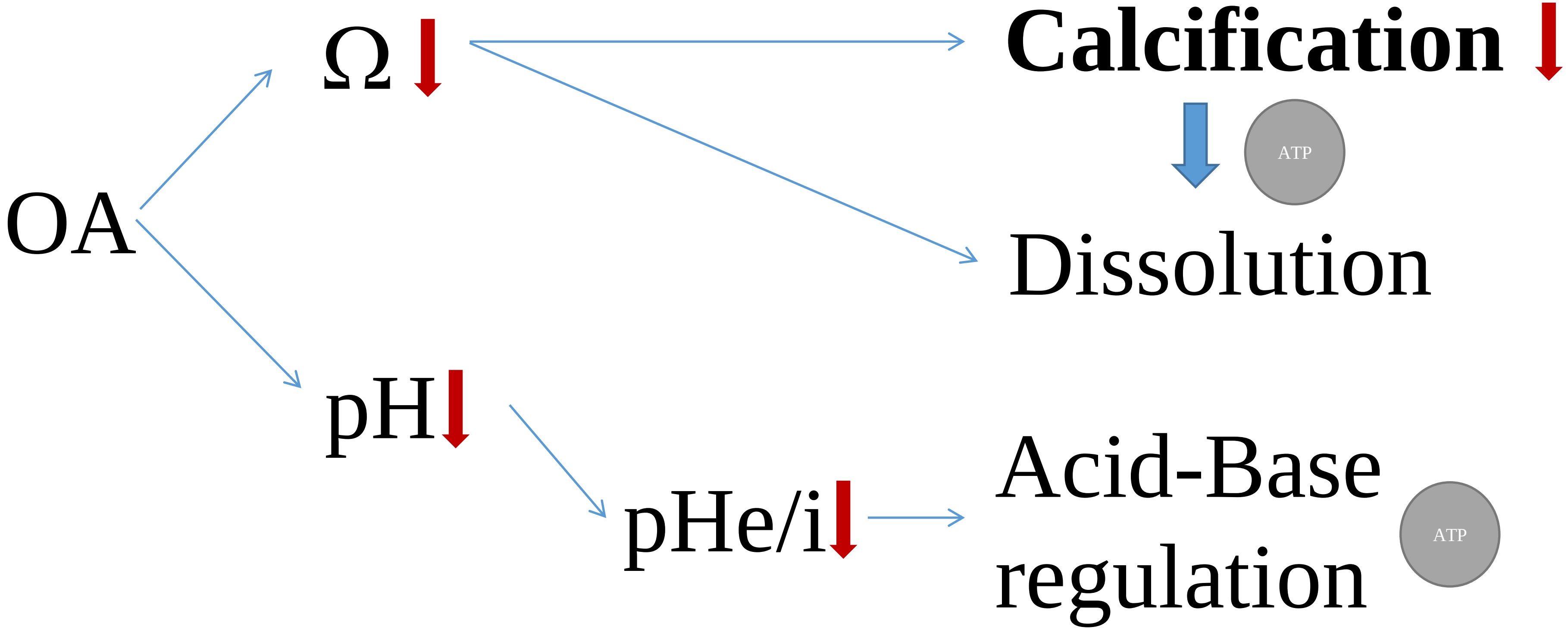
Roleda et al. 2012

(Many) animal exposed to ocean acidification?



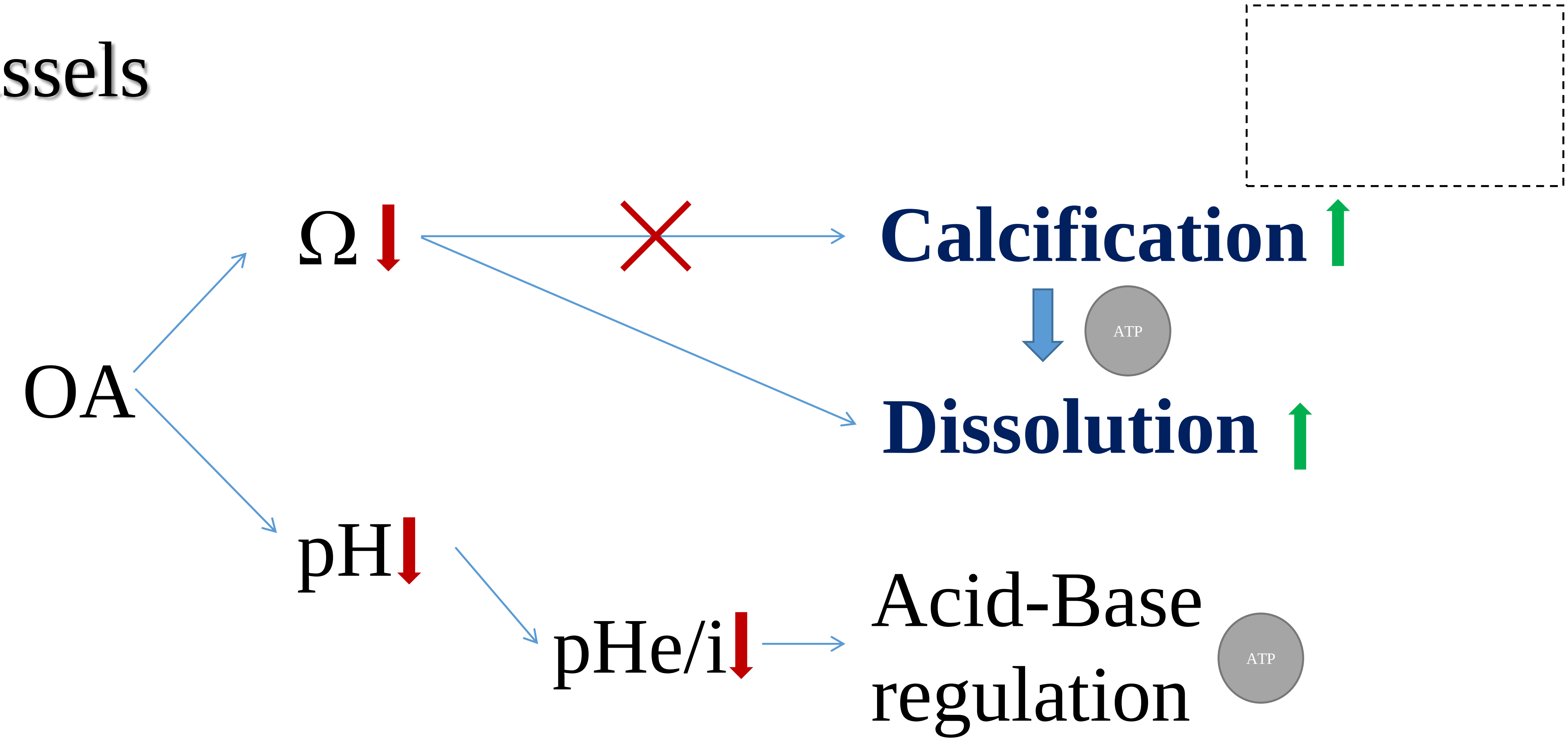
Species sensitivity relates to: ability to protect/compensate & energy

Early oyster larvae

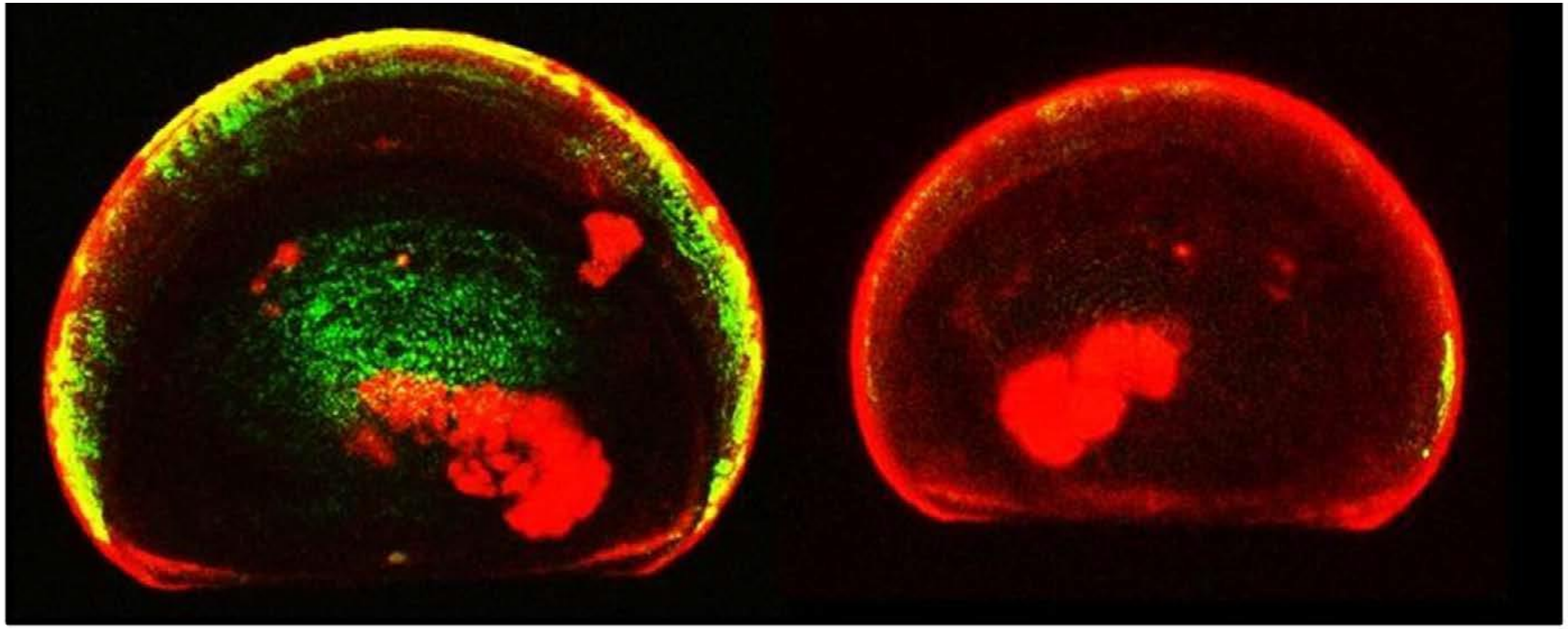


Ω main driver (kinetic constrains)

Mussels


OA
Ω
pH
pHe/i
Calcification
ATP
Dissolution
Acid-Base
regulation
ATP

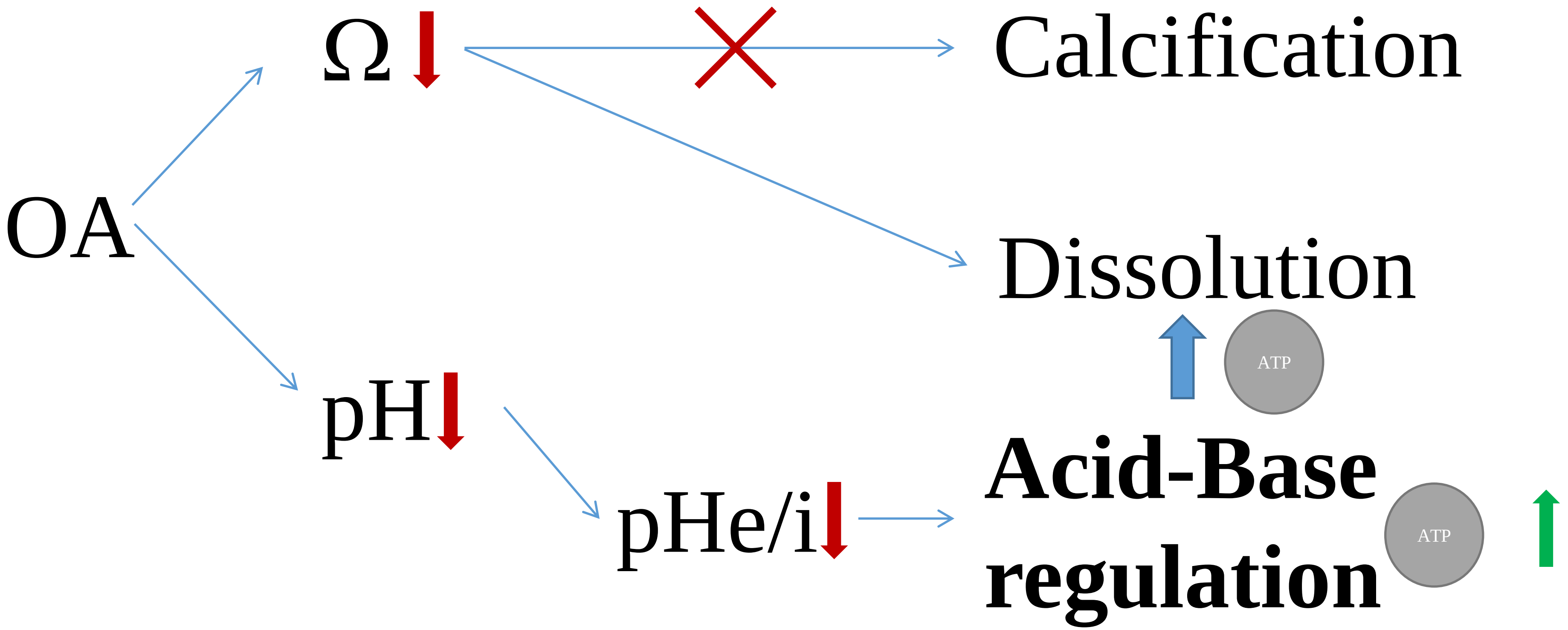
Mussels



Compensatory calcification

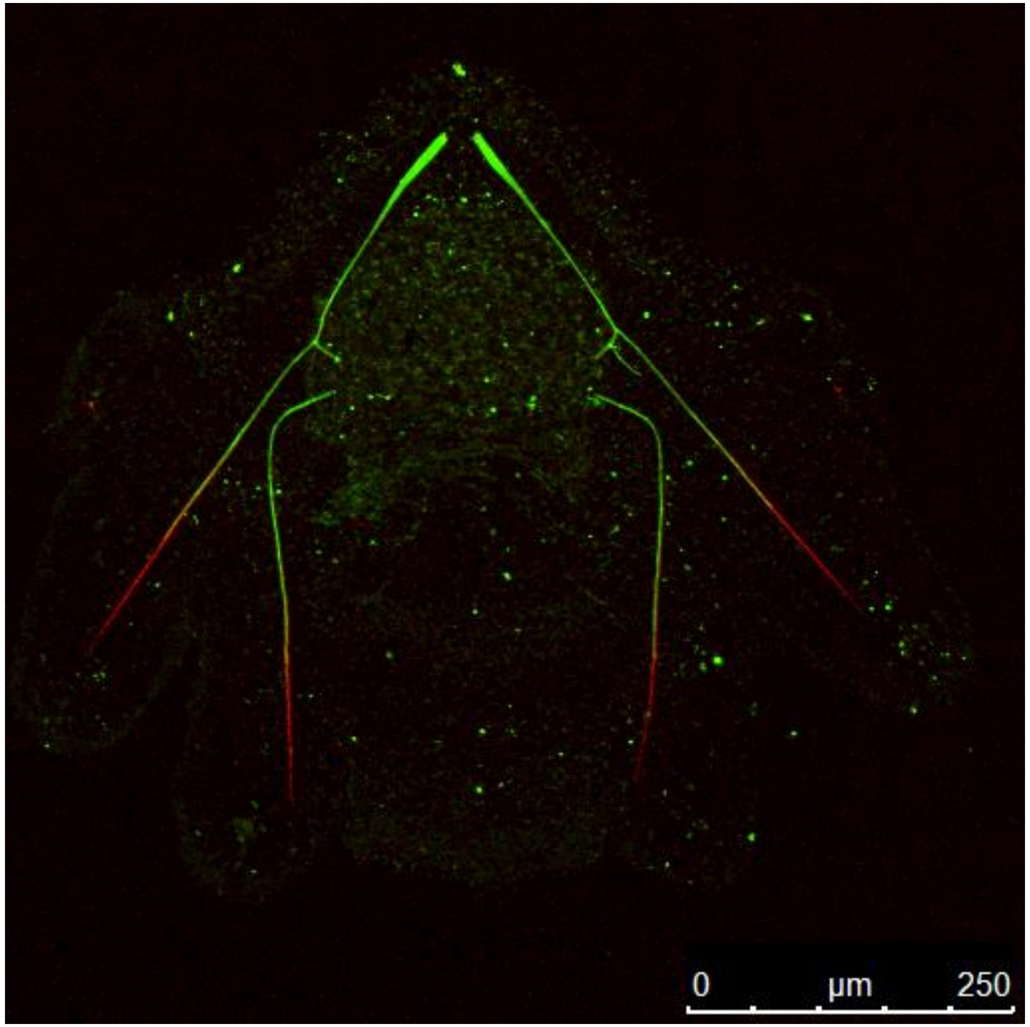
Ventura et al. (2016)

Echinoderms



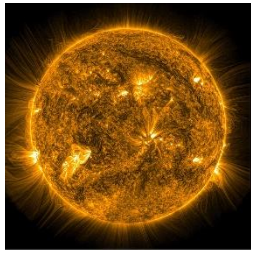
pH main driver (regulation)

Echinoderms



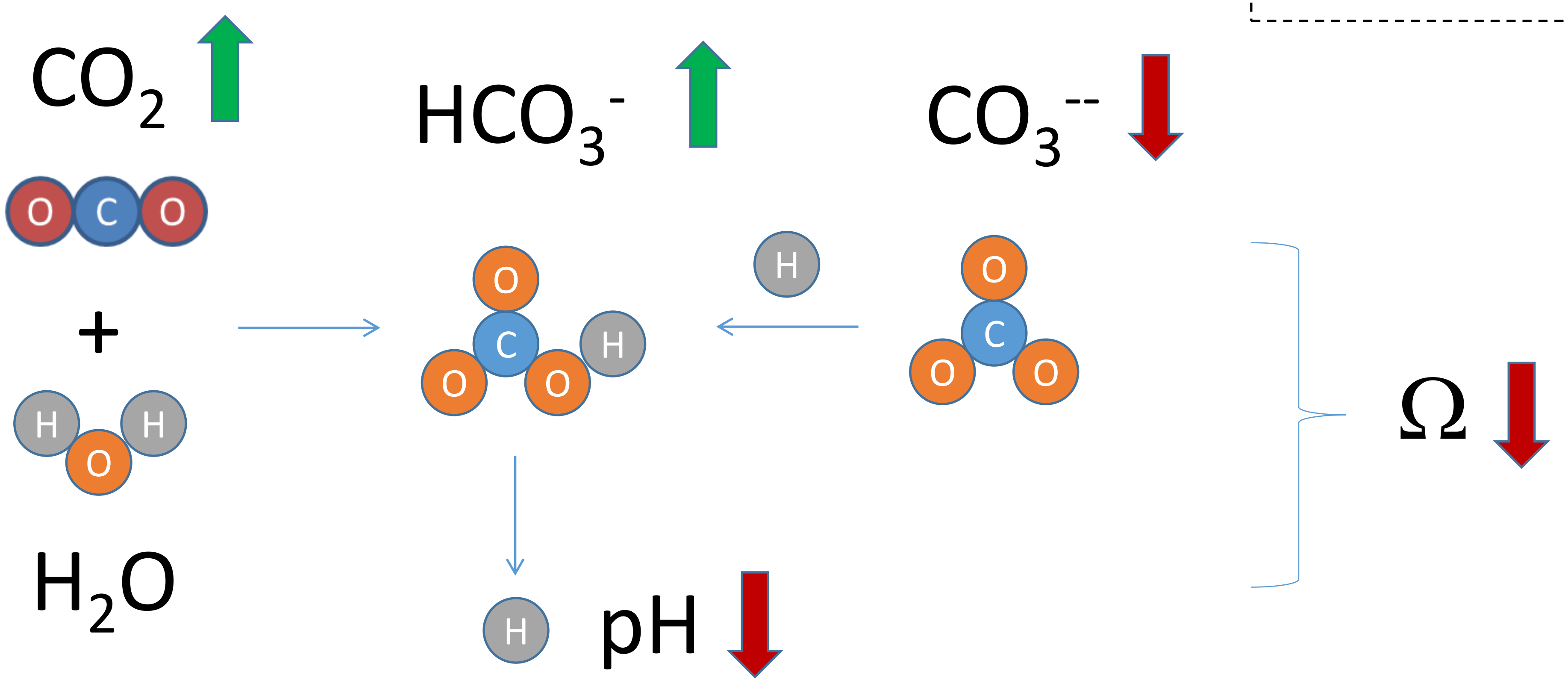
Is it CO_2?

$$6CO_2 + 6H_2O \text{ ------> } C_6H_{12}O_6 + 6O_2$$



Photosynthesis

What is driving biological response?



It depends on species/organisms

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Adapt the frequency and quality to the design

Many biological processes impacts the carbonate chemistry

<u>Day</u>: light
= Photosynthesis + respiration

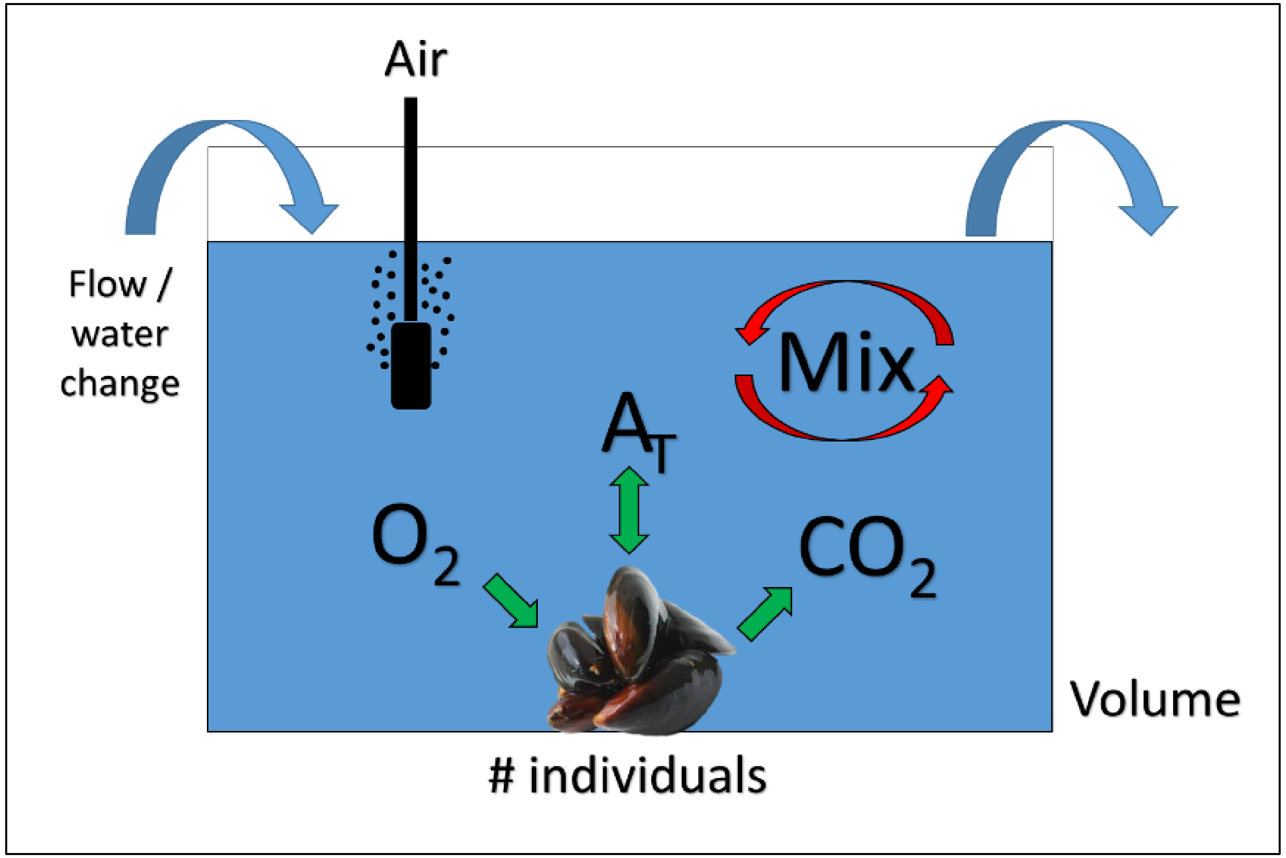
O_2 ↑ CO_2 ↓ pH ↑

<u>Night</u>: dark
= respiration

O_2 ↓ CO_2 ↑ pH ↓

Need to adapt the aquarium system

Depend on the species and stage/size/density/species specificities



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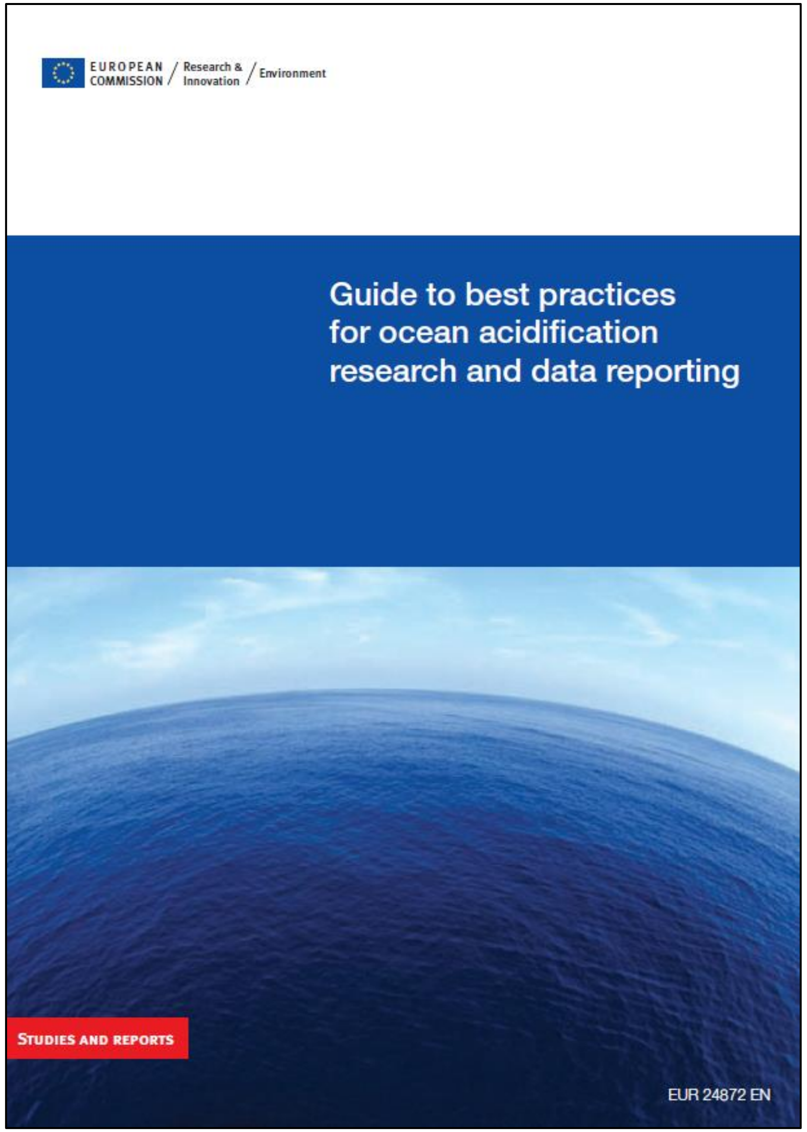
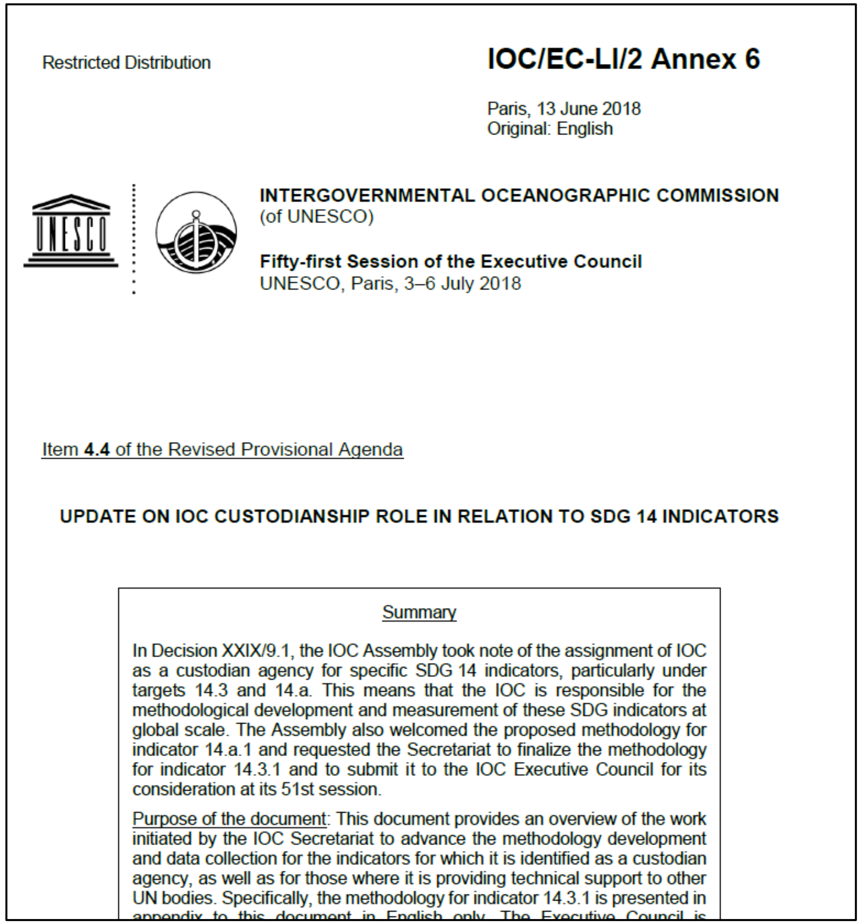
Best Practices and SOP





Restricted Distribution

IOC/EC-LI/2 Annex 6

Paris, 13 June 2018
Original: English

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

Fifty-first Session of the Executive Council
UNESCO, Paris, 3–6 July 2018

Item **4.4** of the Revised Provisional Agenda

UPDATE ON IOC CUSTODIANSHIP ROLE IN RELATION TO SDG 14 INDICATORS

Summary

In Decision XXIX/9.1, the IOC Assembly took note of the assignment of IOC as a custodian agency for specific SDG 14 indicators, particularly under targets 14.3 and 14.a. This means that the IOC is responsible for the methodological development and measurement of these SDG indicators at global scale. The Assembly also welcomed the proposed methodology for indicator 14.a.1 and requested the Secretariat to finalize the methodology for indicator 14.3.1 and to submit it to the IOC Executive Council for its consideration at its 51st session.

Purpose of the document: This document provides an overview of the work initiated by the IOC Secretariat to advance the methodology development and data collection for the indicators for which it is identified as a custodian agency, as well as for those where it is providing technical support to other UN bodies. Specifically, the methodology for indicator 14.3.1 is presented in appendix to this document in English only. The Executive Council is

You can measure

- pH
- DIC
- Alkalinity
- *p*CO_2

Need to measure 2

You also need Temp, salinity, and pressure

+ USE EQUILIBRIUM CONSTANTS FOR THE CALCULATIONS

E.g. pH

	Equipment Cost	Ease of use	Uncertainty in best labs
Electrometric pH cell	Relatively cheap (need *T* control)	Simple to use, needs regular recalibration*	0.02 limited availability of RMs
Using indicator & spectrophotometer	Mid-range k$ 10–25	Can be automated	< 0.01 limited availability of pure mCP

* The Honeywell DuraFET® seems to have a significantly more stable calibration than a conventional pH cell.

OK to use well calibrated pH electrodes

Frequency of measurements?

- ✓ Enough to capture the variability
- ✓ Demonstrate that conditions are "stable" over the course of the experiment (time effect)
- ✓ Demonstrate that no significant differences between replicates
- ✓ Demonstrate that significant differences between treatments

➡ Summary Table & Statistics

Example: Constant pH

Table 1 Seawater carbonate chemistry parameters presented as mean ± SD for 15 replicates and 30 daily measurements per replicate (seawater carbonate chemistry for each replicate is available in Online Resource 1, see Supplementary Material)

Measured			Calculated		
pH_{NBS}	T (°C)	Salinity	pCO_2 (µatm)	Ω_c	Ω_a
8.10 ± 0.02	18.93 ± 0.40	37.36 ± 0.38	499.00 ± 27.00	4.13 ± 0.15	2.69 ± 0.10
7.73 ± 0.02	18.93 ± 0.48	37.34 ± 0.37	1303.72 ± 82.24	1.96 ± 0.10	1.28 ± 0.07
7.46 ± 0.02	18.97 ± 0.40	37.52 ± 0.38	2568 ± 27.00	1.09 ± 0.15	0.71 ± 0.10
$F = 3941.56$	$F = 1.08$	$F = 30.67$	$F = 30493.40$	$F = 89846.70$	$F = 89407.70$
$p < 0.0001$	$p = 0.340$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

Daily averages of measured parameters (pH, T, S) are presented. Seawater pH on the NBS scale (pH_{NBS}), temperature (T; °C), salinity, and total alkalinity of 2440 ± 65.09 mmol kg^{-1} (measured three times during the experiment for each treatment) were used to calculate CO_2 partial pressure (pCO_2; µatm) as well as aragonite and calcite saturation states (respectively, Ω_a and Ω_c). Results of ANOVA I ($F_{2,1349}$ value and p value) testing the difference between the tested pH treatments are given for each parameter

Example: Fluctuating pH

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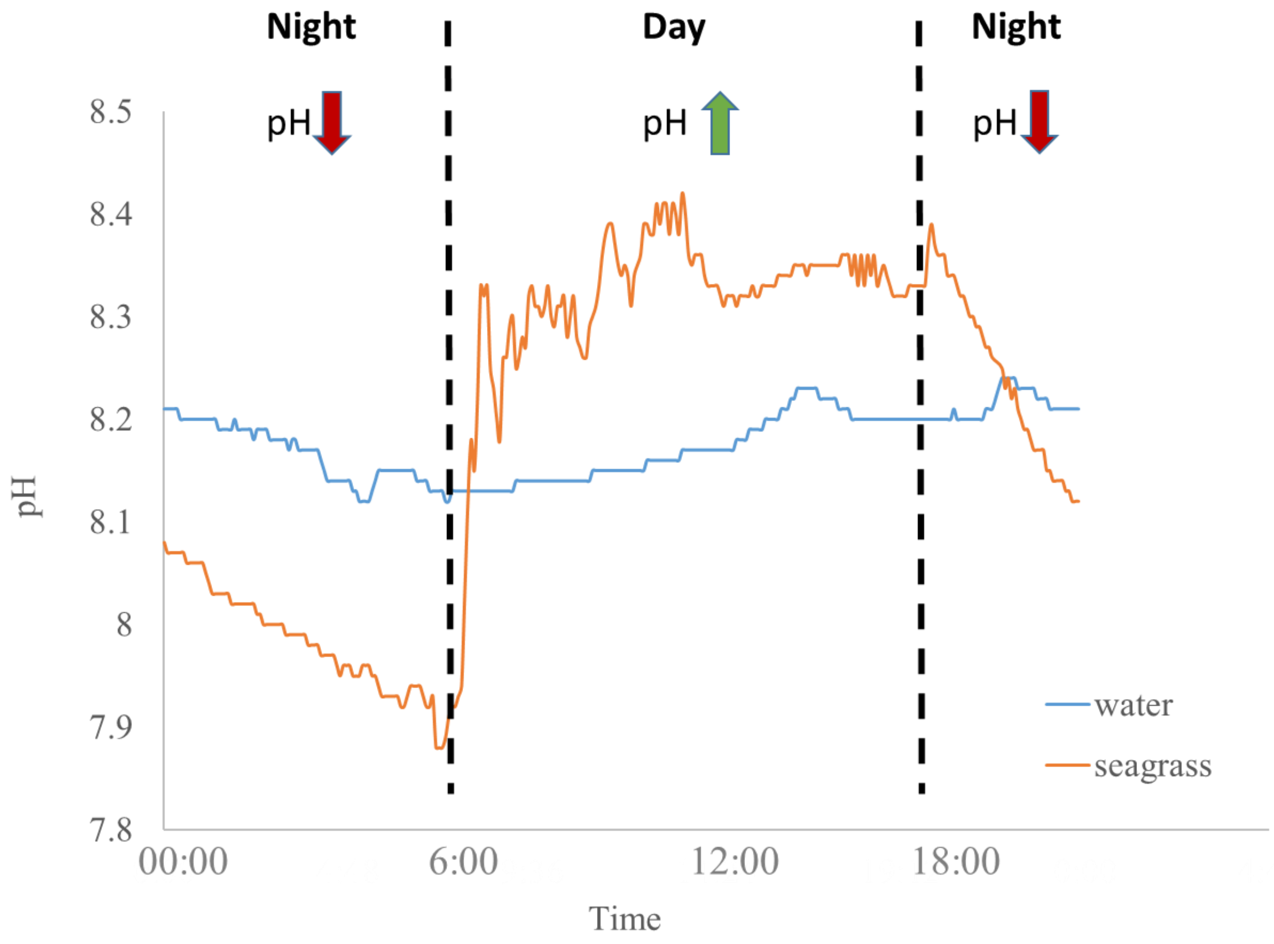

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