IAEA Ocean Acidification International Coordination Centre 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

Endpoints

An impossible task?

It is NOT possible to test ALL species/ecosystems, in ALL locally relevant conditions including LOCAL variability (today and future)

We need to understand the mechanisms

Dupont & Pörtner (2013) Nature

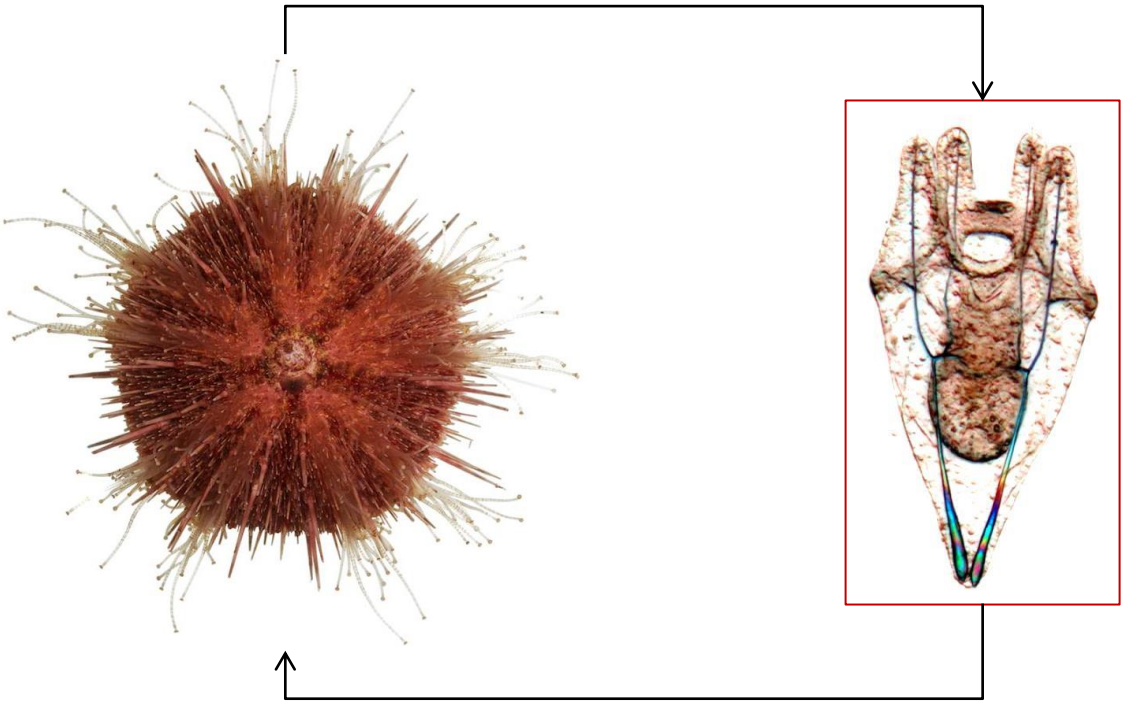
E.g. organism response to multiple drivers

1. Good data on local variability / future scenarios
2. Good understanding of biological response for each driver [mode of action]
3. Build models

Mix all the ingredients & test using scenarios [field, laboratory]

Sea urchin

- Keystone species
- Commercially important
- Genome available + GRN
- Functional tools
- Centuries of data (model)
- Sensitive to acidification



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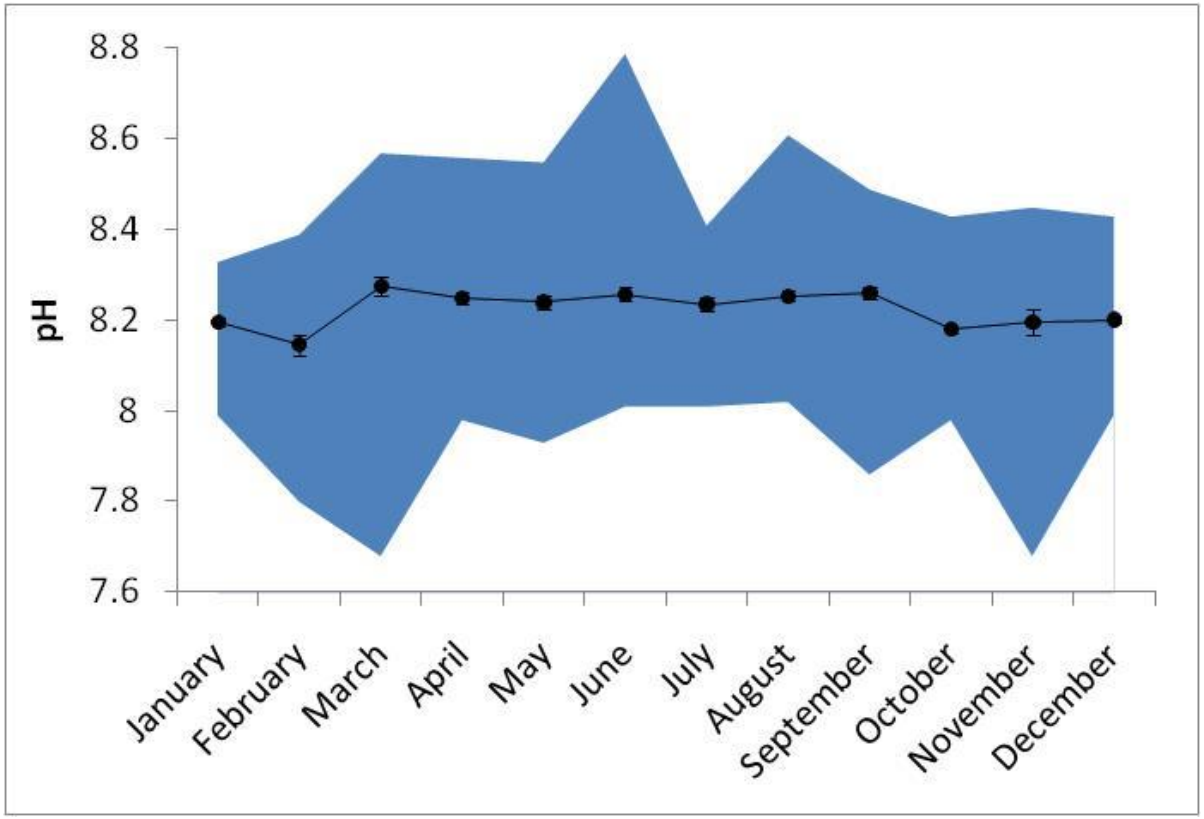


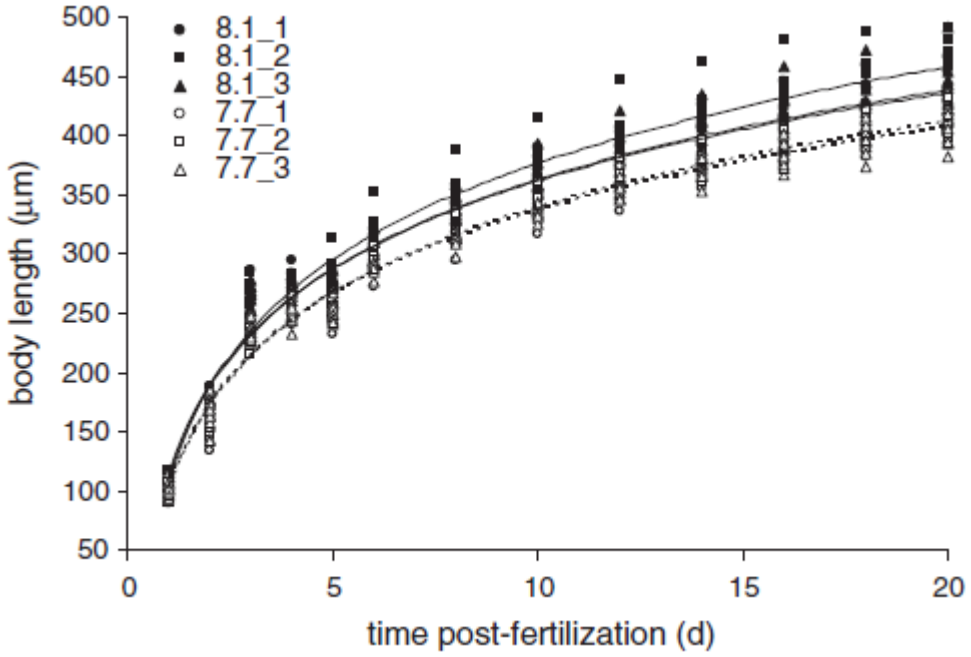
(Dorey et al. 2013)

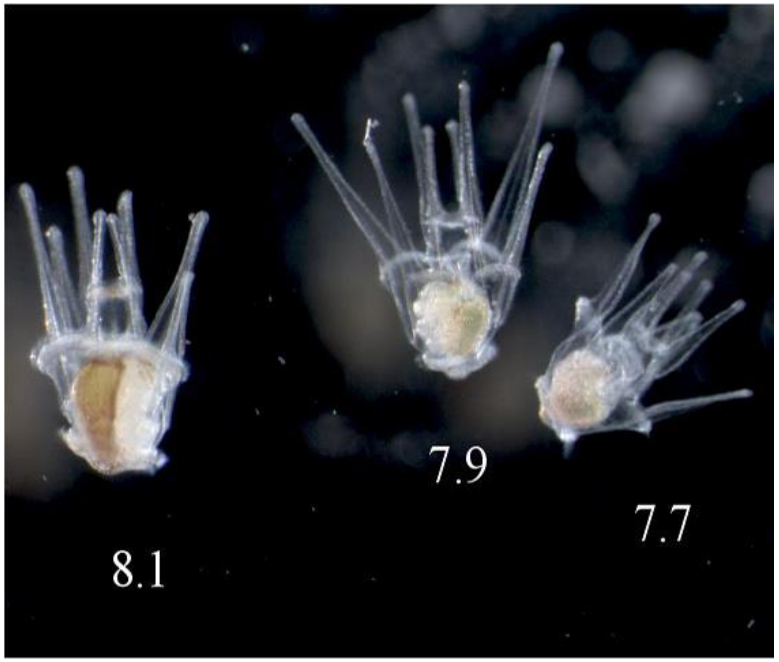
E.g. organism response to multiple drivers

1. Good data on local variability / future scenarios
2. Good understanding of biological response for each driver [mode of action]
3. Build models

Mix all the ingredients & test using scenarios [field, laboratory]

2. Good understanding of a species response

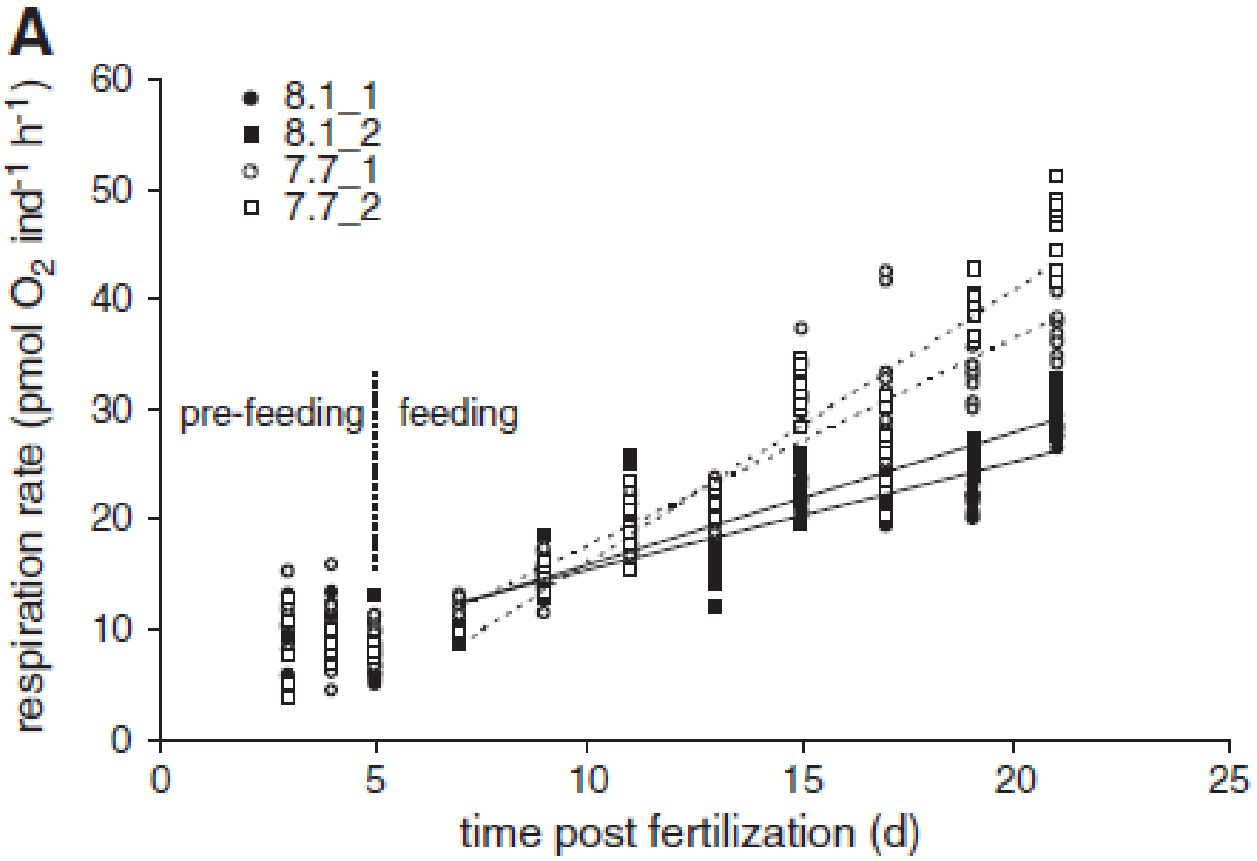




Delay in development

e.g. Martin et al. (2011) J. Exp. Biol; Stumpp et al. (2011a,b) Comp. Biochem Physiol

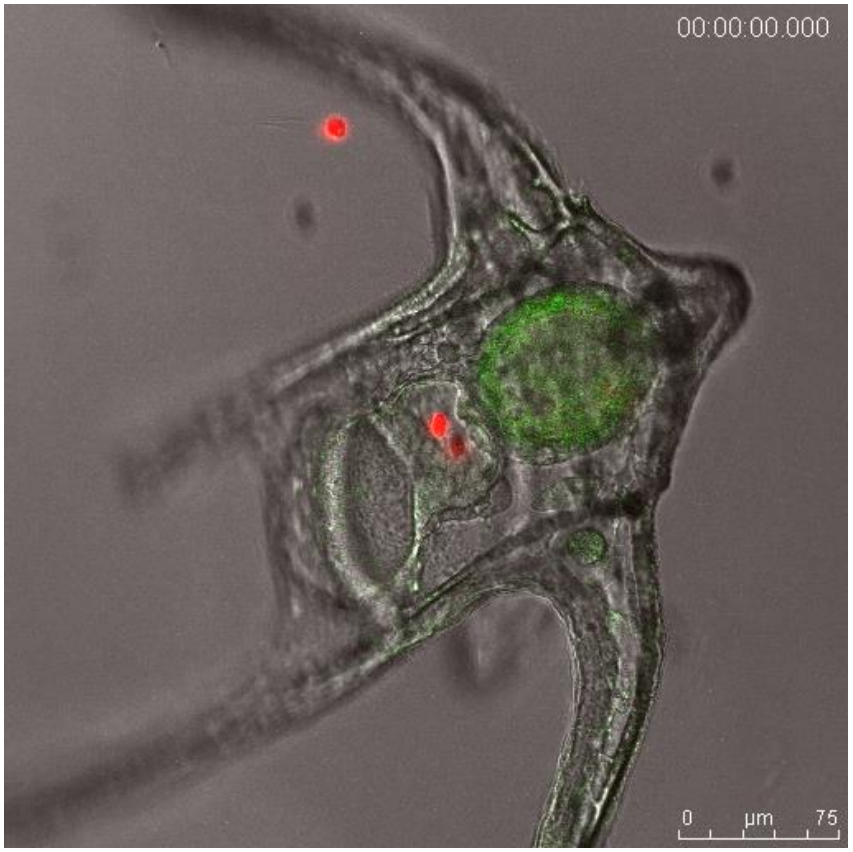
Dissecting the energy budget



Increased respiration

Stumpp et al. (2011a,b) Comp. Biochem. Physiol.

Feeding physiology

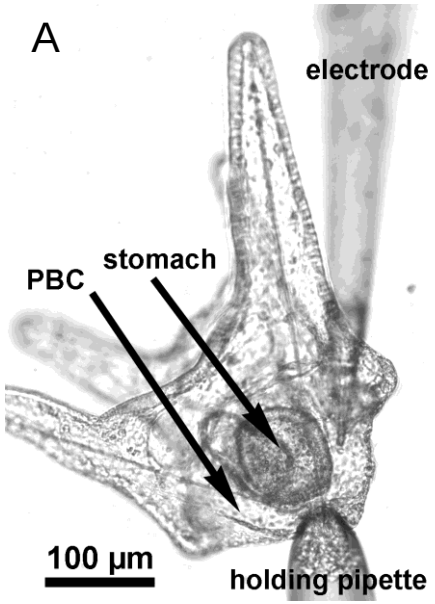


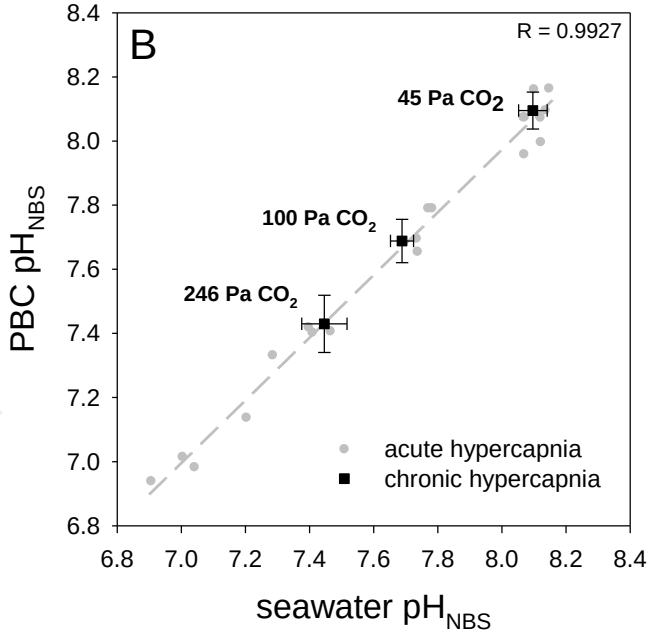
- **Ingestion/Digestion rates**
- **pH in the digestive track**
- **Enzymatic activity**
- **Cellular structure**

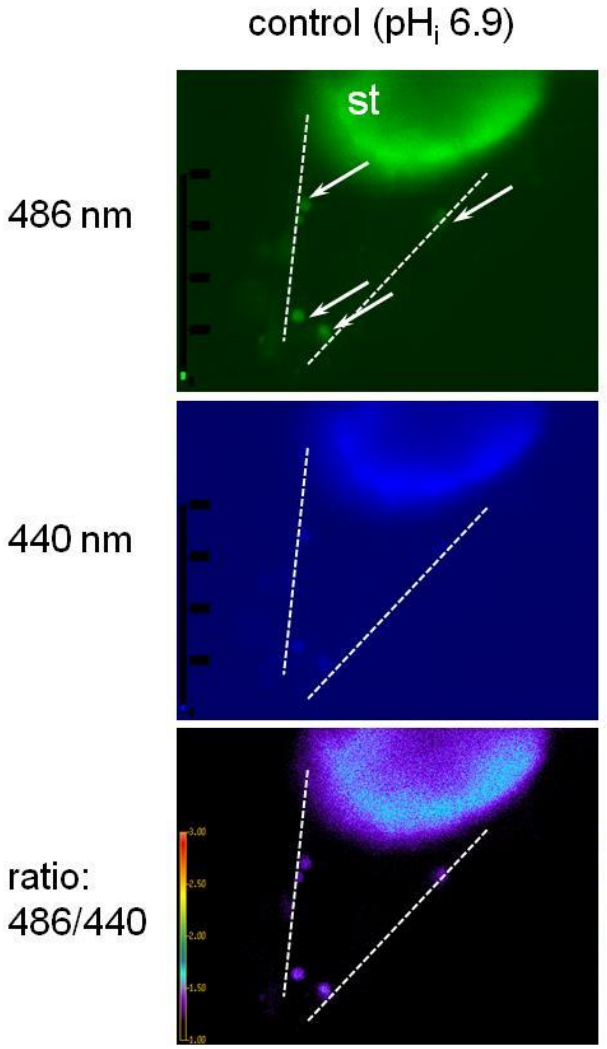
- **Stomach is alkaline**
- **Compensation mechanisms**
- **Extra costs**

Stumpp et al. (2013) Nature Climate Change

Acid-base regulation

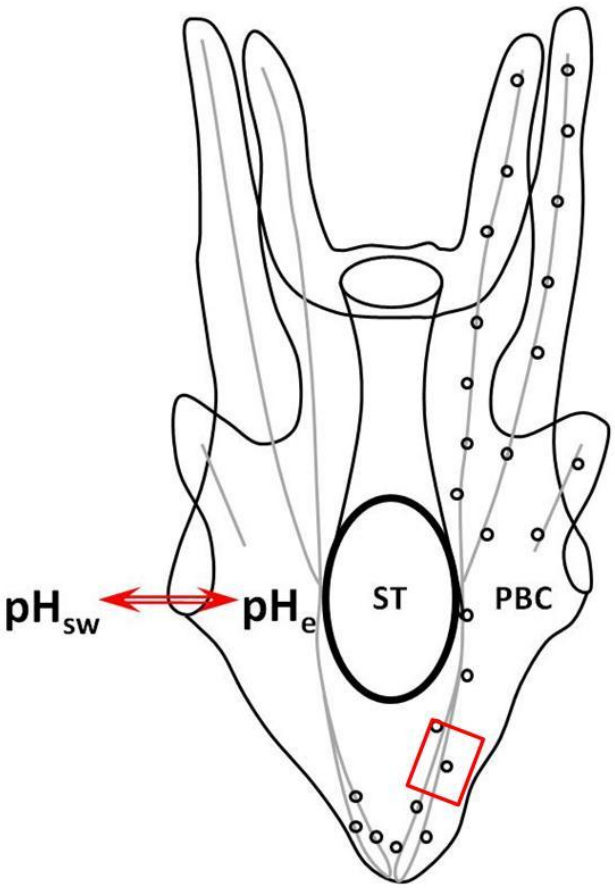


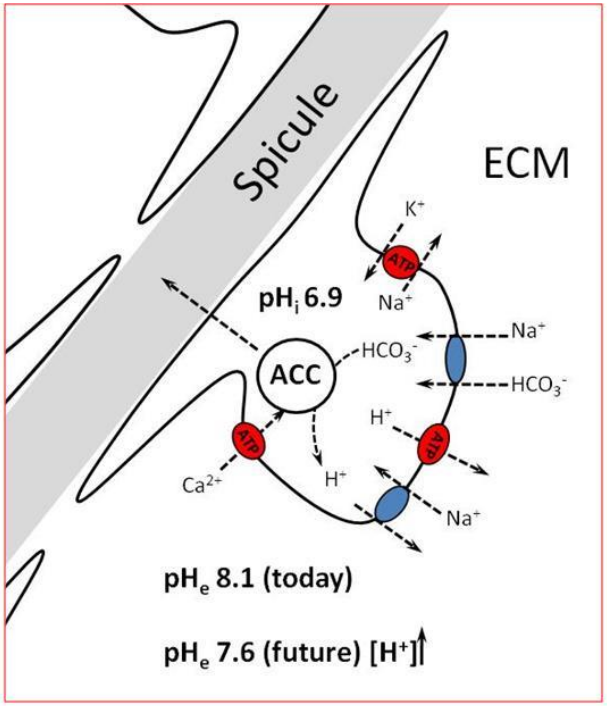




Stumpp et al. (2012) PNAS

Acid-base regulation





pH 7.6 vs. pH 8.1

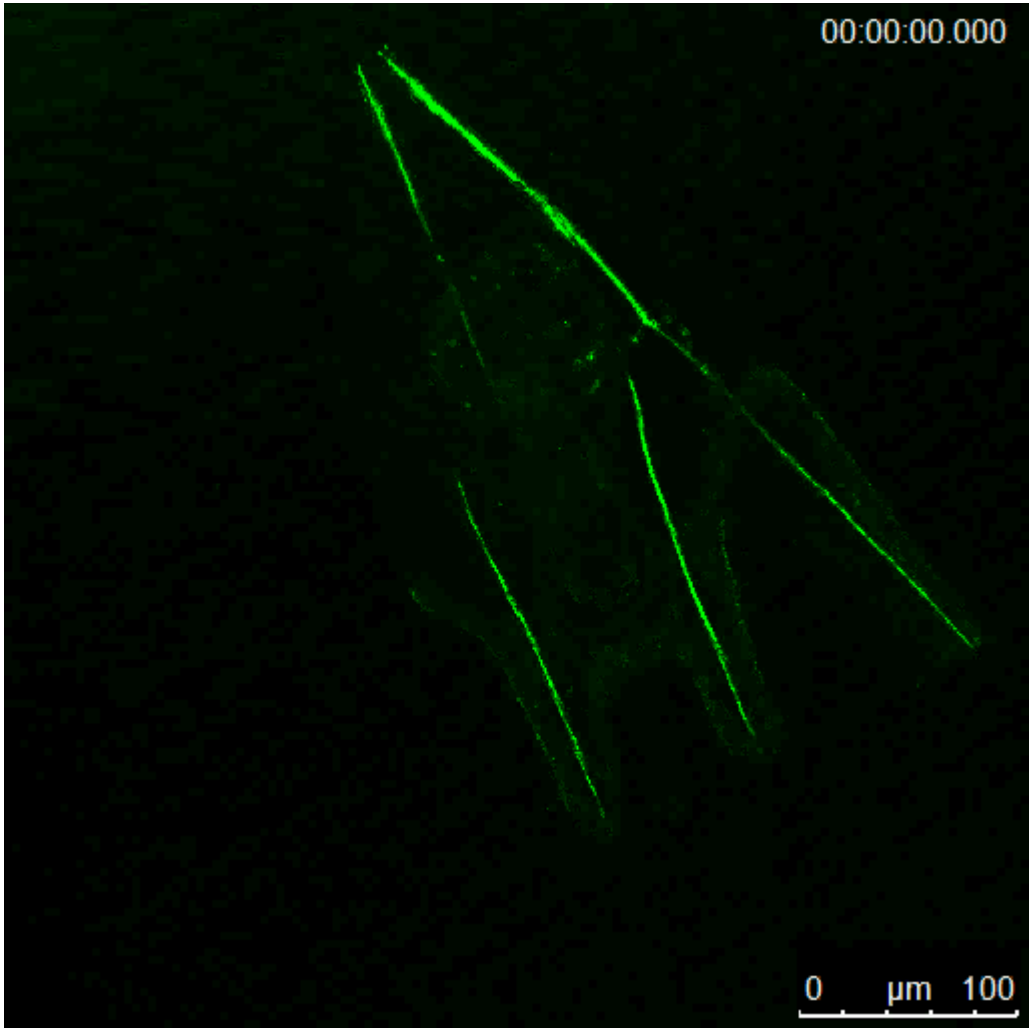
- ↑ Energetic costs
- ↓ Energy for growth and development
- ↓ Juvenile energy reserves

- **No pHe regulation**
- **pHi regulation**
- **Role of $HCO3^-$, H^+-pumps**
- **Extra costs**

Stumpp et al. (2012) PNAS

Acid-base regulation

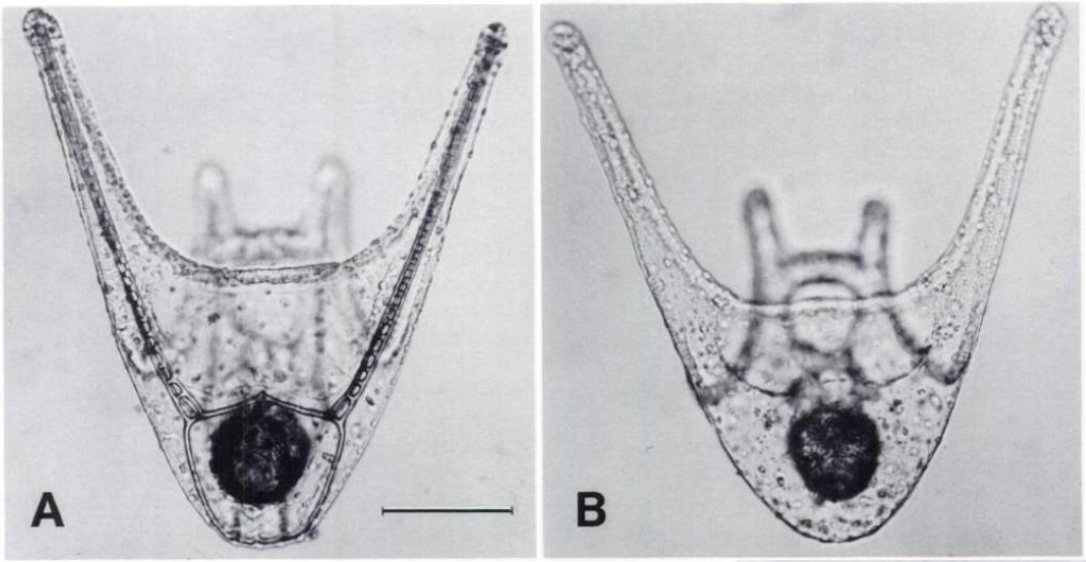
- **Key role of H+-pumps**



(Dupont et al., unpublished)

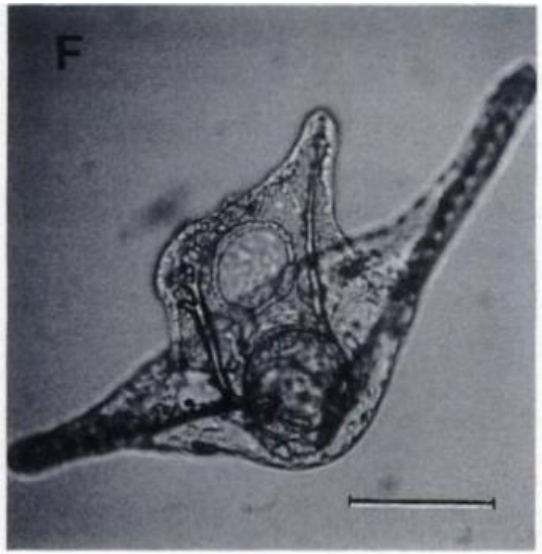
Methods from other disciplines

Méthodes utilisées dans d'autres disciplines

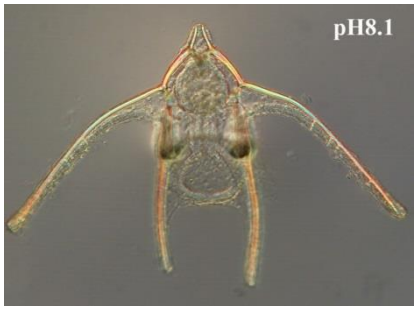


What is the cost of calcification?

Quel est le coût de la calcification?

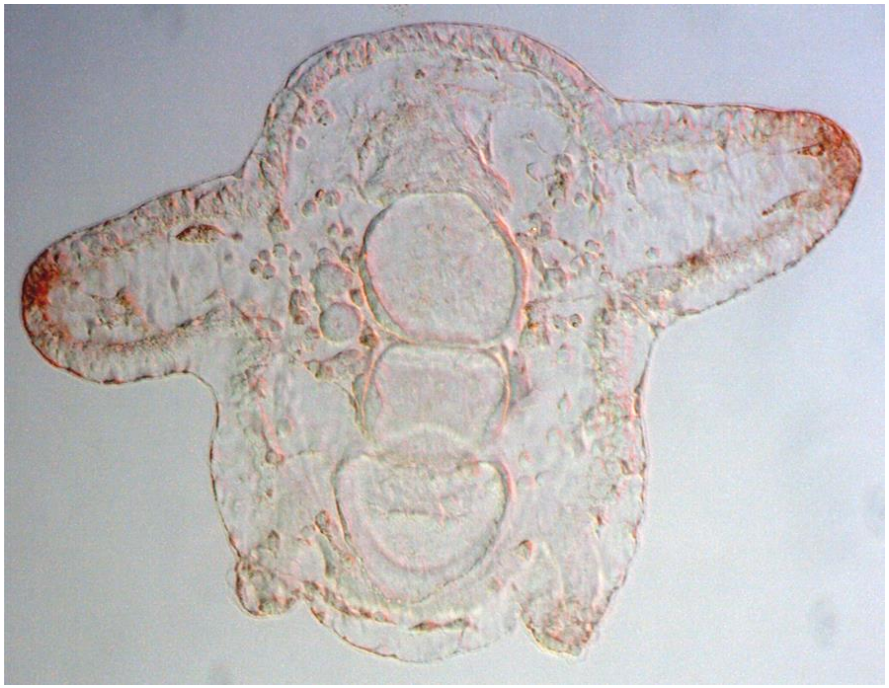


(*Pennington & Strathmann 1990*)



Pluteus 7d (control)

pH 5.8..3 days



7d pluteus + 3d decalcification

3d pluteus

EARTH'S
AC ID TEST

As the oceans rapidly grow more acid scientists are scrambling to discover h marine life is likely to react.

BY QUIRIN SC

CHIERMEIER

The Friday night beers made Sam Dupont forget all about his sea urchins. Earlier that day, in April 2010, the young Belgian eco-physiologist had put a batch of urchin larvae into a bath of highly acidic water to see how their skeletons would fare. When nothing obvious happened after a few hours, Dupont decided to join some friends at the pub and check on the experiment later

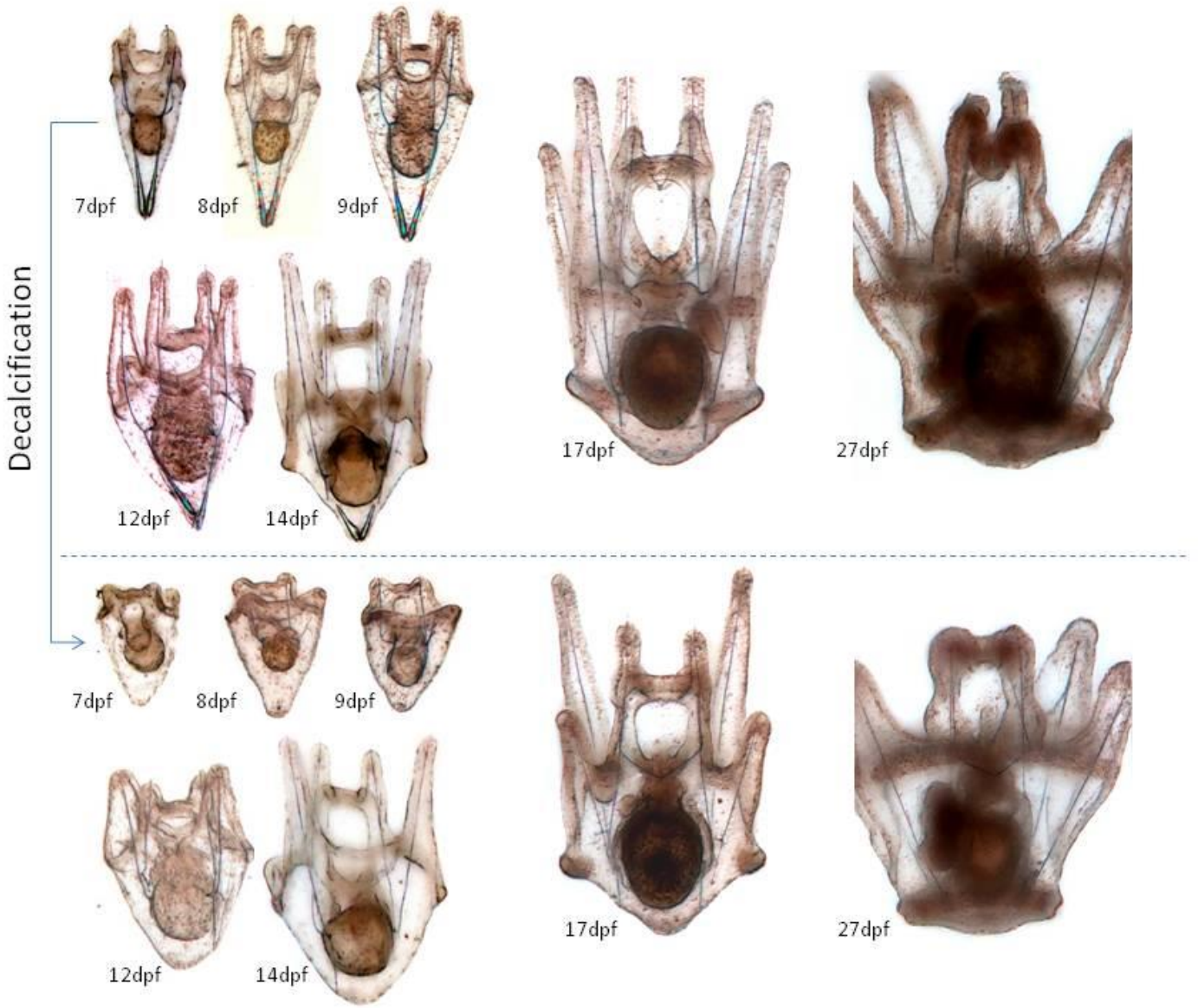
J.-P. GATTUSO/CNRS

climbed by 30% over the past 150 years, and some regions have already become corrosive enough to inhibit the growth of corals and other species for part of the year. According to projections, most creatures with calcium carbonate shells, such as mussels and snails, could run into problems within a few decades. By the end of this century, the acidification could even impede the growth of important groups of plankton, thus endangering entire marine ecosystems, from fisheries to coral reefs.

Although the urchin experiment hints that some organisms are able to survive brief exposures to highly acidic water, other studies are revealing unexpected problems that might threaten even creatures without hard shells, such as fin fish. Preliminary work suggests that responses could be highly variable, depending on factors such as water temperature, a creature's evolutionary history and the availability and quality of food.

An experiment off the coast of Spitsbergen tests the effects of elevated carbon dioxide concentrations on marine life.

"Les bières du vendredi soir ont fait oublier ses oursins à Sam Dupont"



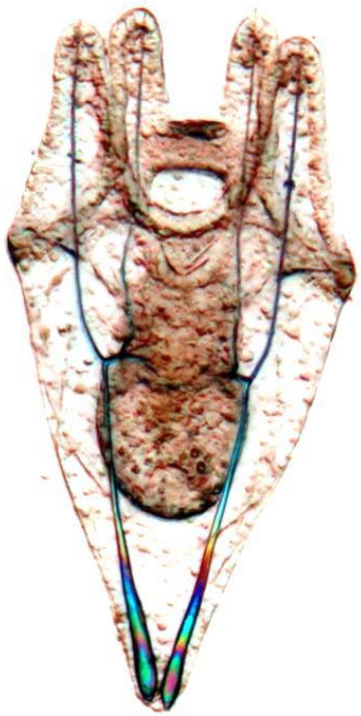
Calcification = <10% of energy budget

Calcification = <10% du budget énergétique

Mechanistic understanding

Settle
[Garcia et al. 2015]

Growing
[e.g. Dorey et al. 2013]



Surviving
[Dorey et al. 2013; Dupont et al. 2012]

Swimming
[Chan et al. 2015a,b]

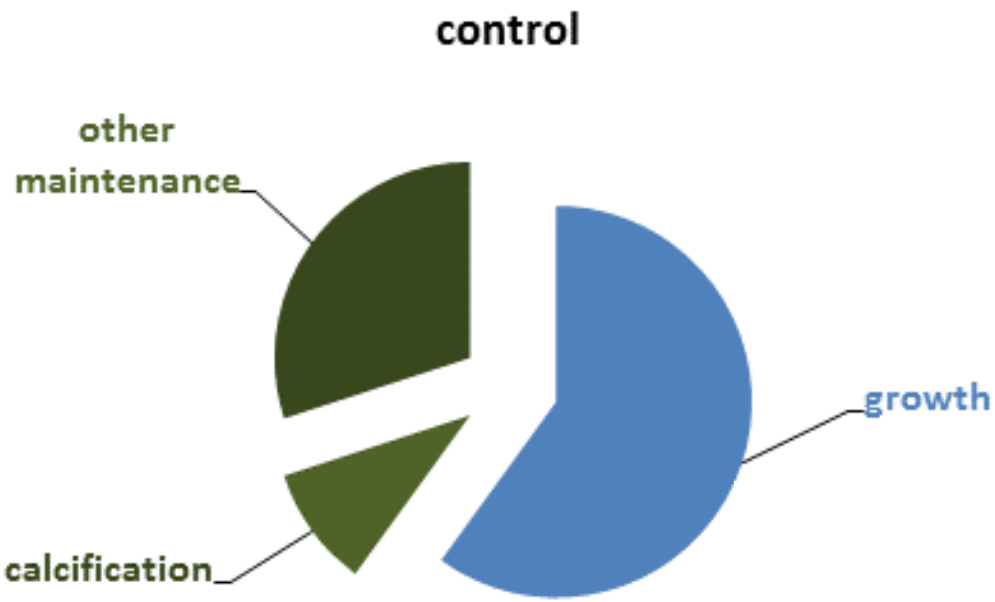
Calcifying
[Dupont et al. In prep]

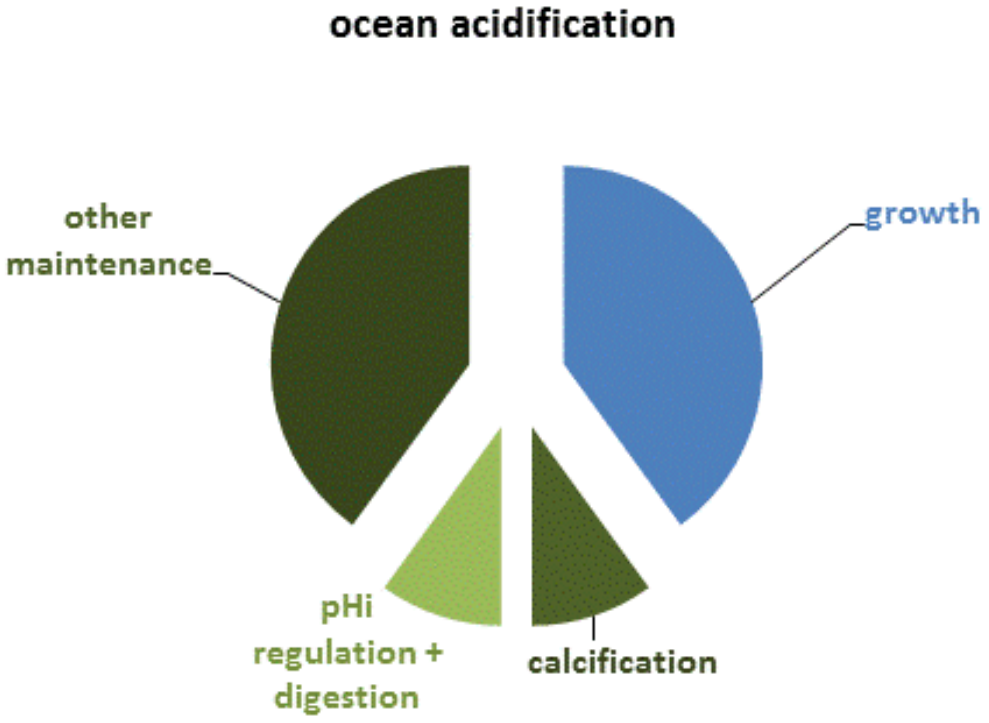
Feeding
[Stumpp et al. 2013]

Respiration
[Dorey et al. 2013]

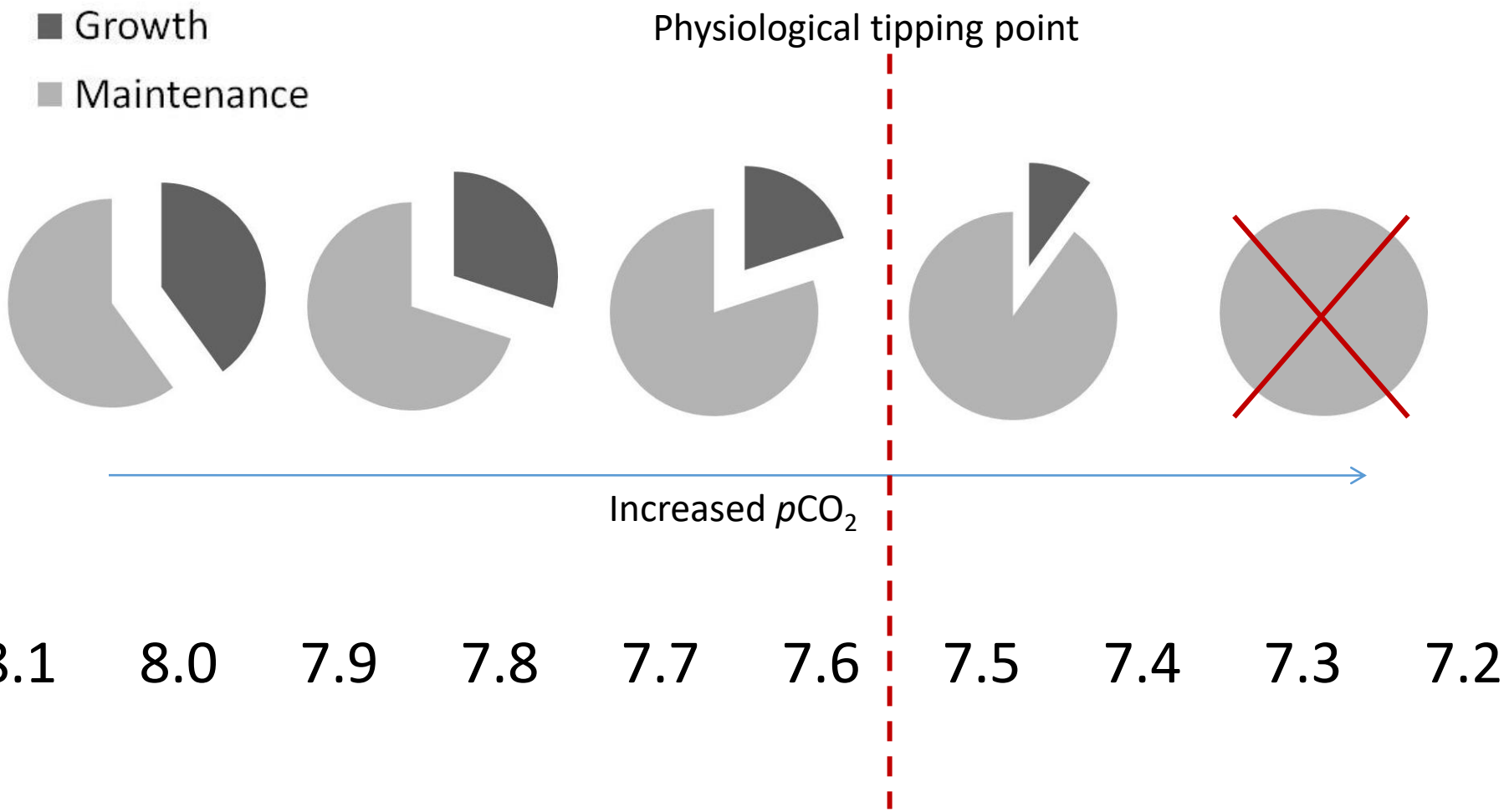
Acid-base regulation
[Stumpp et al. 2012]

Shift in energy budget

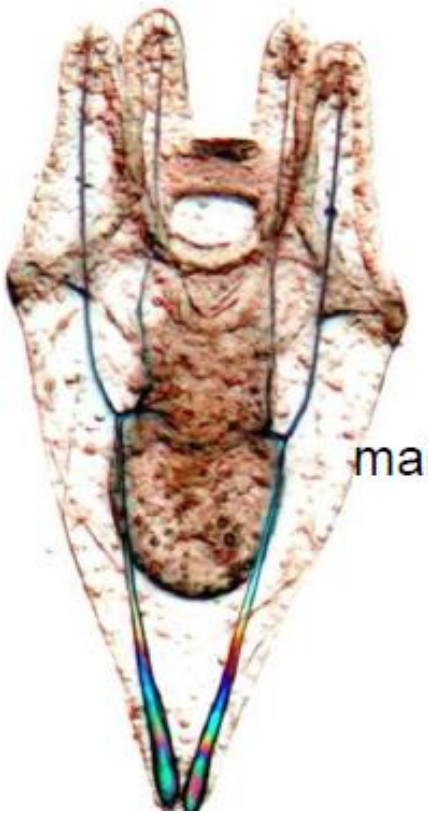


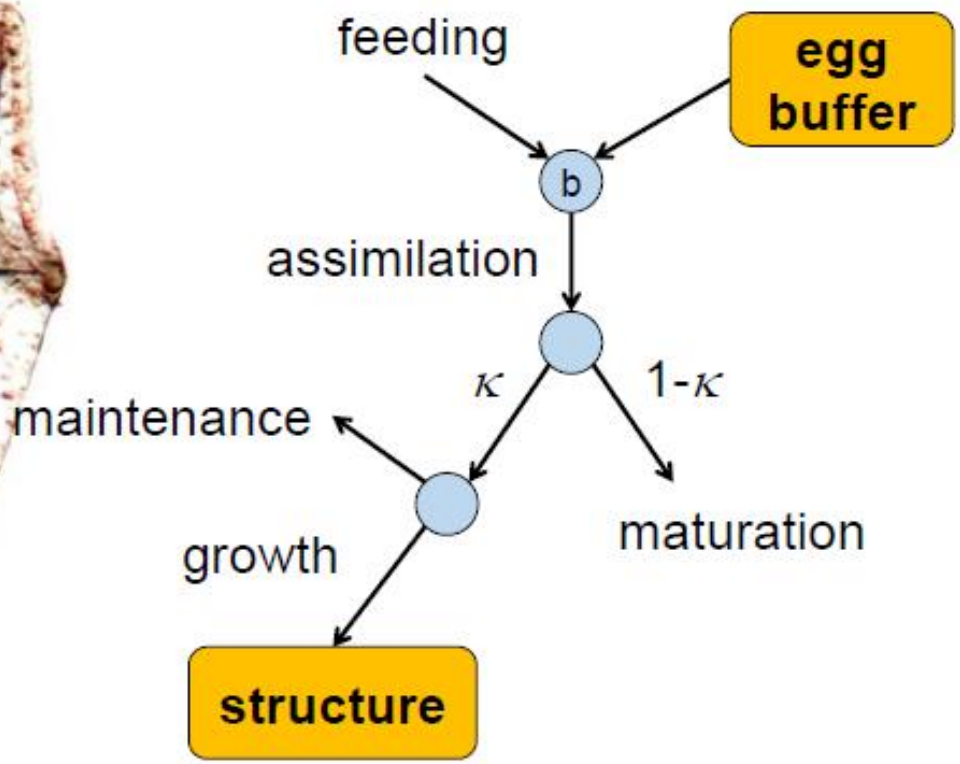


Shift in energy budget



Multidrivers model





Journal of Experimental Marine Biology and Ecology 474 (2016) 11–17

Contents lists available at ScienceDirect

Journal of Experimental Marine Biology and Ecology

journal homepage: www.elsevier.com/locate/jembe

Near-future ocean acidification impacts maintenance costs in sea-urchin larvae: Identification of stress factors and tipping points using a DEB modelling approach

Tjalling Jager [a,*], Elisa Ravagnan [b], Sam Dupont [c]

Plasticity vs stress

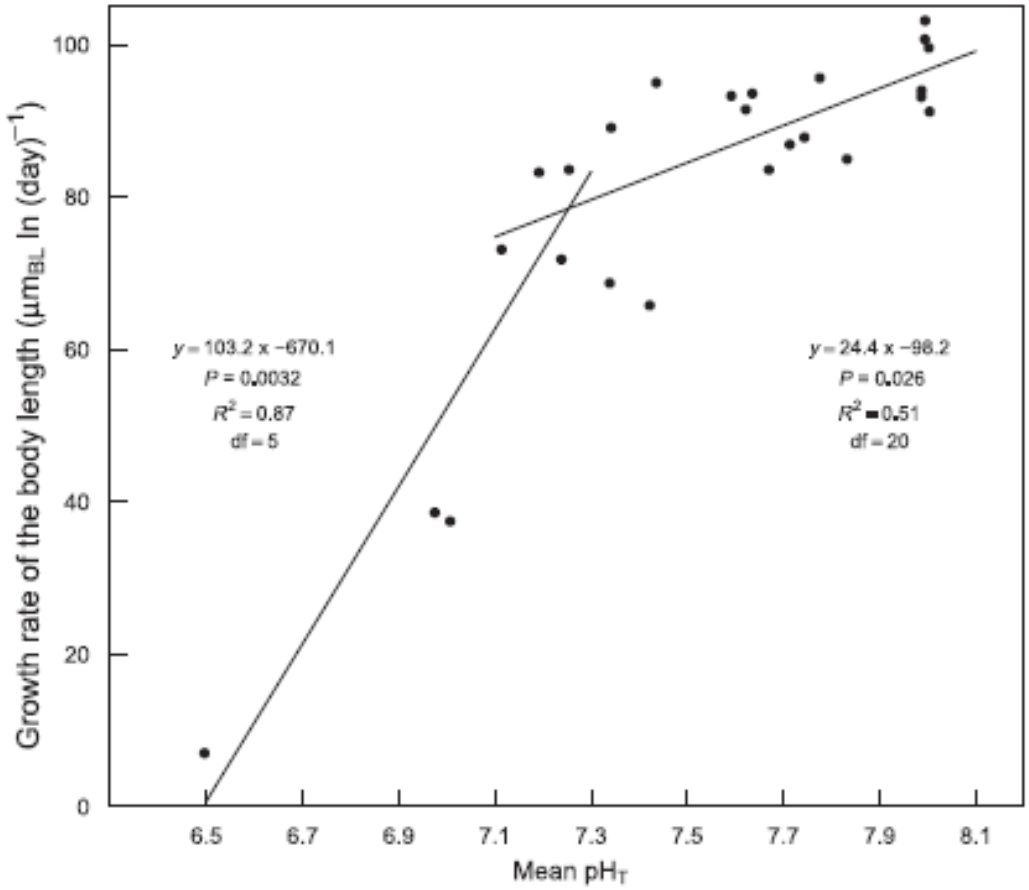
Global Change Biology

Global Change Biology (2013), doi: 10.1111/gcb.12276

Assessing physiological tipping point of sea urchin larvae exposed to a broad range of pH

NARIMANE DOREY*, PAULINE LANÇON*, MIKE THORNDYKE† and SAM DUPONT*

*Department of Biological and Environmental Sciences, The Sven Lovén Centre for Marine Sciences – Kristineberg, University of Gothenburg, Fiskebäckskil 45178, Sweden, †The Royal Swedish Academy of Sciences, The Sven Lovén Centre for Marine Sciences – Kristineberg, Fiskebäckskil 45178, Sweden



Physiological tipping point reached when out of present range of variability

E.g. organism response to multiple drivers

1. Good data on local variability / future scenarios
2. Good understanding of biological response for each driver [mode of action]
3. Build models

Mix all the ingredients & test using scenarios [field, laboratory]

George E. P. Box

"Essentially, all models are wrong, but some are useful"

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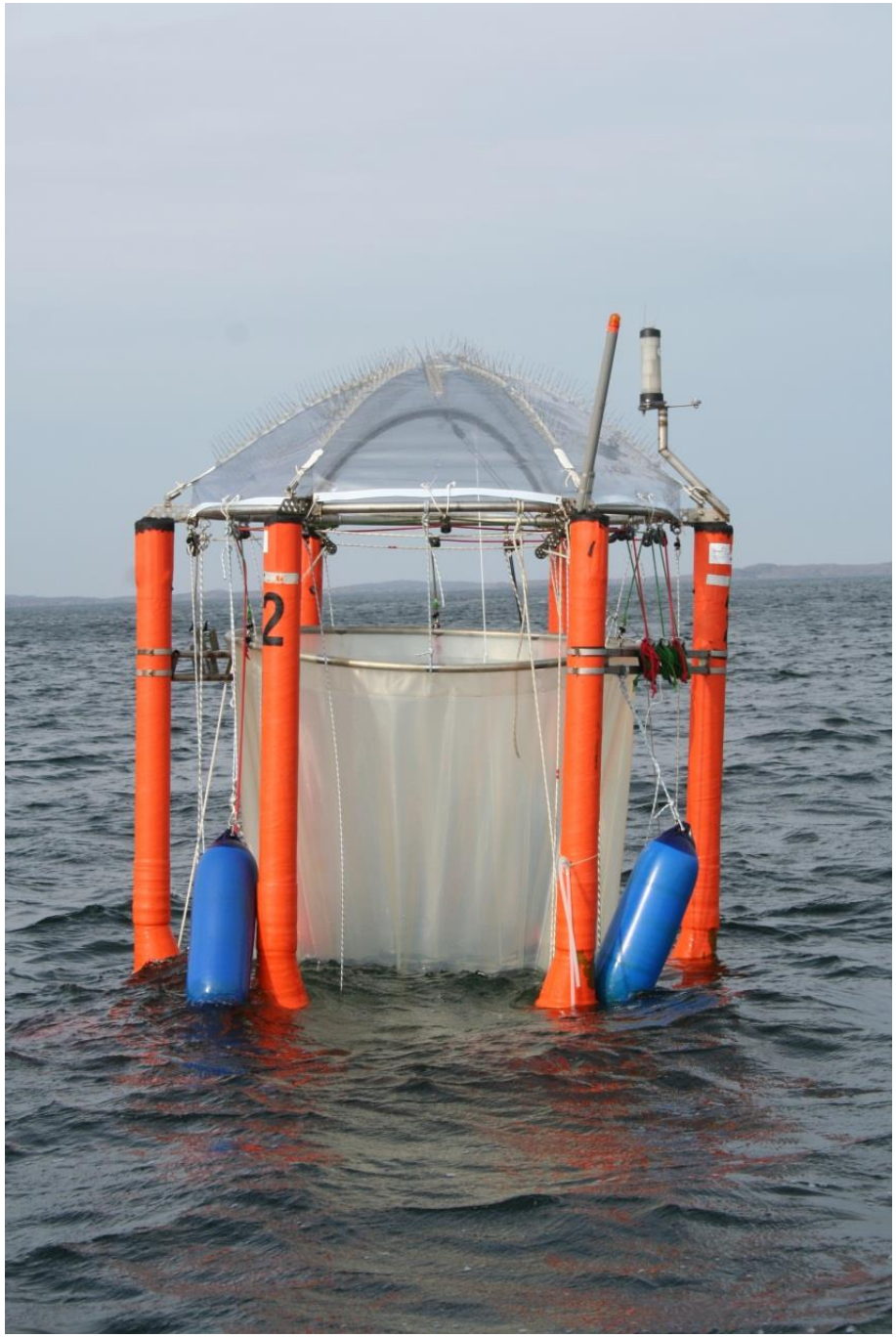


KOSMOS rocks

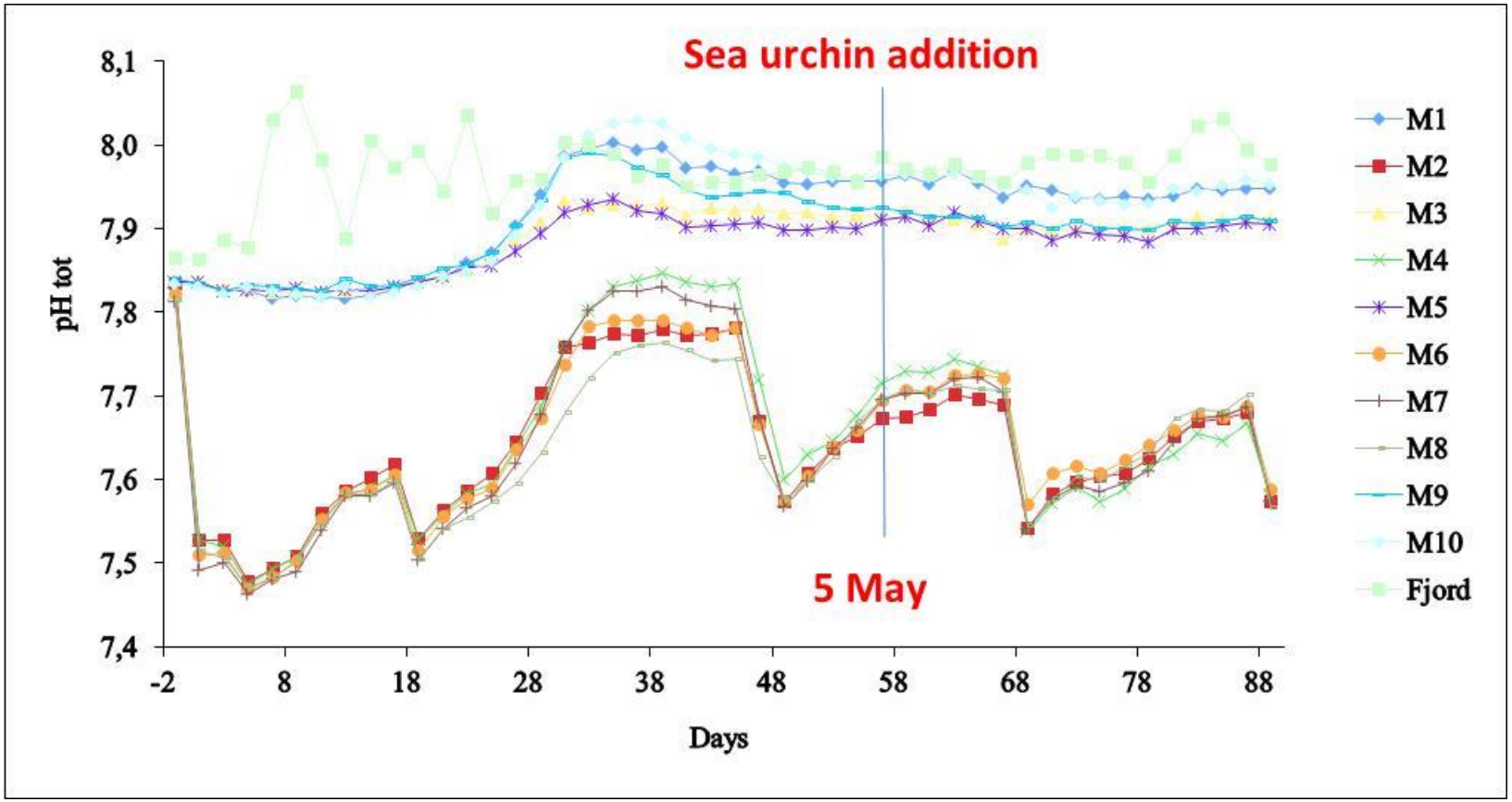
BIOACID

6 months / 50 researchers

10 x 55m^3

2 treatments: ctl vs low pH

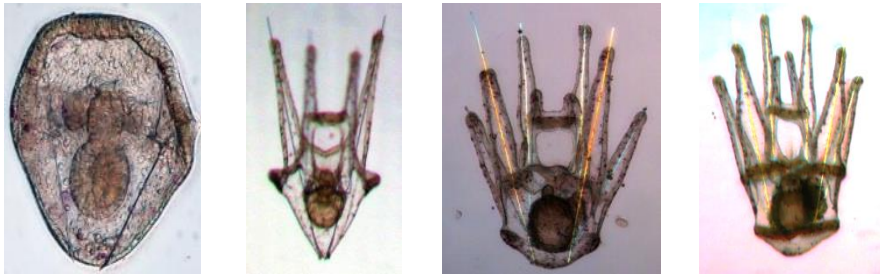
Into the wild



Bach et al. (2016) PloS one

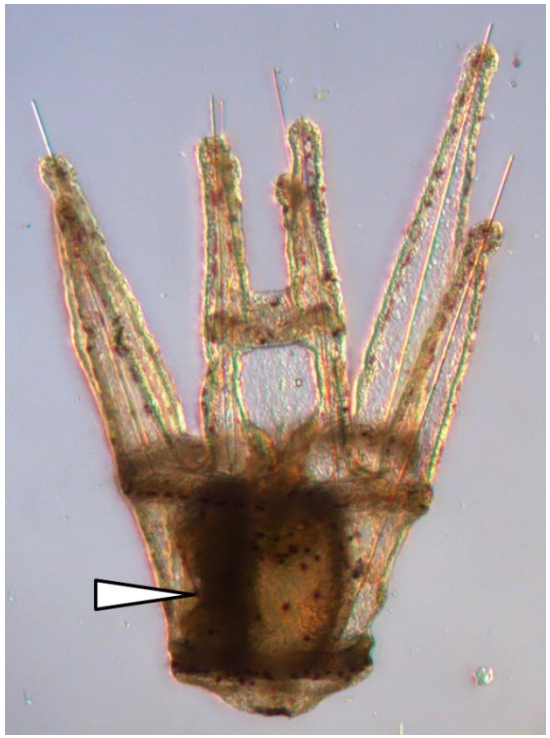
Into the wild

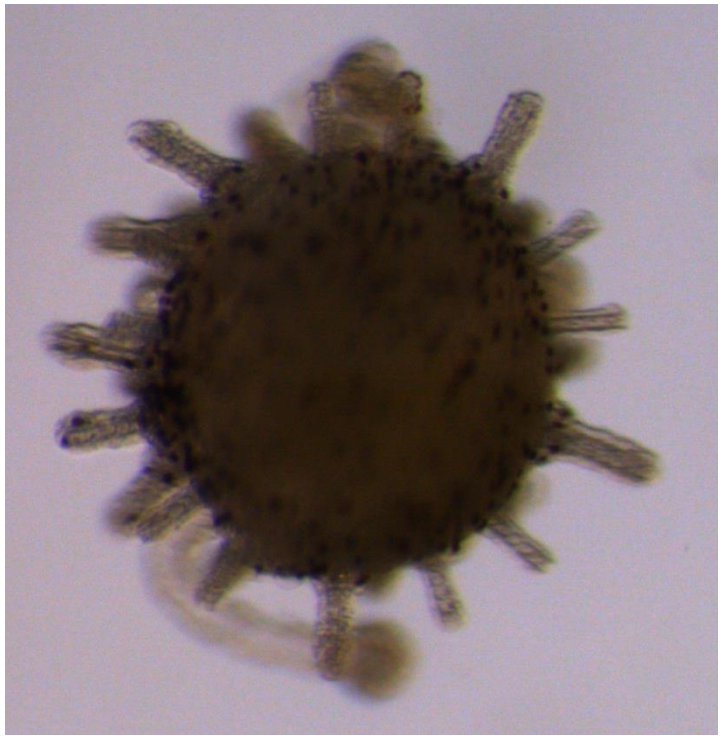
d1 d9 d17 d25



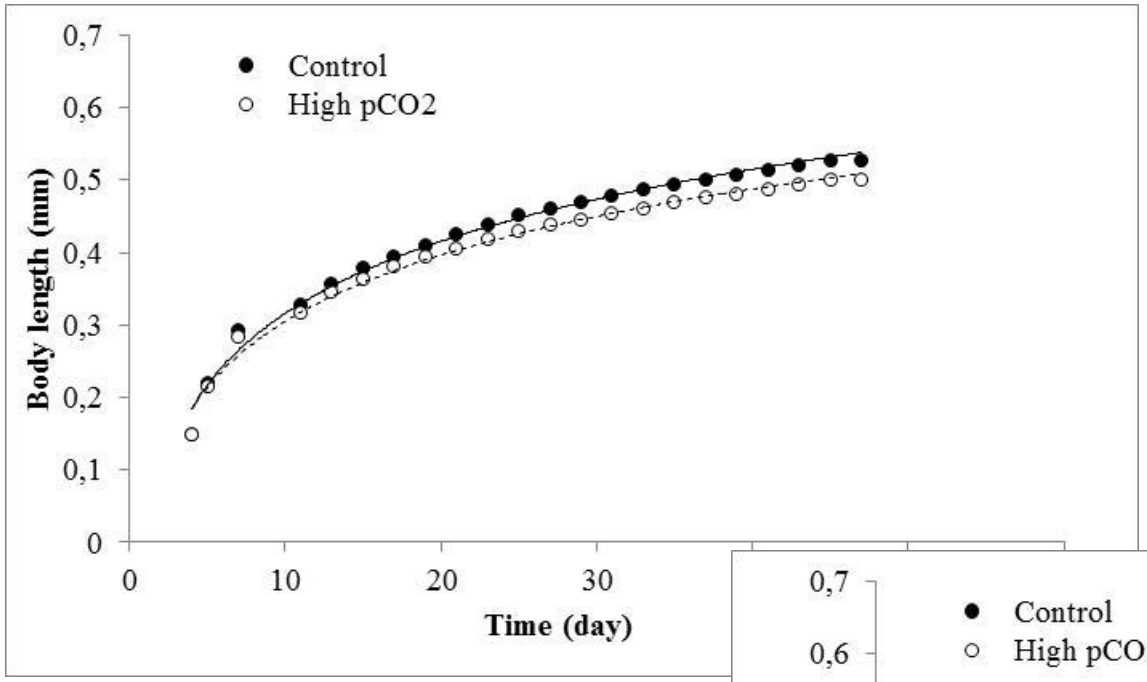
- **Same mortality**
- **Delay in development**
- **“Desperate” larvae**

d32





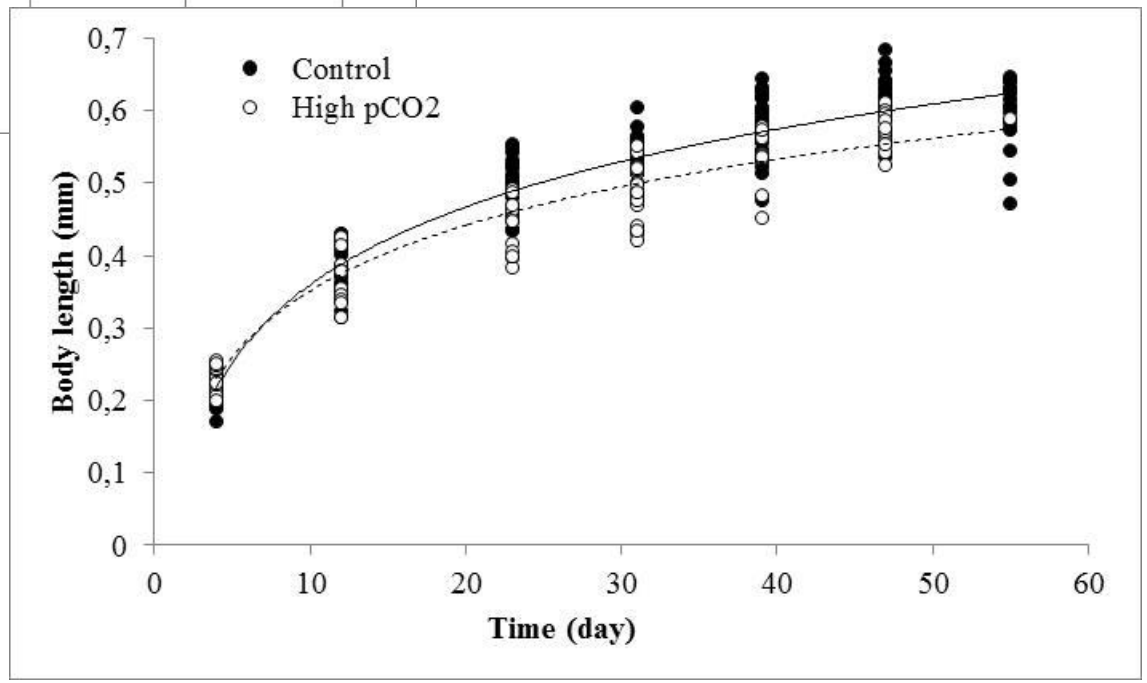
Field validation



Predicted

[mesocosm chemistry + Dorey et al. 2013]

Observed



Into the wild

1. Good data on local variability / future scenarios
2. Good understanding of biological response for each driver [mechanisms – ecology, evolution, physiology]
3. Build models

Mix all the ingredients & test using scenarios [field, laboratory]

It works !!!