SD4

Improved understanding of the potential population, community and ecosystem impacts for all life stages for commercially important species and their capacity to resist and adapt

Kevin J Flynn et al.

Swansea University
Prifysgol Abertawe

University of Exeter

University of Strathclyde Glasgow

PML Plymouth Marine Laboratory

The Team

- **Swansea**: finfish & decapods; mechanistic physiological models
- **Exeter**: bivalves
- **Strathclyde**: fisheries modelling
- **PML**: socio-economic modelling

Swansea University
Prifysgol Abertawe

University of Exeter

University of Strathclyde Glasgow

PML | Plymouth Marine Laboratory

The individuals …

- ***Swansea***: **Kevin J Flynn**, Robin Shields, Purazen Chingombe, Ingrid Lupatsch, Alex Keay, Jake Scolding, Maria Scolamacchia; **Ed Pope**, Gemma Webb
- ***Exeter***: Rod Wilson, Ceri Lewis, **Rob Ellis**, Rebecca Hunter
- ***Strathclyde***: Dougie Speirs
- ***PML***: Caroline Hattam, **Nicola Beaumont,** Gorka Merino, Mel Austen

(short-form) aims of SD4 are

- Aim 4.1 Examine physiological
responses of commercial
- Aim 4.2 Scale up
population/
ana

The essence of the subject area for SD4 is the impact of OA upon higher trophic levels

esp. commercial species

planktonic and
sult of ocean
upon the production and
mercial fish and shellfish stocks.

4.4 Investigate possible socio-economic consequences of OA at an ecosystem level.

Experimental - organisms

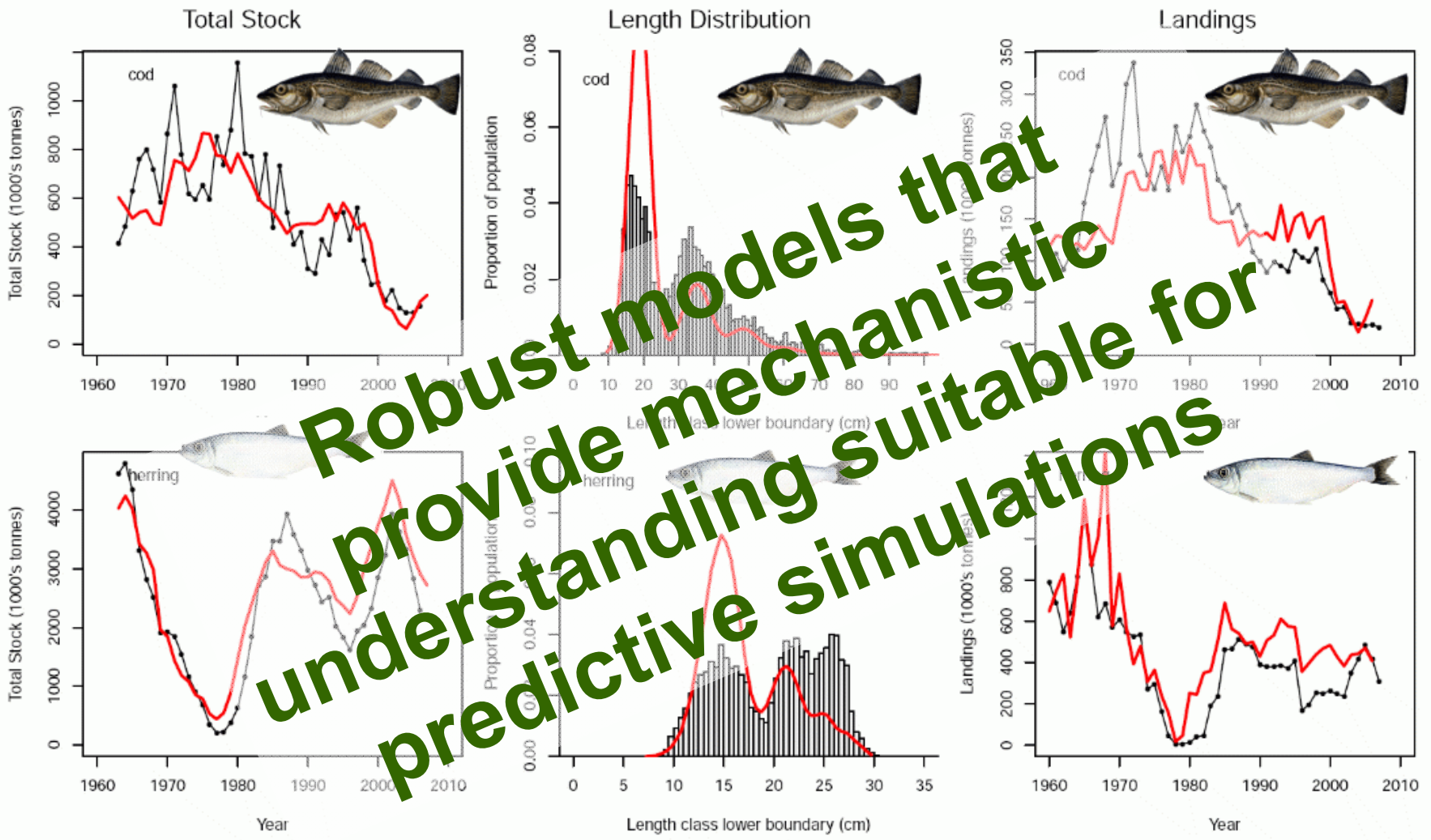
- *Pecten maximus* (scallop)
- *Crassostrea gigas* (Pacific oyster)
- *Nephrops norvegicus* (langoustine, scampi)
- *Clupea harengus* (herring)
- *Melanogrammus aeglefinus* (haddock)
- *Dicentrarchus labrax* (European sea bass)
- **diatom, prymnesiophyte, cryptophyte**
- **copepods**

Experimental - conditions

- Matrix of 2 OA + 2 temperatures
- OA – equivalent to extant **&** 750ppm CO_2
- Temperature – upper range of extant (90-95% limit for species under study) **&** that value + 4°C (or +2°C)

  i.e. not a single fixed temp, but varies with season

What we are aiming for …..



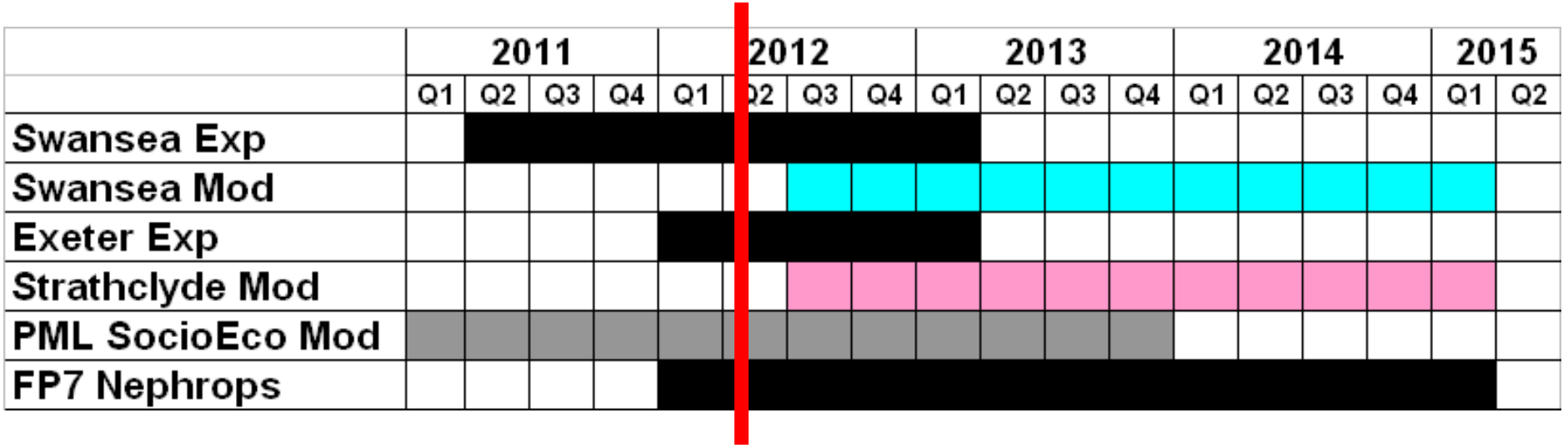
Timetable

- Start date delay affected project run-out
- Series of experimental challenges

  (esp. lack of good quality field-sourced organisms)
- Loss of original Swansea PDRA to a commercial company
- Rescheduling of all bivalve work to Exeter, allowing Swansea to concentrate on others
- Integration with FP7 Nephrops project

  (will provide further scope for OA experiments at Swansea)
- Socio-economics on track
- Fisheries model on track to start soon

Project Timetable



Presentations

- Status at **Swansea**: finfish and decapods
- Status at **Exeter**: bivalves
- Status at **PML**: socio-economics

- Status at **Strathclyde**: not started, PDRA to commence soon

"Historic"
pCO_2 280 ppm
bulk water pH 8.165

"Extant"
pCO2 390
bulk water pH 8.03

"Future"
pCO_2 750
bulk water pH 7.76

ESD: diameter µm of the particle or aggregate

Cflux: +ve is C-fix

C-fix "compensates" OA

Respiration "exaggerates" OA

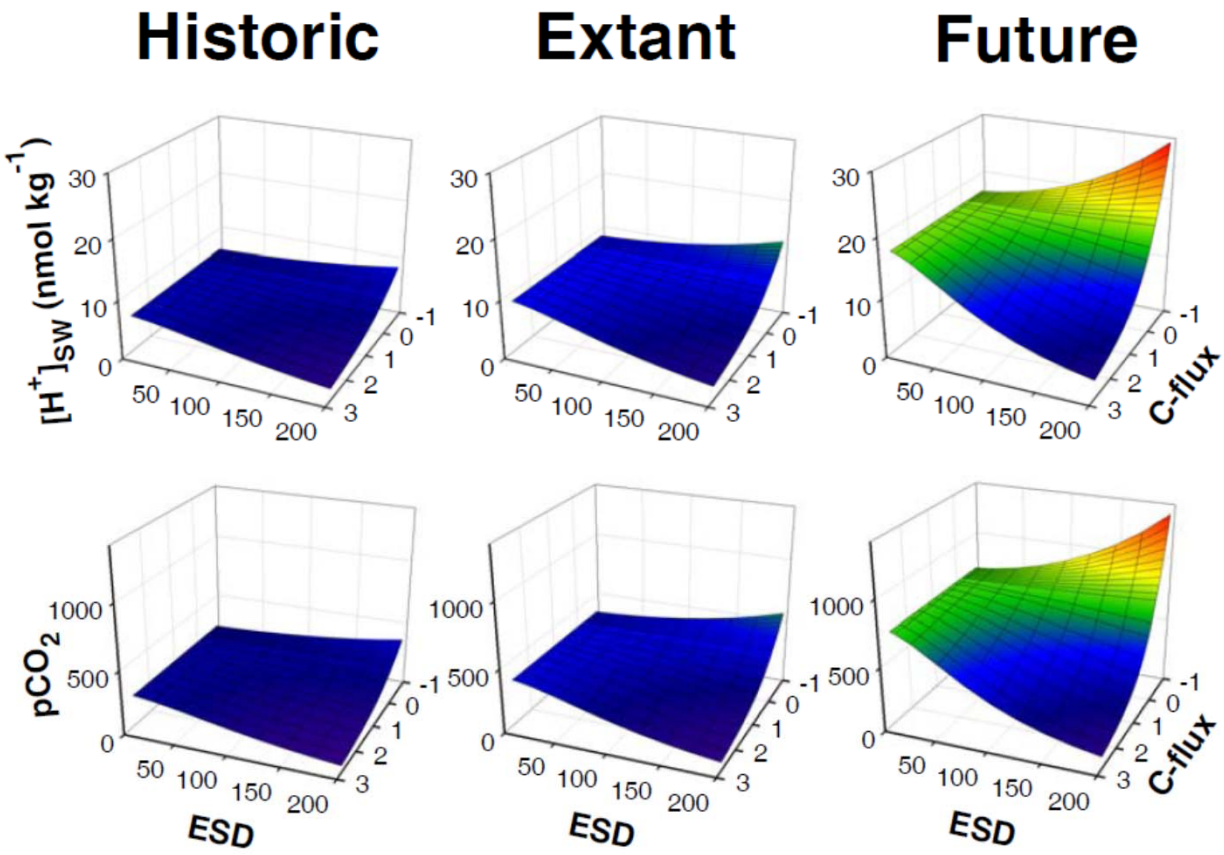
nature climate change

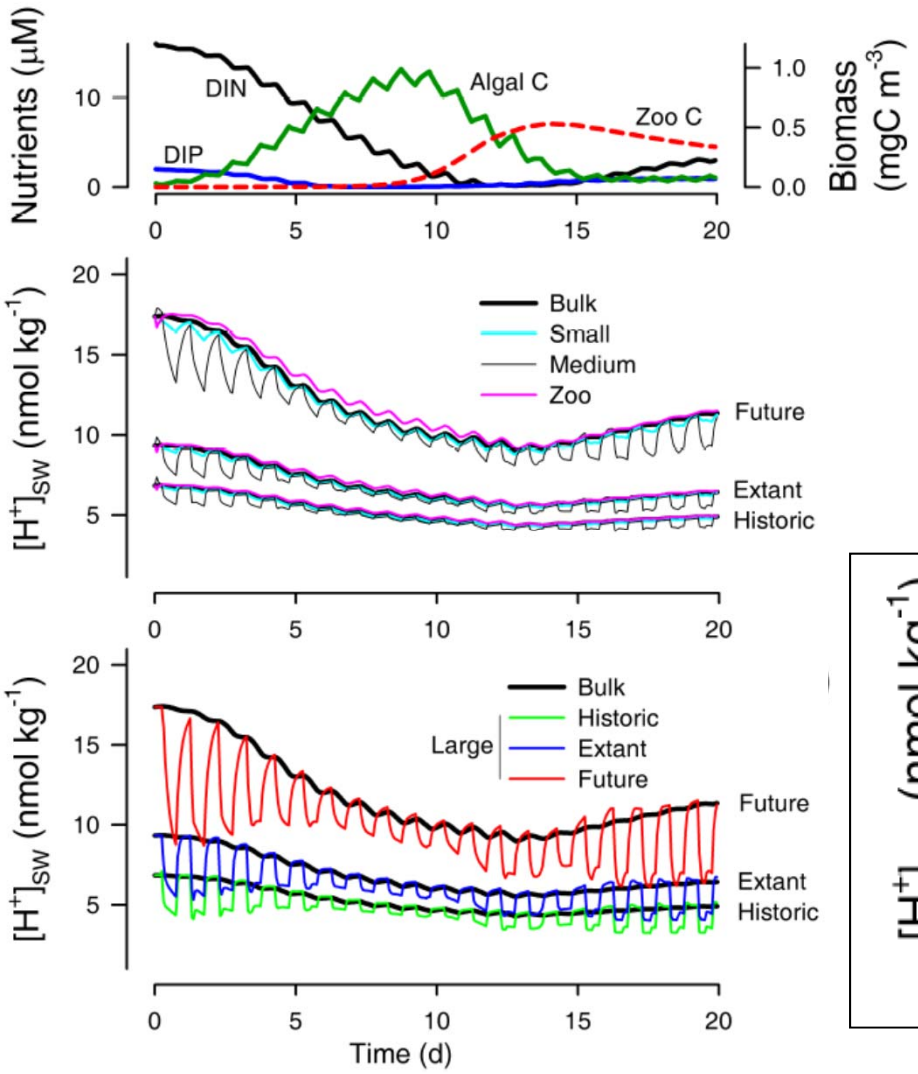
LETTERS

PUBLISHED ONLINE: XX MONTH XXXX | DOI: 10.1038/NCLIMATE1489

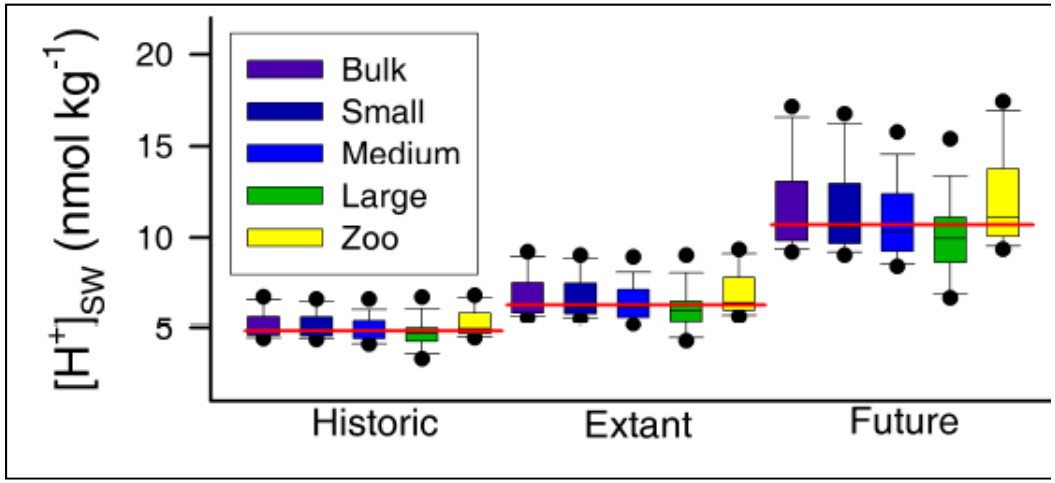
Changes in pH at the exterior surface of plankton with ocean acidification

Kevin J. Flynn[1]*, Jerry C. Blackford[2], Mark E. Baird[3], John A. Raven[4], Darren R. Clark[2], John Beardall[5], Colin Brownlee[6], Heiner Fabian[1] and Glen L. Wheeler[2,6]





- Larger and more active organisms “see” greater deviation from bulk water conditions
- For a given level of activity, deviations become greater at higher acidity (lower pH) as buffering capacity falls



Displaying data on pH scales, and especially as ΔpH, is misleading because of log scaling

Swansea: finfish & decapods

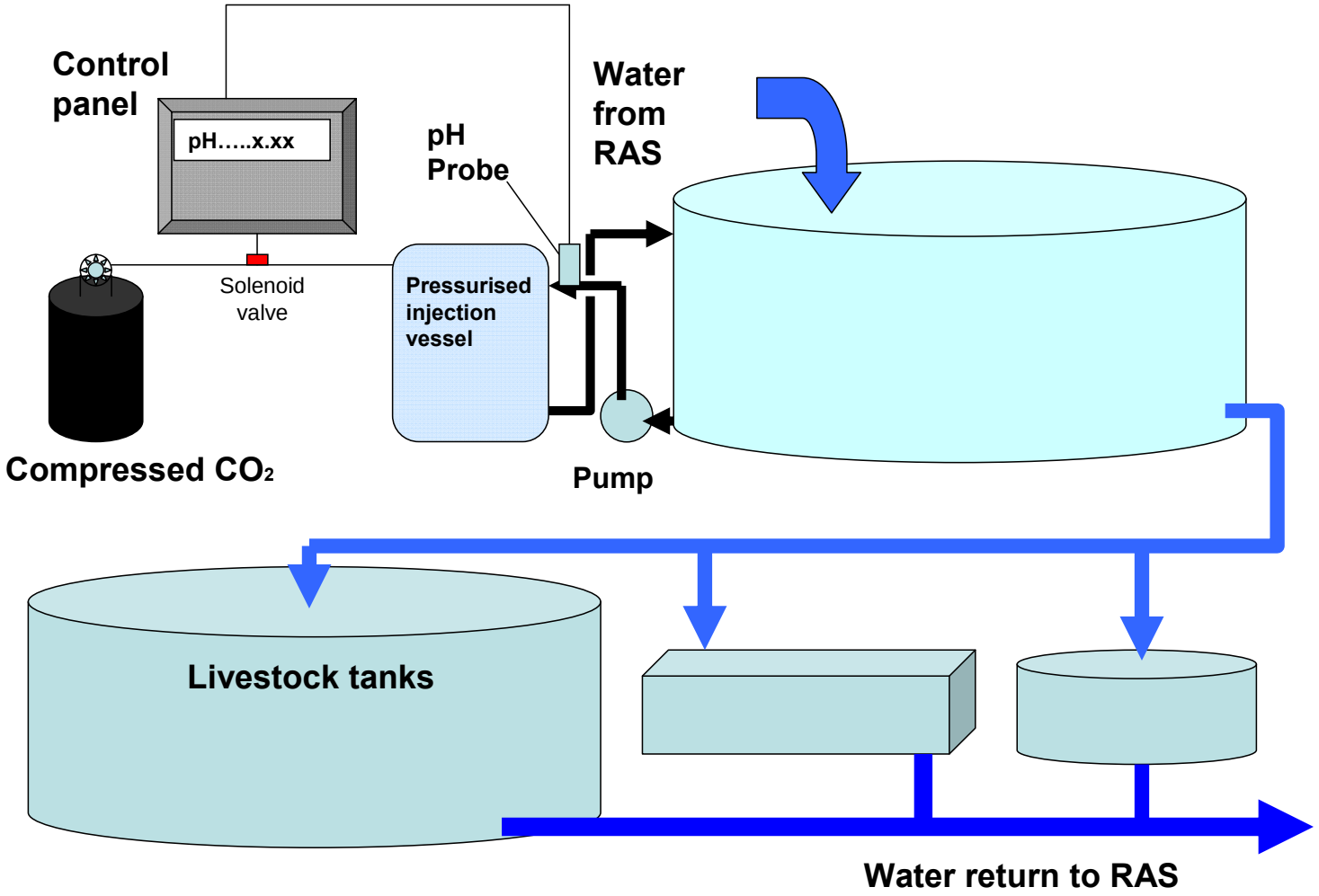
SD4 – Finfish and Decapods

Ed Pope (e.c.pope@swansea.ac.uk)

Swansea University
Prifysgol Abertawe

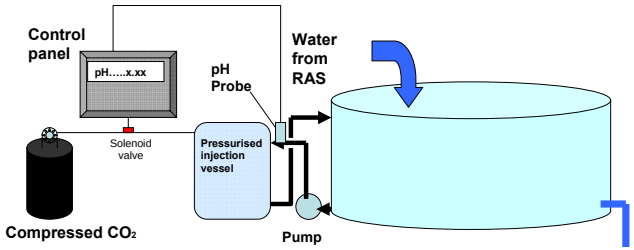
Centre for Sustainable Aquatic Research
CSAR

pH / CO_2 control system with temperature control



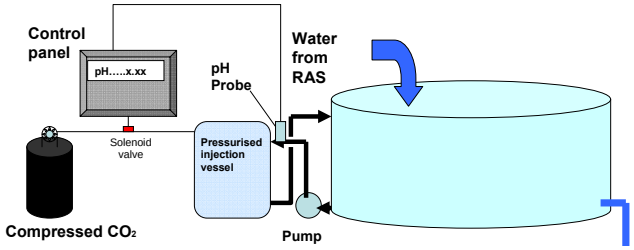
4 separate systems

System 1



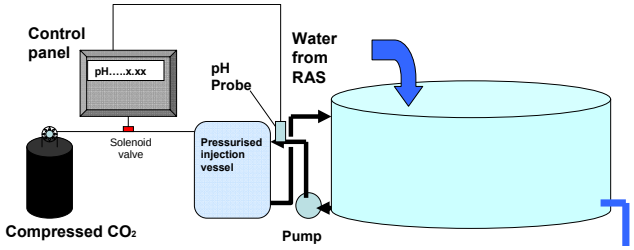
Future pH / CO_2 (750ppm)
Elevated temperature (ambient +2°C)

System 2



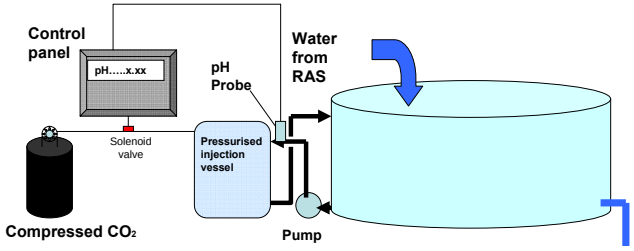
Future pH / CO_2 (750 ppm)
Extant temperature (ambient)

System 3

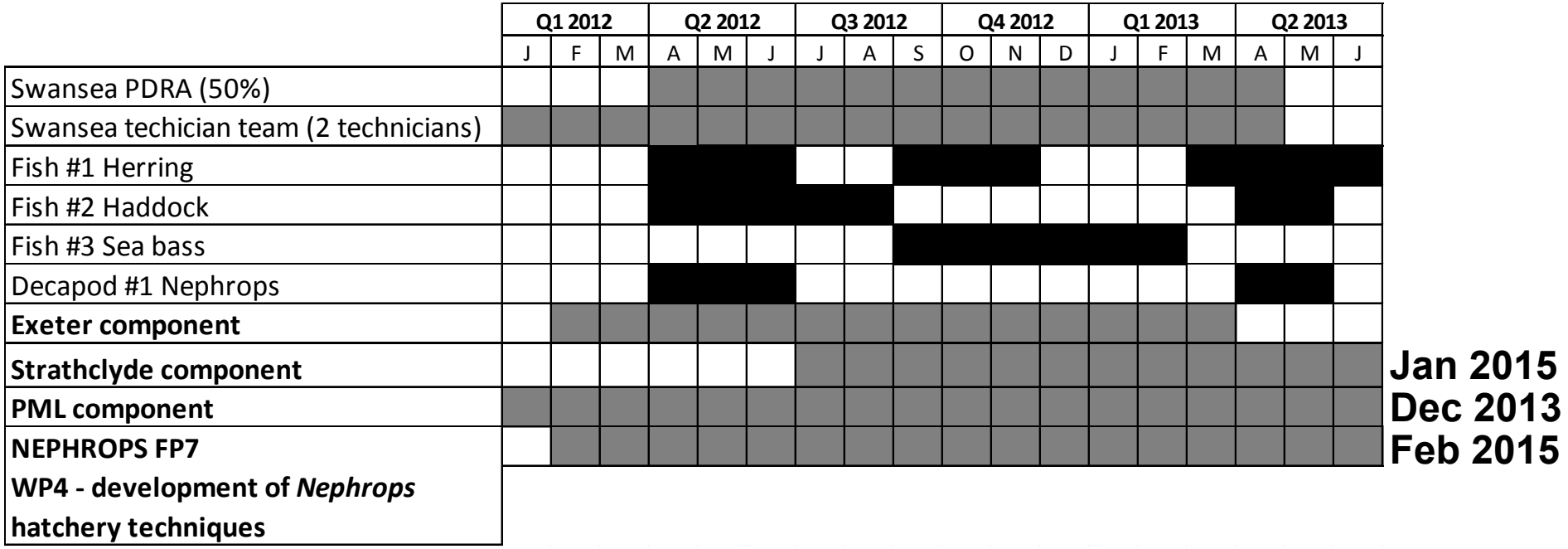


Extant pH / CO_2 (380ppm)
Extant temperature

System 4



Extant pH / CO_2 (380ppm)
Elevated temperature (ambient +2°C)

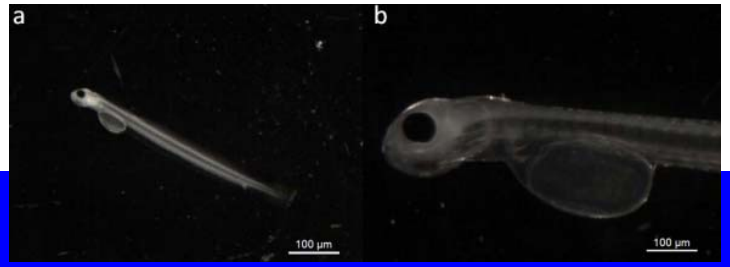

Q1 2012
Q2 2012
Q3 2012
Q4 2012
Q1 2013
Q2 2013
J F M A M J J A S O N D J F M A M J
Swansea PDRA (50%)
Swansea techician team (2 technicians)
Fish #1 Herring
Fish #2 Haddock
Fish #3 Sea bass
Decapod #1 Nephrops
Exeter component
Strathclyde component
PML component
NEPHROPS FP7
WP4 - development of Nephrops hatchery techniques
Jan 2015
Dec 2013
Feb 2015

Key parameters

- Embryonic development
- Survival (to hatch; larvae to post-larvae)
- Growth
- Hatching rate
- First feeding success
- Feed intake

- Metabolic rate
- Calcification

Herring (*Clupea harengus*); preliminary experiment 2011



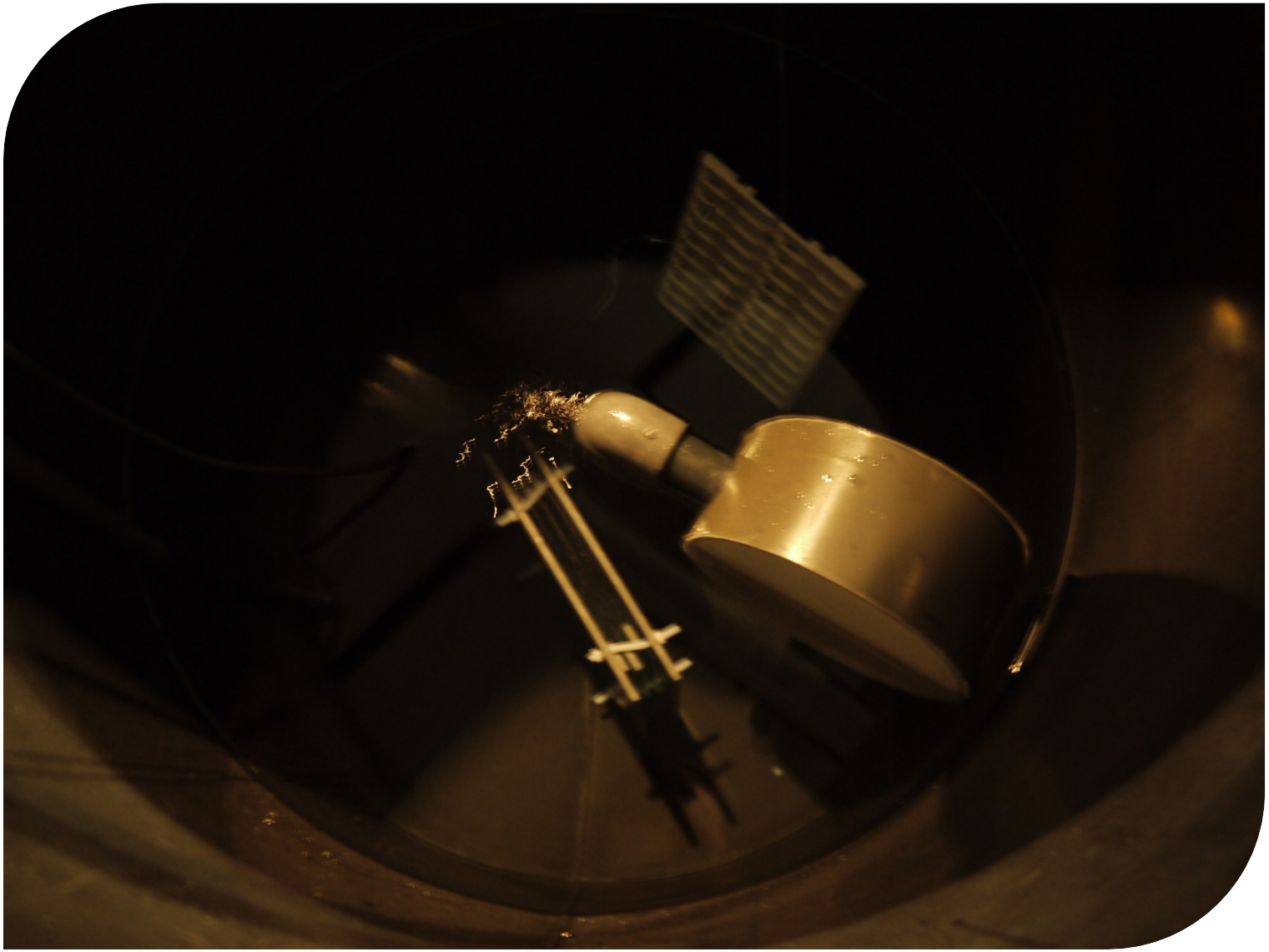
No significant differences were observed in the relationship between body length or yolk sac area with regard to pH treatments after 11 d PF (8 d post-hatch).

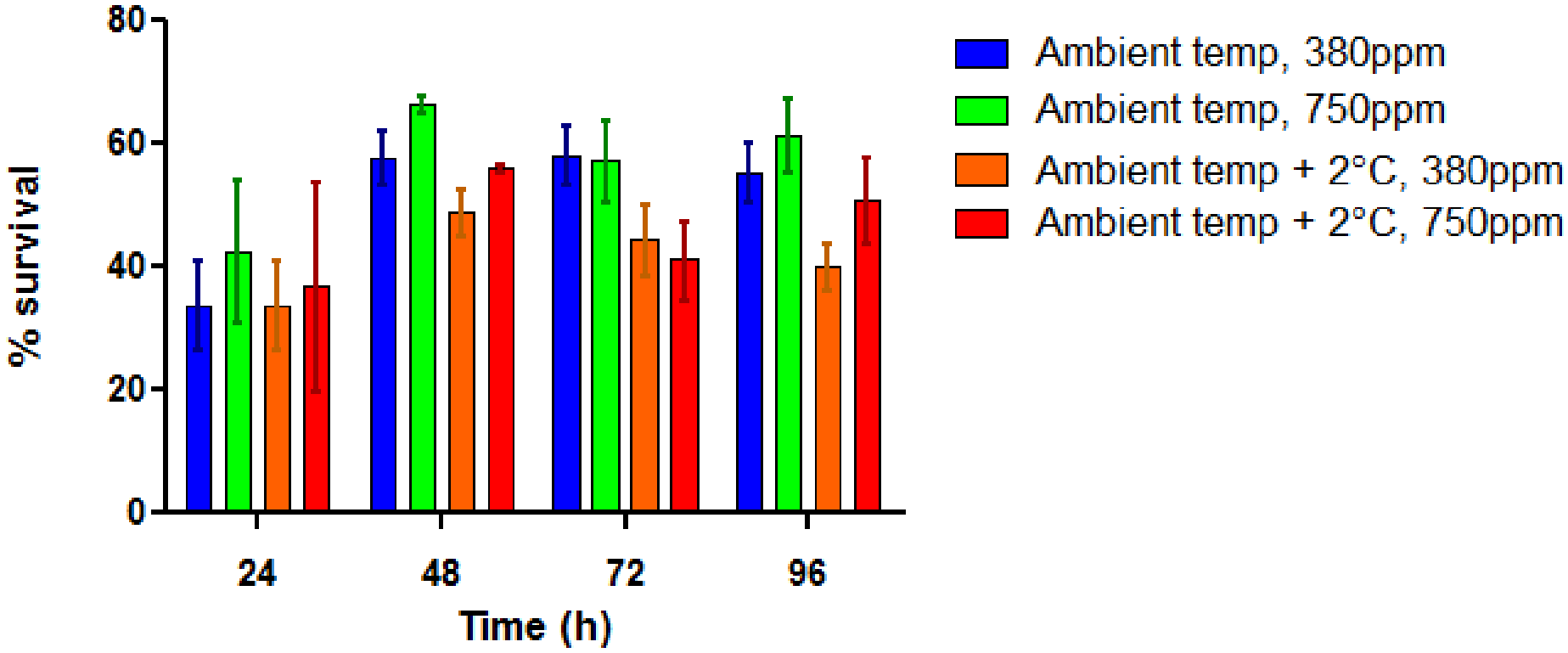
Fish 1: Herring (*Clupea harengus*)

- Locally caught mature adults available February – April
- First fish were caught on Friday
- Two priorities:
    - **Survival of eggs, hatch rate, growth**
    - **Production of sufficient larvae for feeding, energetics**
- Gonads brought to CSAR and fertilised within hours
- Eggs adhered to glass plates and suspended in OA tanks for incubation (3 x 150L tanks per treatment)
    - **Microscope slides for egg survival (*ca.* 100 eggs per slide)**
    - **Glass plates (thousands per plate)**
- Future fish will be used for fertilisation experiments

    (fertilisation rates under OA conditions)


74
THE FRIDGE/FREEZER
½ BROKE




80
60
40
20
0
% survival
24
48
72
96
Time (h)
Ambient temp, 380ppm
Ambient temp, 750ppm
Ambient temp + 2°C, 380ppm
Ambient temp + 2°C, 750ppm

Fish species #2 and #3

- **Haddock** – problems with obtaining sufficient numbers of eggs. We will keep trying
- **Sea Bass** – farmed, egg availability is non-seasonal
    - **BUT temperature of the system will need to be higher, incompatible with the other species (herring, *Nephrops*)**
- Further work with autumn spawning stocks of **herring** - these fish will require a warmer system temperature, compatible with simultaneous sea bass work
- **Alternative species?**

Nephrops norvegicus

- We have berried females producing larvae

  (currently not under OA conditions)

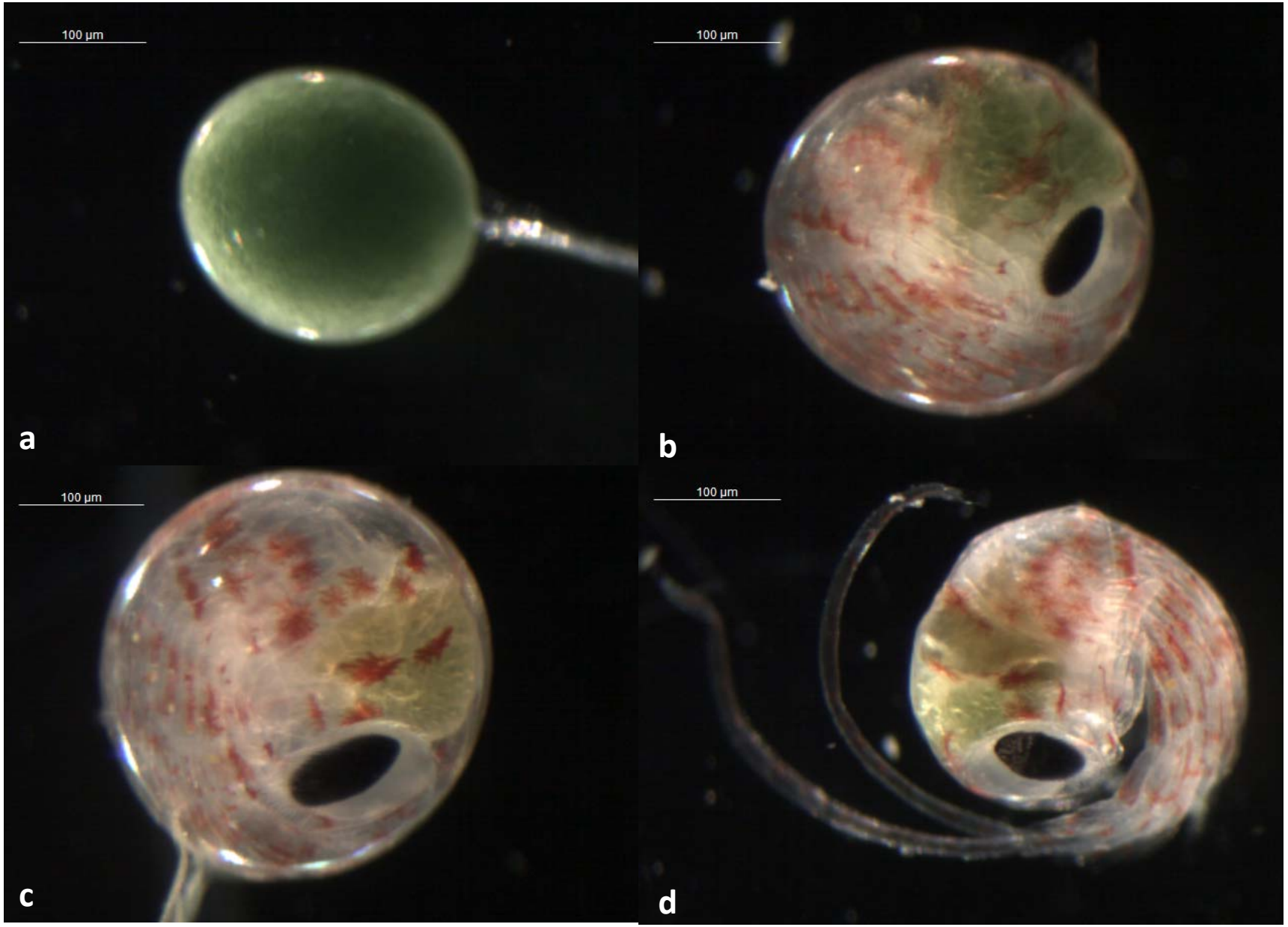
- Regular production of low **(<100 d^{-1})** numbers of larvae, which go into 4 treatments
- Currently running larval survival trials

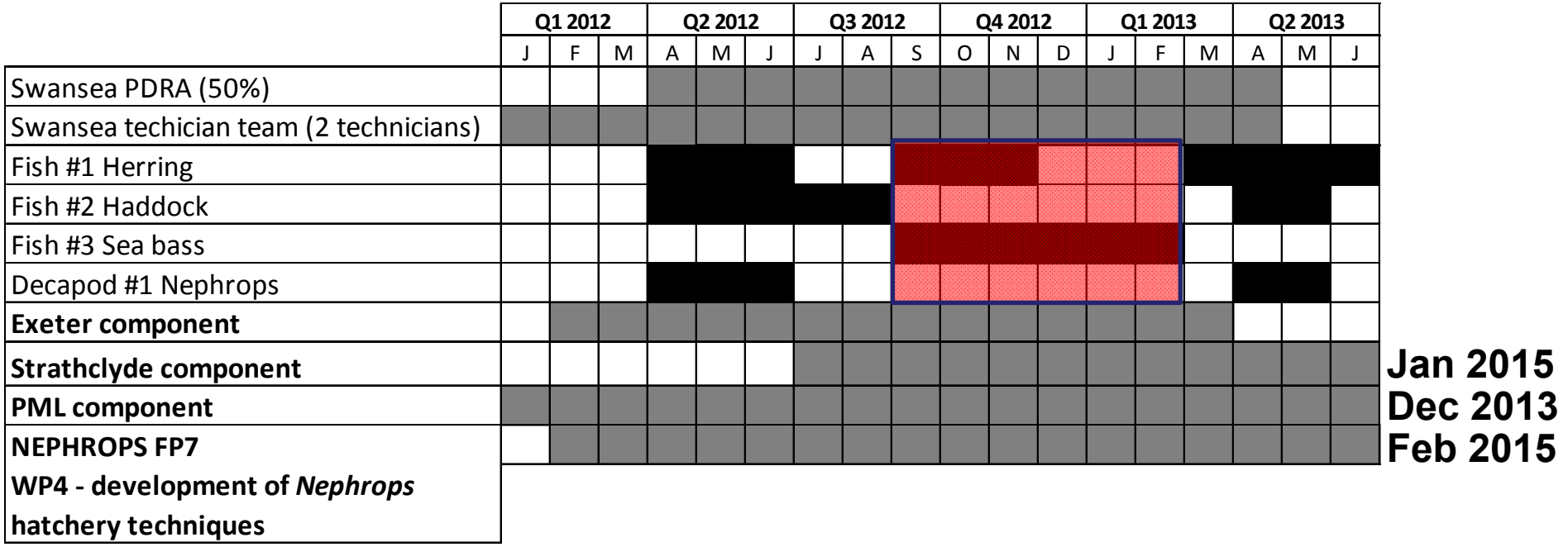
  (up to stage IV, *ca.* 1 month)

- Later work in Orkney cells

  (feeding, moulting, growth, calcification)

- NEPHROPS FP7 project – near-continuous supply of *Nephrops* larvae for future work


100 µm
a
100 µm
b
100 µm
c
100 µm
d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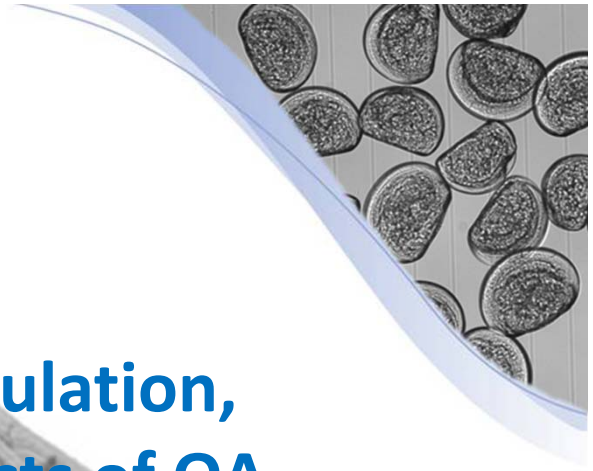
Exeter: bivalves



Improved understanding of population, community and ecosystem impacts of OA for commercially important species

Experimental studies at Exeter

Robert Ellis

University of Exeter

UKOARP Annual Science meeting, Exeter,
18th April 2012

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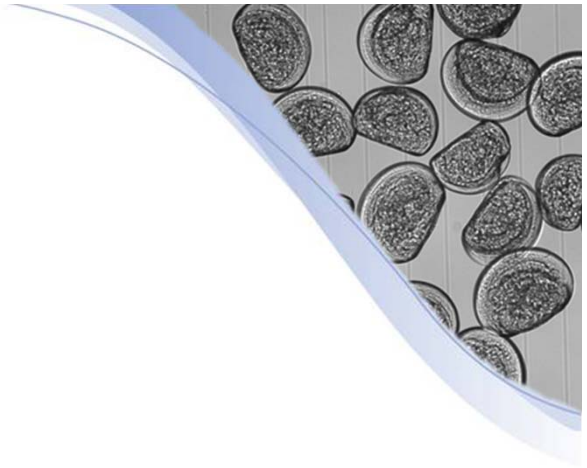
Study species at Exeter



Crassostrea gigas – Pacific oyster

- 2008 oysters contributed >31% of global mollusc production, worth 4.17 billion US$ (FAO 2010)
- Introduced for aquaculture from Japan to Europe in 1970's
- Invasive populations established around UK coastline
- Available year round

Study species at Exeter

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Pecten maximus – King scallop

- 2010, value of 1st sale landings of scallops £54.5million in UK (DEFRA 2011)
- Native to UK, wide distribution around UK coast
- Available May-September, hand collected

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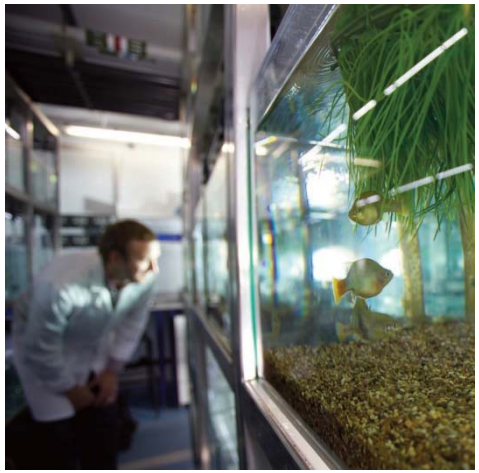
Aquatic research centre

- £9million research facility, costing opened late 2011, designed to investigate impact of various stressors on aquatic ecosystems

- Computer controlled water treatment, removes all potential contaminants and produce high quality water

- Runs at any salinity from ion poor fresh water to fully marine, and at any temperature between 10 °C and 28 °C (± 1 °C)



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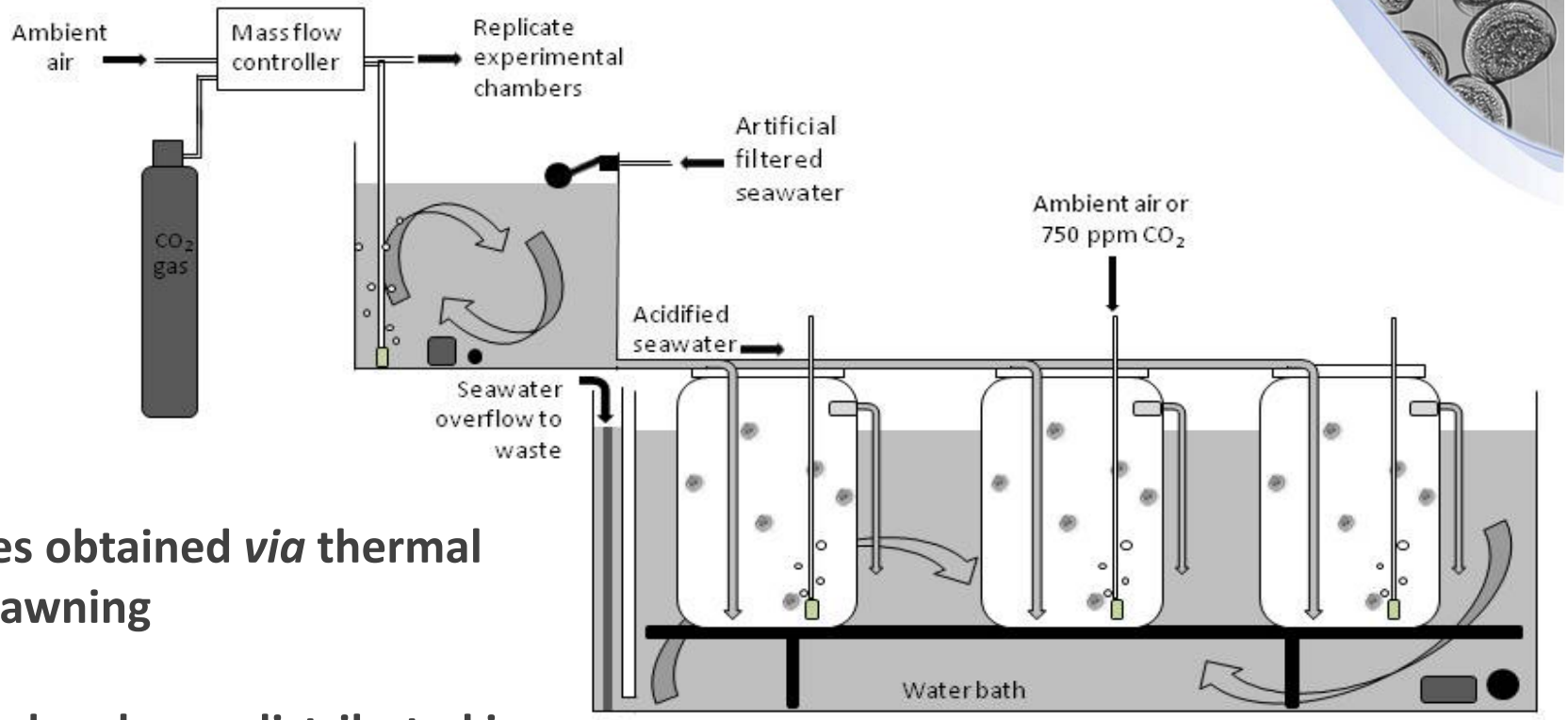
Experimental approach

Experimental setup

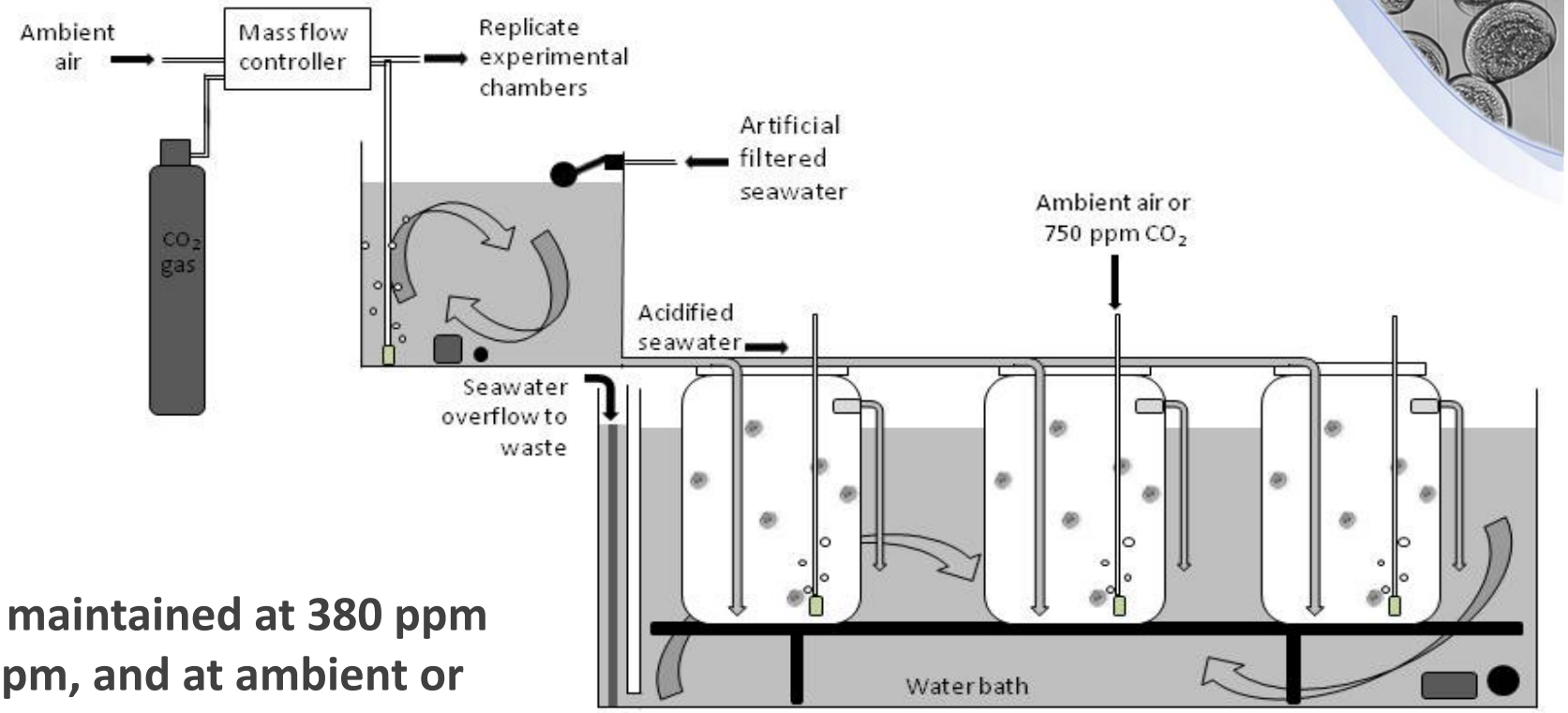


- **Gametes obtained *via* thermal shock spawning**

- **Fertilized embryos distributed in experimental chambers (N=16)**

Experimental approach

Experimental setup

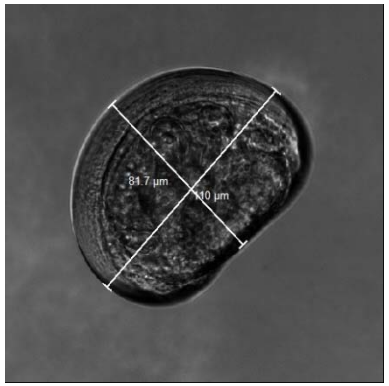


- **Larvae maintained at 380 ppm or 750 ppm, and at ambient or +4 ^{o}C, from fertilisation until settlement**

Experimental approach

Parameters measured

- Survival, developmental staging and growth rate



Larvae sampled and fixed 1h, 2h, 4h, 6h, 8h, 10h, 12h, 18h, 24h, 36h and 48h into development

Subsequently sampled every 24h until settlement

Measure survival, abnormalities and morphology

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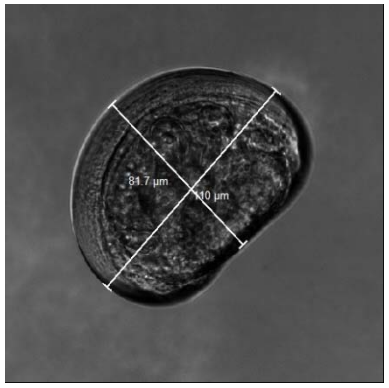
Experimental approach

Parameters measured

- **Respiration, excretion and feeding rate**



Oxygen consumption and ammonium excretion will be measured 4 d after fertilisation, and every 4 days until settlement

Feeding rate, measured as clearance efficiency over 24 , measured every 4 days, from 4 d post fertilisation until settlement

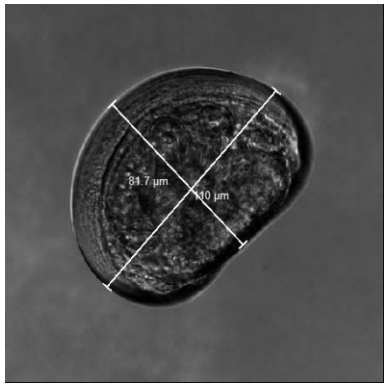
Experimental approach

Parameters measured

- Calcification

Calcium carbonate deposition, through incorporation of calcein in larval shell, using confocal microscopy

Measured over 48h, every 4 days from 4 d post fertilisation until settlement



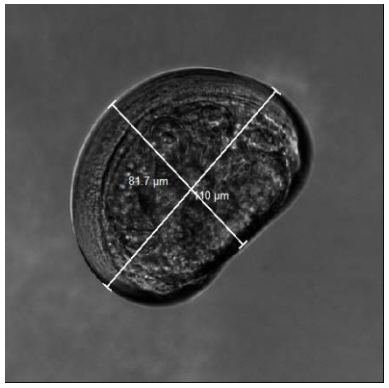
Experimental approach

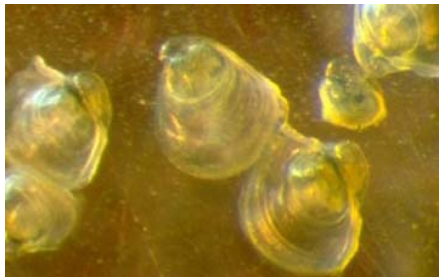
Parameters measured

- Settlement

Settlement assessed from 19 days post fertilisation, settlement panel introduced into each experimental chamber

Panel assessed daily, measure number of individuals settled and collect spat for morphology/physiology

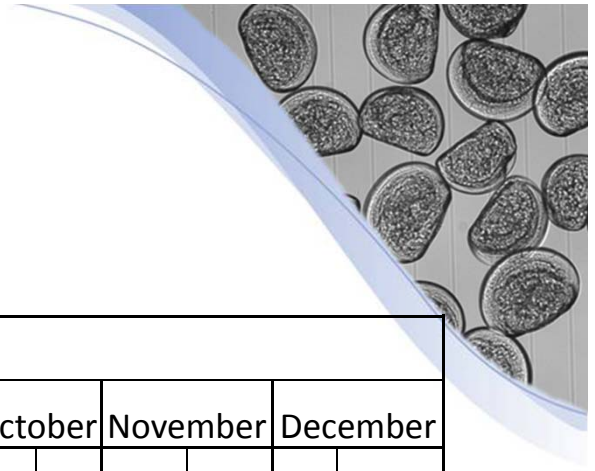




T. Renault (2011) Ifremer

Experimental approach

Proposed timetable



	2012																	
	April		May		June		July		August		September		October		November		December	
Finalise experimental Set up																		
Oyster availability																		
Scallop availability																		
1st Oyster Trail																		
1st Scallop Trail																		
2nd Scallop Trail																		
2nd Oyster Trail																		
Work up outstanding morphological data																		
Work up outstanding confocal microscopy																		

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PML: socio-economics