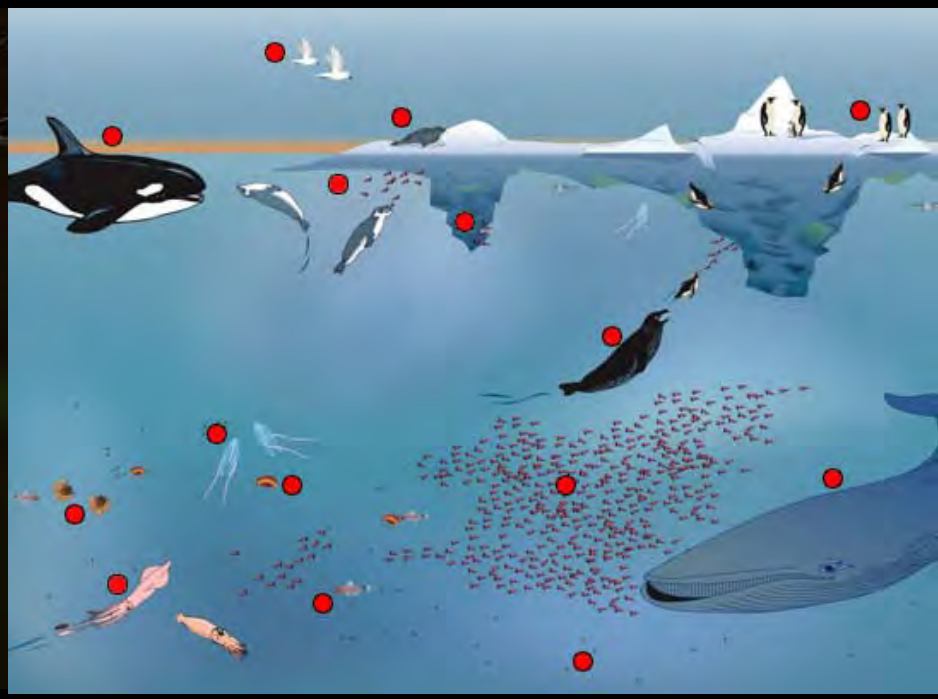
The 2nd International Symposium “Effects of Climate Change on the World’s Oceans”
May 15-19, Yeosu

Antarctic krill in a high CO_2 Southern Ocean: potential impacts on early development and adult growth

Atsushi Ishimatsu[1], Awantha Dissanayale[1], So Kawaguchi[2], Robert King[2], Haruko Kurihara[3], Akio Ishida[4] and Masahide Wakita[4]
[1]Institute for East China Sea Research, Nagasaki University
[2]Australian Antarctic Division
[3]Transdisciplinary Res Org for Subtropics and Island Studies, Univ of the Ryukyus
[4]Research Inst for Global Change, JAMSTEC

Antarctic krill (*Euphausia superba*)

Max. total length 6-6.5 cm
Life span 5-7 yr



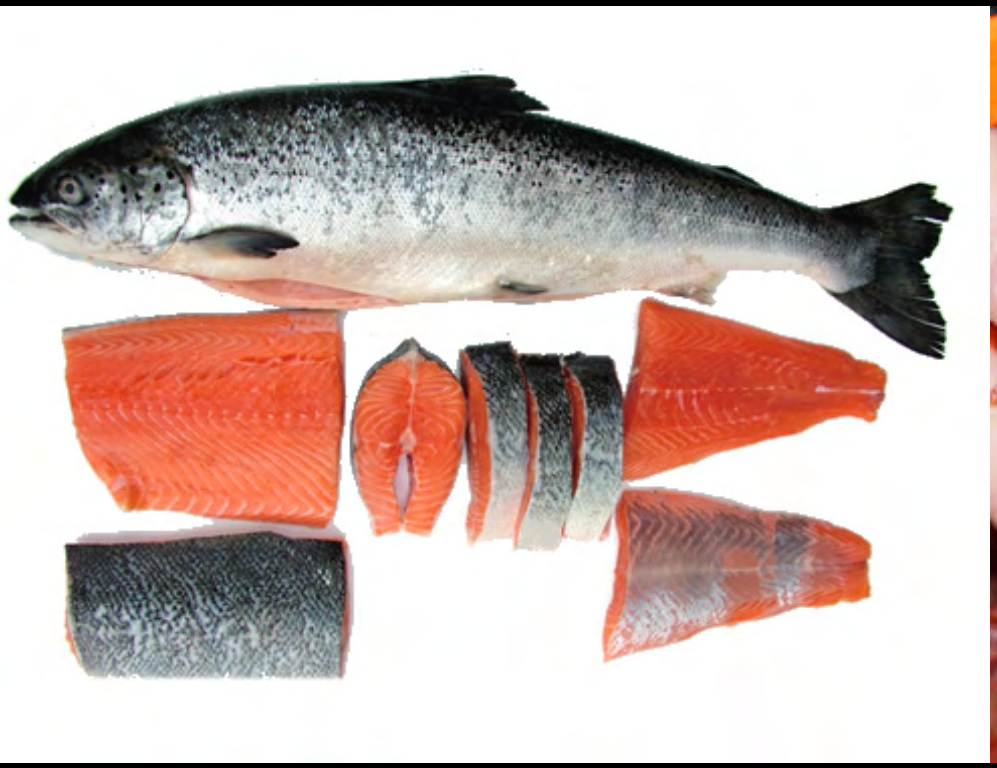
Ecologically- and economically-important species

Annual catch of *Euphausia superba* by the major fishing nations (x 10^3 tonnes). Data from FAO

Country/year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Japan	67	51	60	34	23	33	24	38	21
South Korea	8	14	20	25	27	43	33	38	43
Norway	-	-	-	-	-	9	40	63	44
Poland	14	16	9	9	4	5	7	8	8
Ukraine	14	32	18	12	22	15	-	8	0
USSR/Russia	-	-	-	-	-	-	-	0	10
USA	2	12	10	9	2	-	-	-	-
Vanuatu	-	-	-	29	48	-	-	-	-
Total	104	125	117	118	129	104	106	156	125

A dash means “no catch”; a zero indicates a small catch < 500 t.

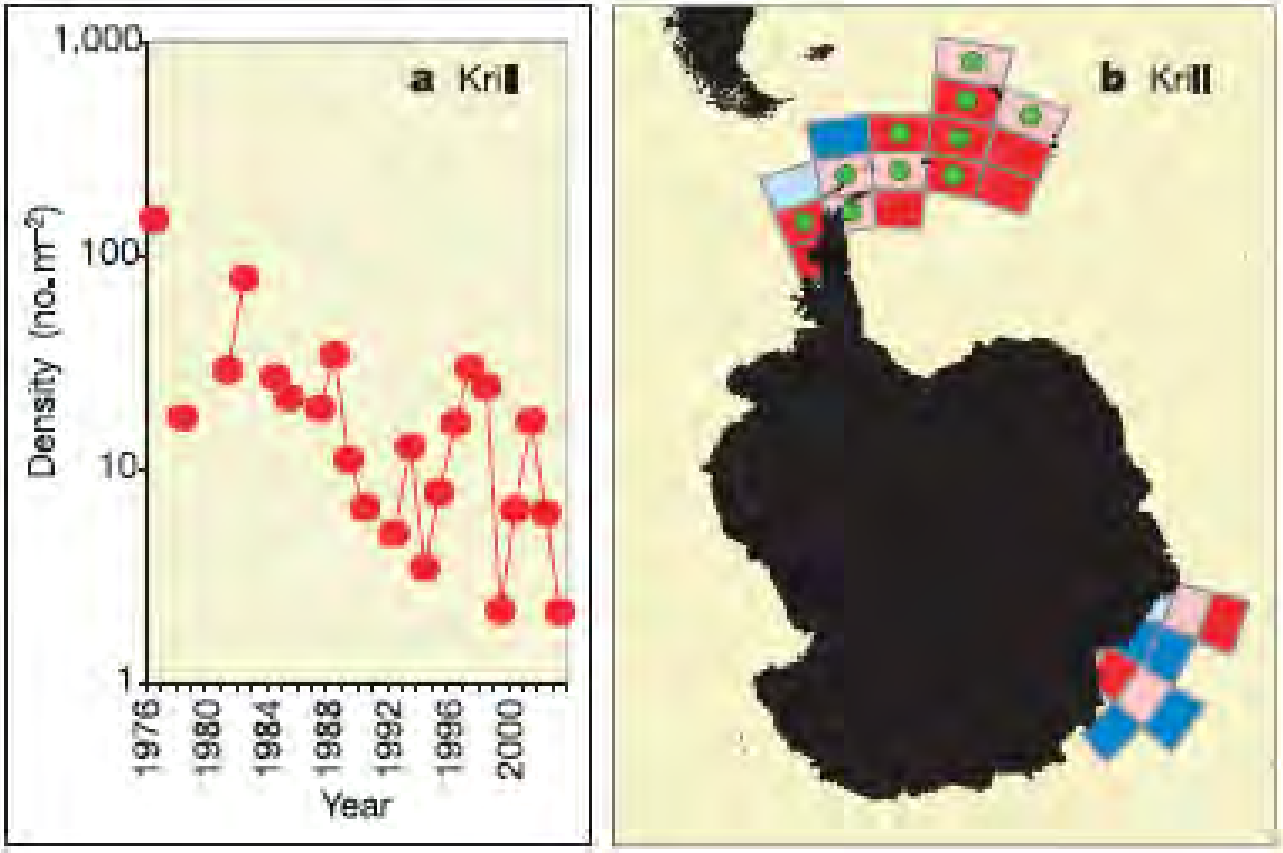
Krill products



Astaxanthin in salmon feed from krill

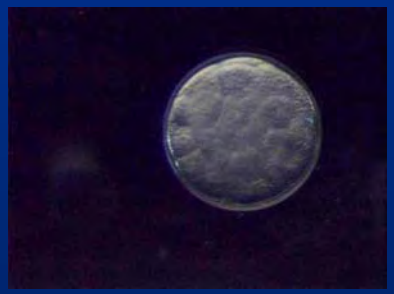
Long-term decline in krill stock and increase in salps within the Southern Ocean

Angus Atkinson[1], Volker Siegel[2], Evgeny Pakhomov[3,4] & Peter Rothery[5]



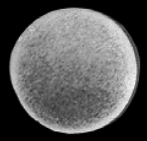
Nature 432, 100-103

Experimental evaluation of CO_2 impacts on Antarctic krill



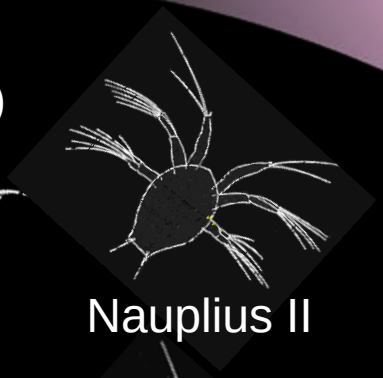
- Embryonic development
- Adult growth and metabolism

The Krill Cycle

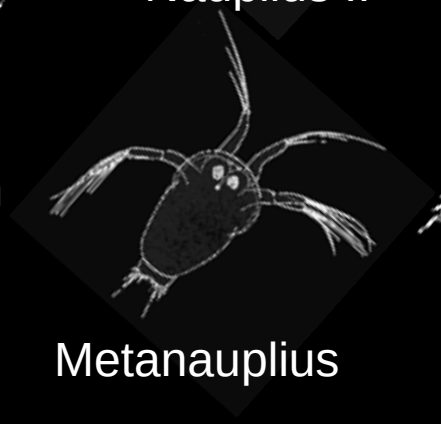


Egg (summer)

Nauplius I (hatch at 800-1000 m depths)

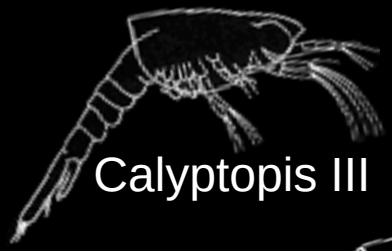


Nauplius II



Metanauplius

Calyptopis I (start feeding)



Calyptopis III

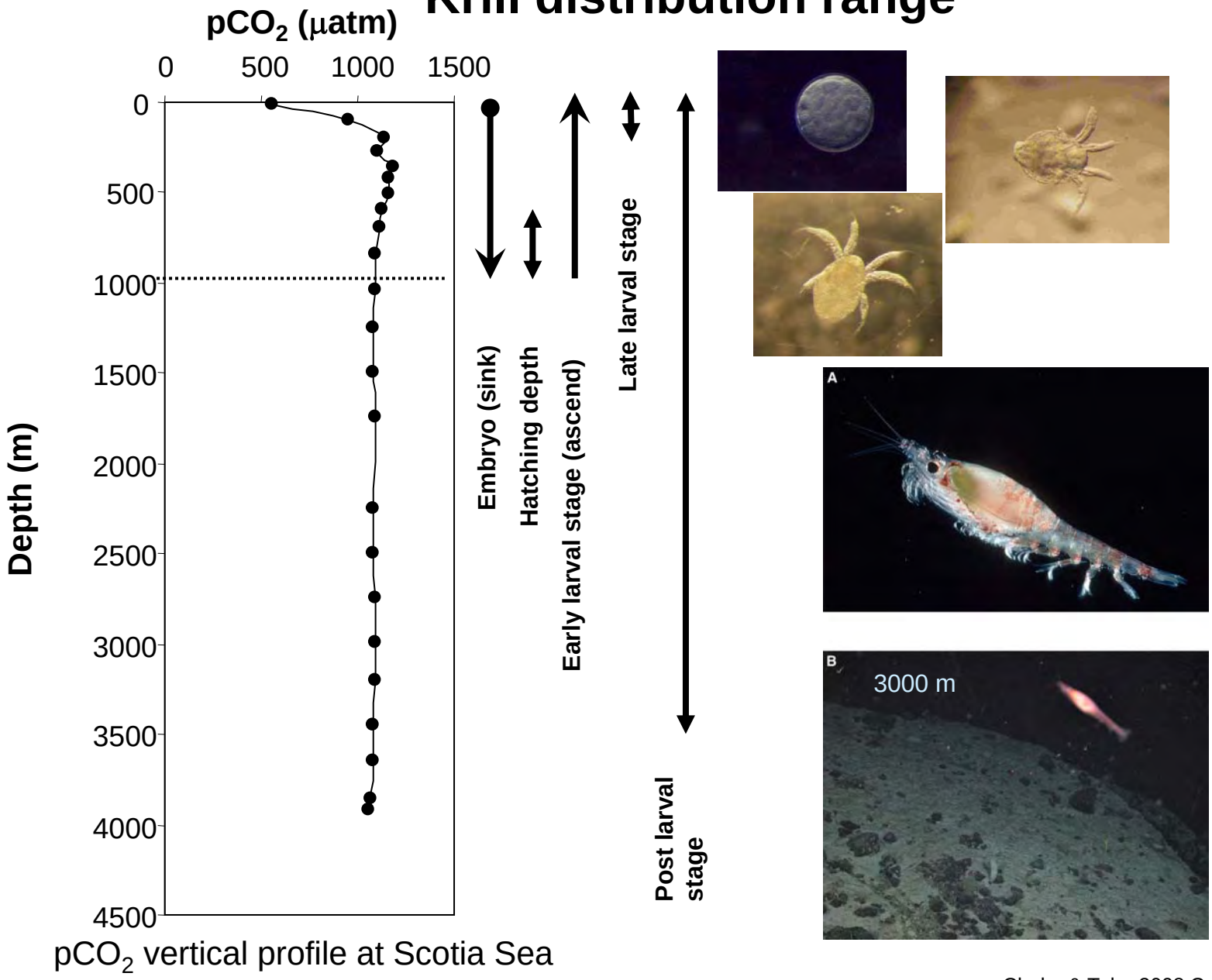
Furcilia II

Furcilia V

Six furicilia stages (summer, autumn and winter)

Juvenile (Spring)

Krill distribution range



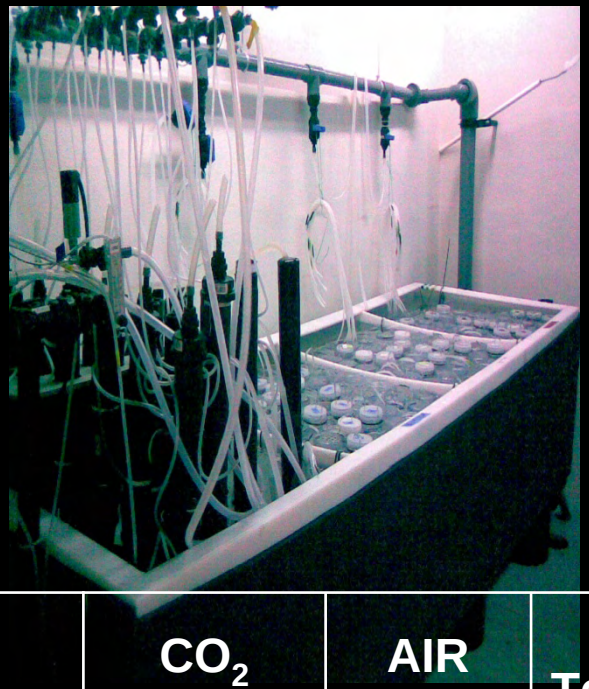
pCO_2 vertical profile at Scotia Sea

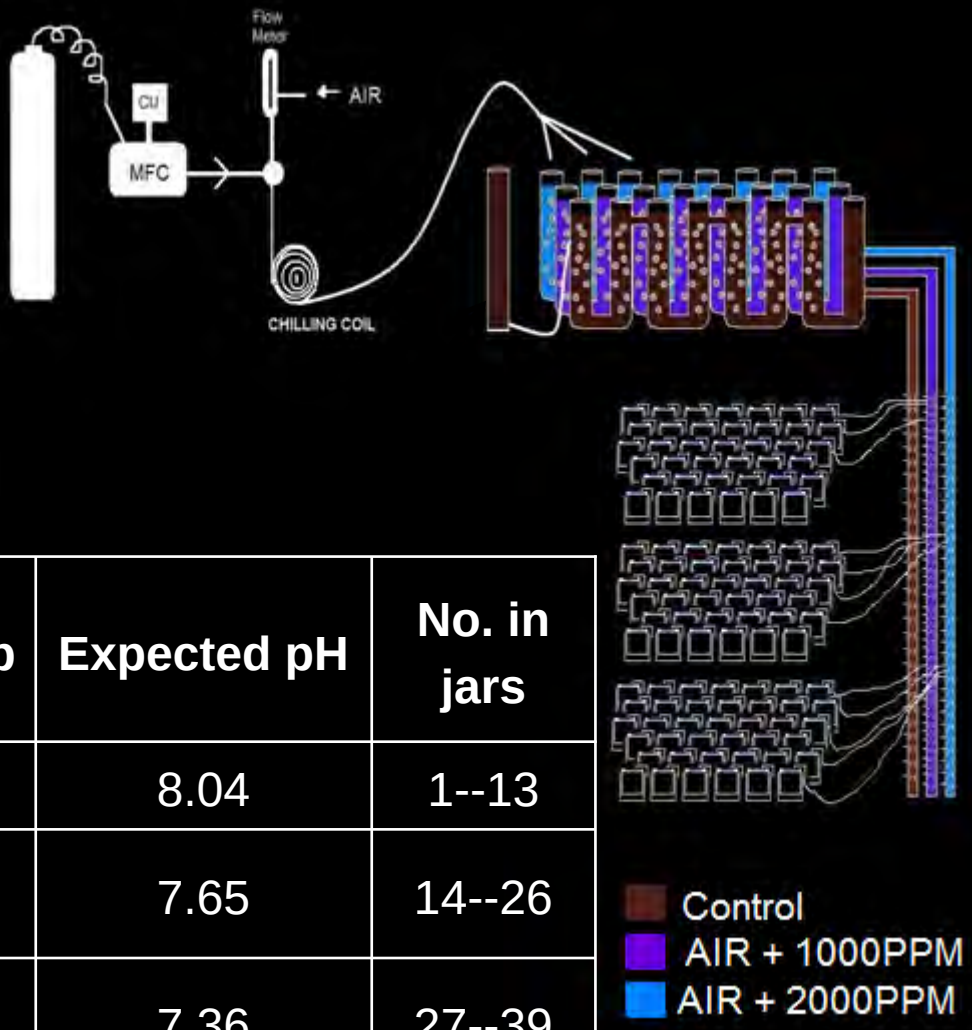
Data source: Carbon Dioxide Analysis Information Center
http://cdiac.ornl.gov/oceans/home.html

Kawaguchi et al. 2011 Biol Lett 7, 288

Clarke & Tyler 2008 Curr Biol 18, 282

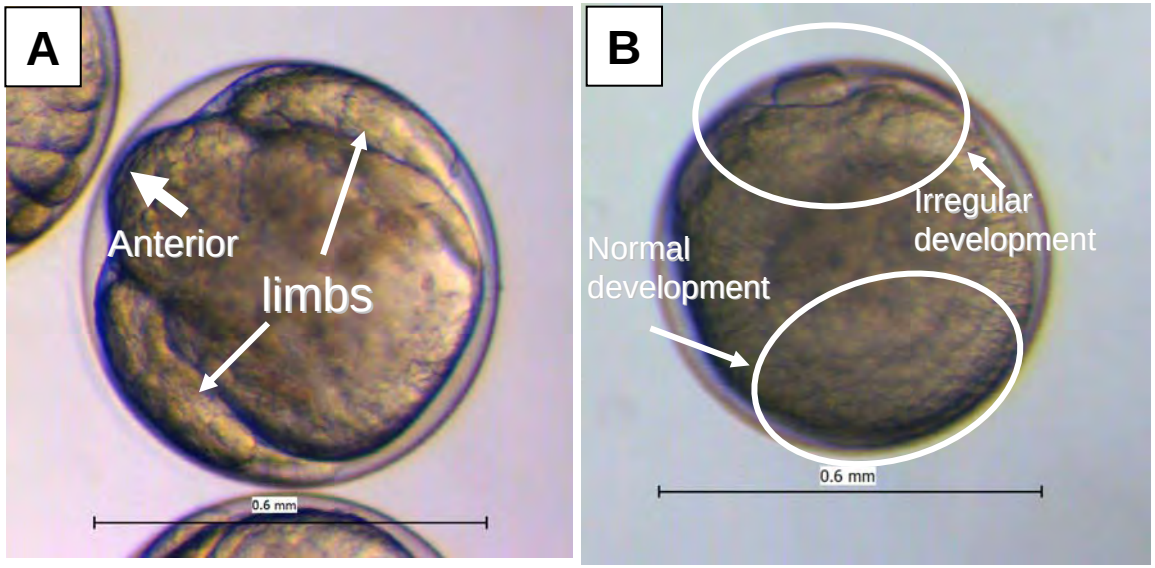
Experimental design

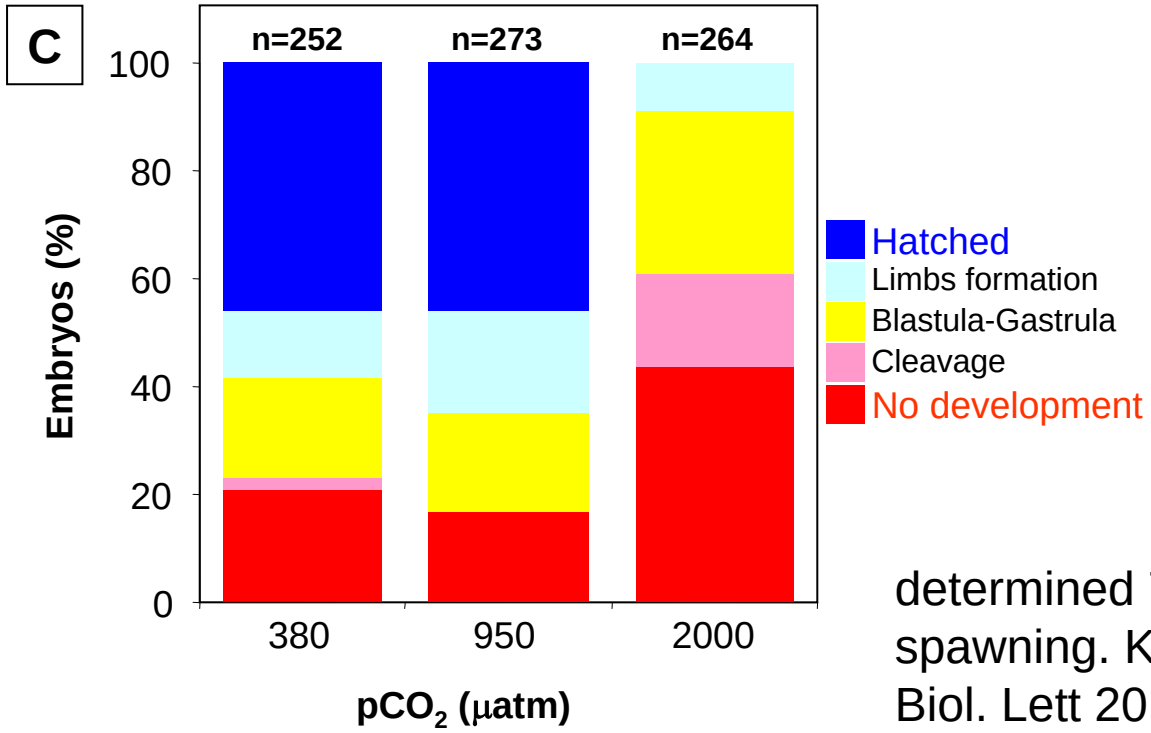




	CO_2 (ml/min)	AIR (l/min)	Temp	Expected pH	No. in jars
Control	0	12	1ºC	8.04	1--13
950 ppm	9.72	12	1ºC	7.65	14--26
2000 ppm	19.44	12	1ºC	7.36	27--39

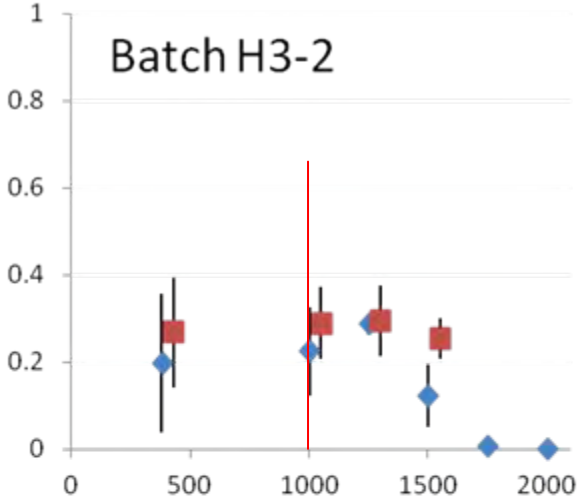
(Hale et al., unpublished)

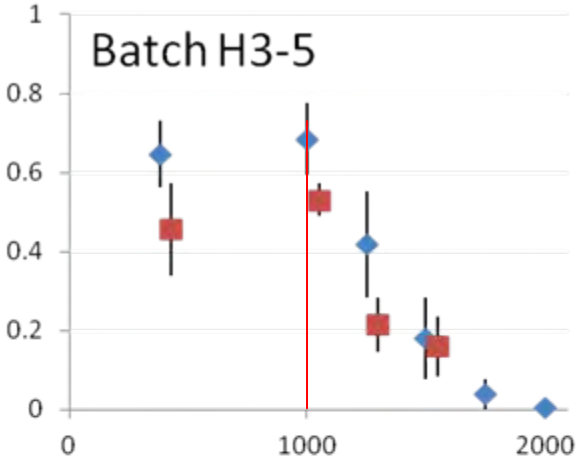


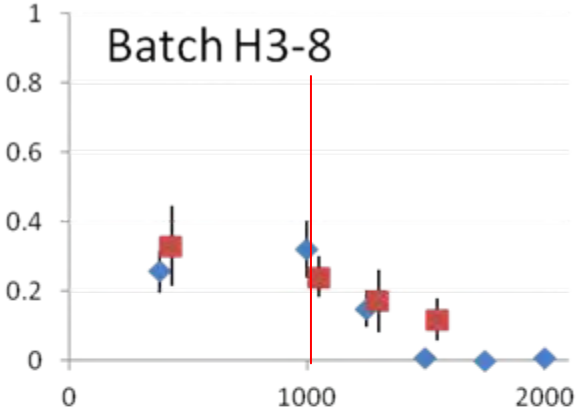


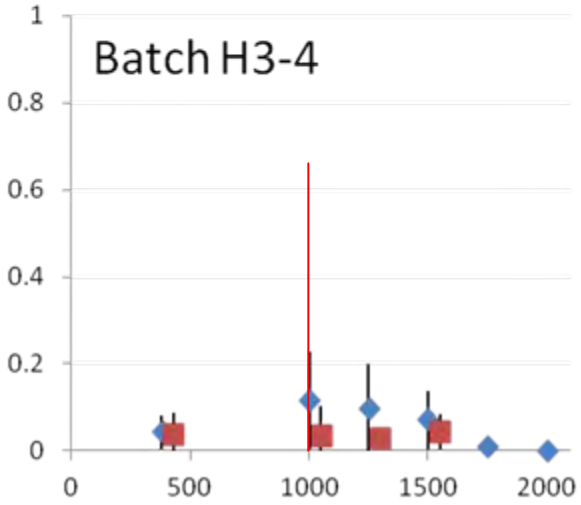
determined 7-10 days after spawning. Kawaguchi et al. Biol. Lett 2011, 7, 288

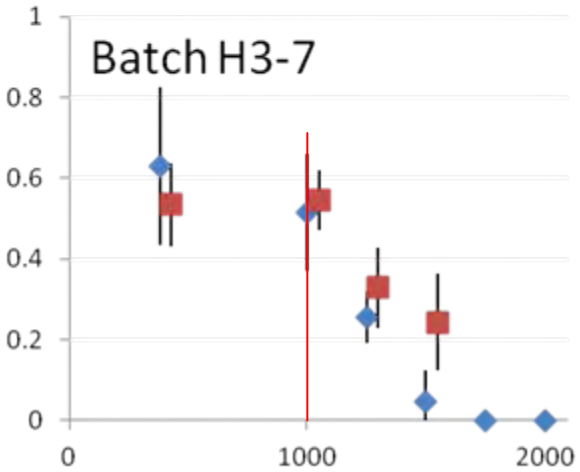
Effect of CO_2 on hatching rate

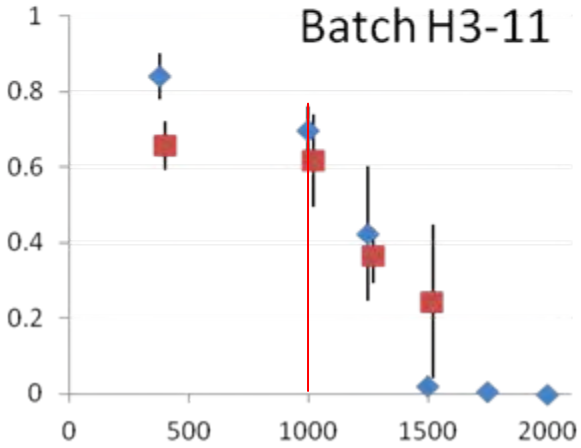








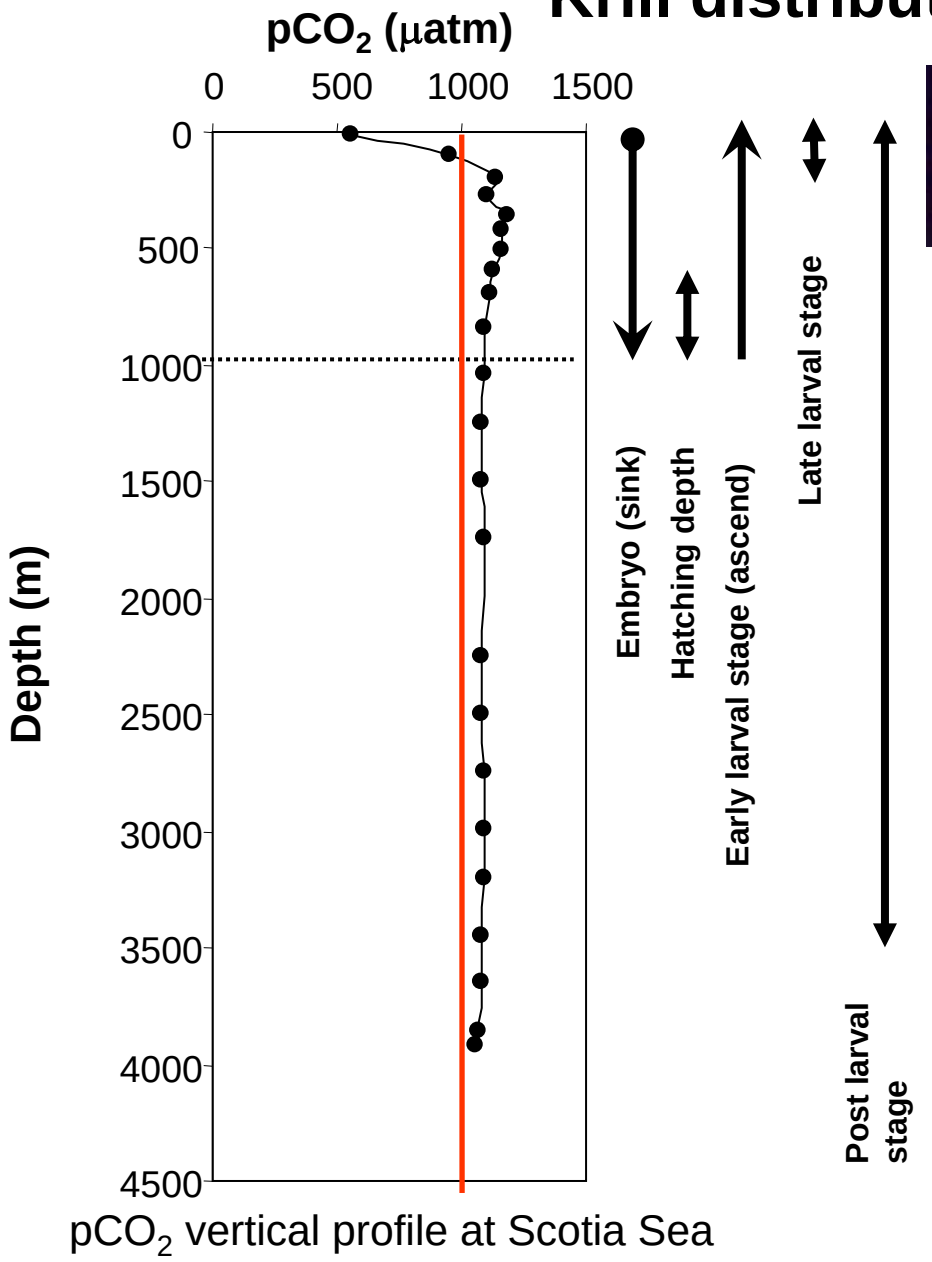




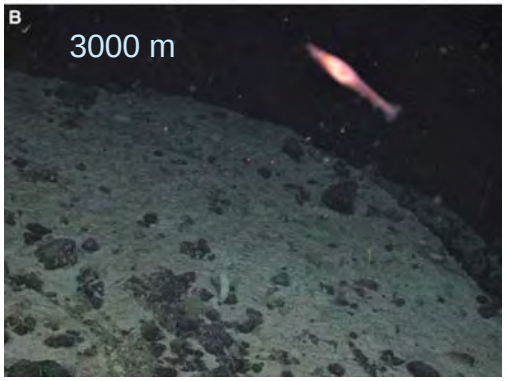
N = 6, X + SD

Blue : Low temp 0.5C, Red : High temp 3.0C

Krill distribution range



pCO$_2$ vertical profile at Scotia Sea



Clarke & Tyler 2008 Curr Biol 18, 282

Data source: Carbon Dioxide Analysis Information Center
http://cdiac.ornl.gov/oceans/home.html Kawaguchi et al. 2011 Biol Lett 7, 288

Control
Calyptopis I

950 ppm
Calyptopis I

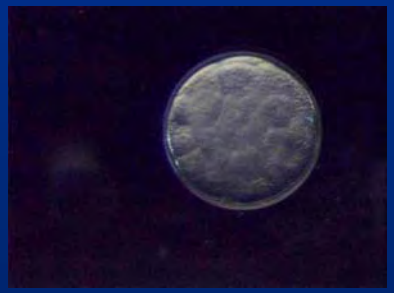
(Hale et al., unpublished)

Preliminary Observations on swimming

Day	Stage	CO2		
		Control	950 ppm	2000 ppm
7	Nauplius I	Swimming actively throughout water column	Swimming actively throughout water column	unhatched
12	Nauplius II	Swimming actively throughout water column	Fairly active	unhatched
17	Metanauplius	Swimming actively throughout water column	Stuggling to swim (in circles only).	unhatched
26	Calyptopis I	Swimming actively throughout water column	Laying on side/back on bottom, barely moving	unhatched

(Hale et al., unpublished)

Experimental evaluation of CO_2 impacts on Antarctic krill



- Embryonic development
- Adult growth and metabolism









Thank you for your attention