

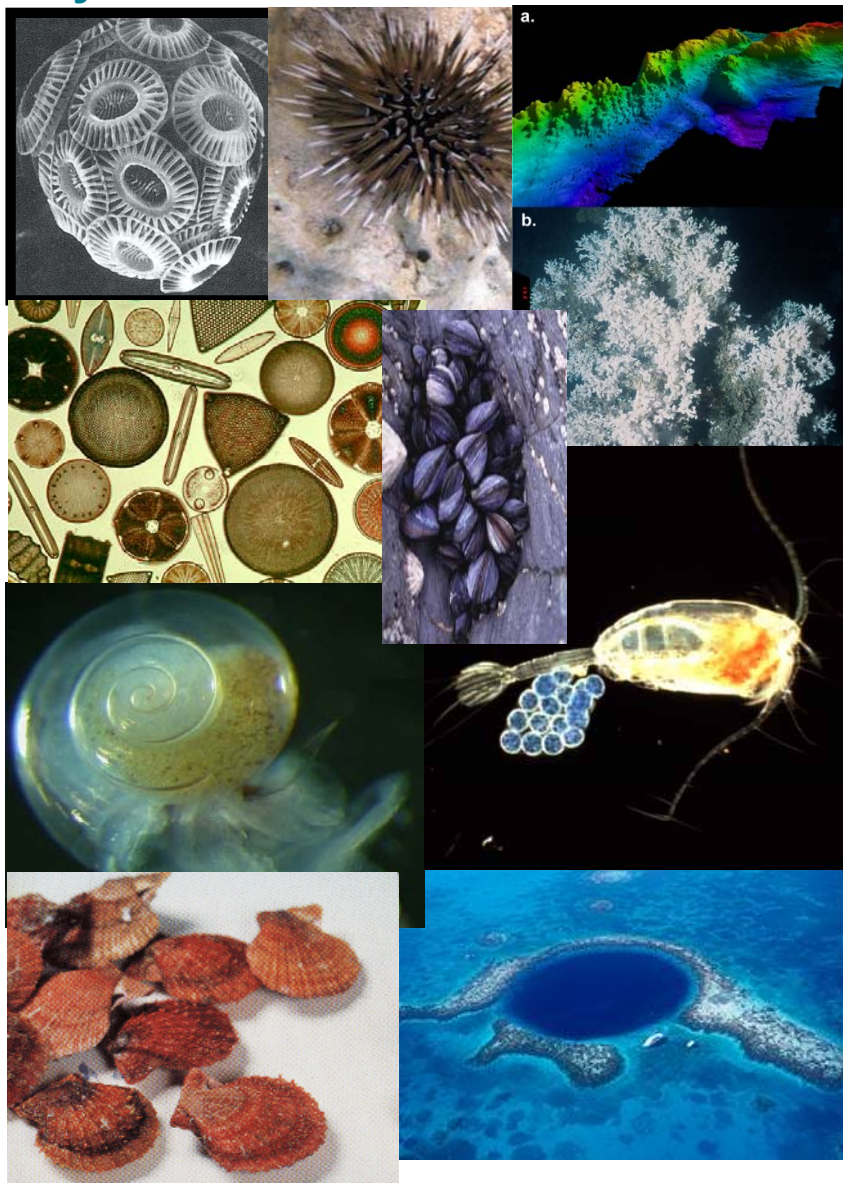
Socio-Economic Aspects of Ocean Acidification

Carol Turley & Phillip Williamson

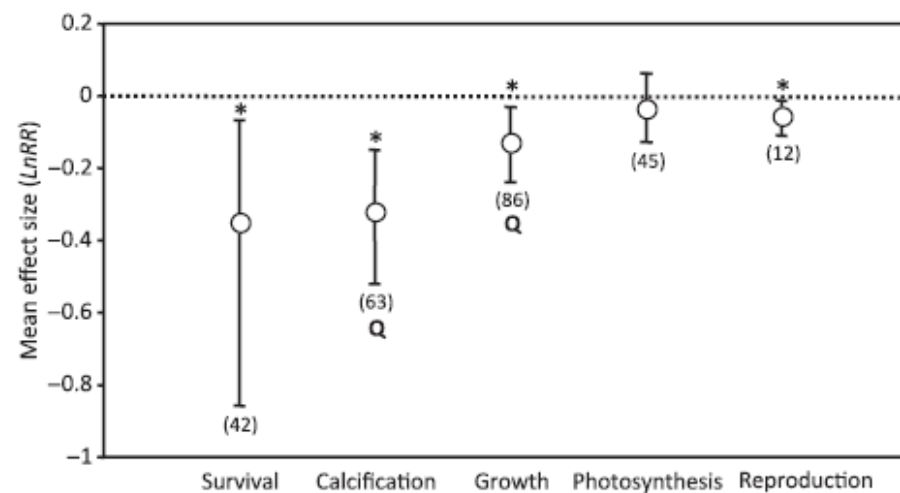
Plymouth Marine Laboratory and University of East Anglia, UK
Coordinators of the UK Ocean Acidification Research Programme



Mounting Concern for Survival of Many Marine Organisms, Food Webs & Ecosystems.....

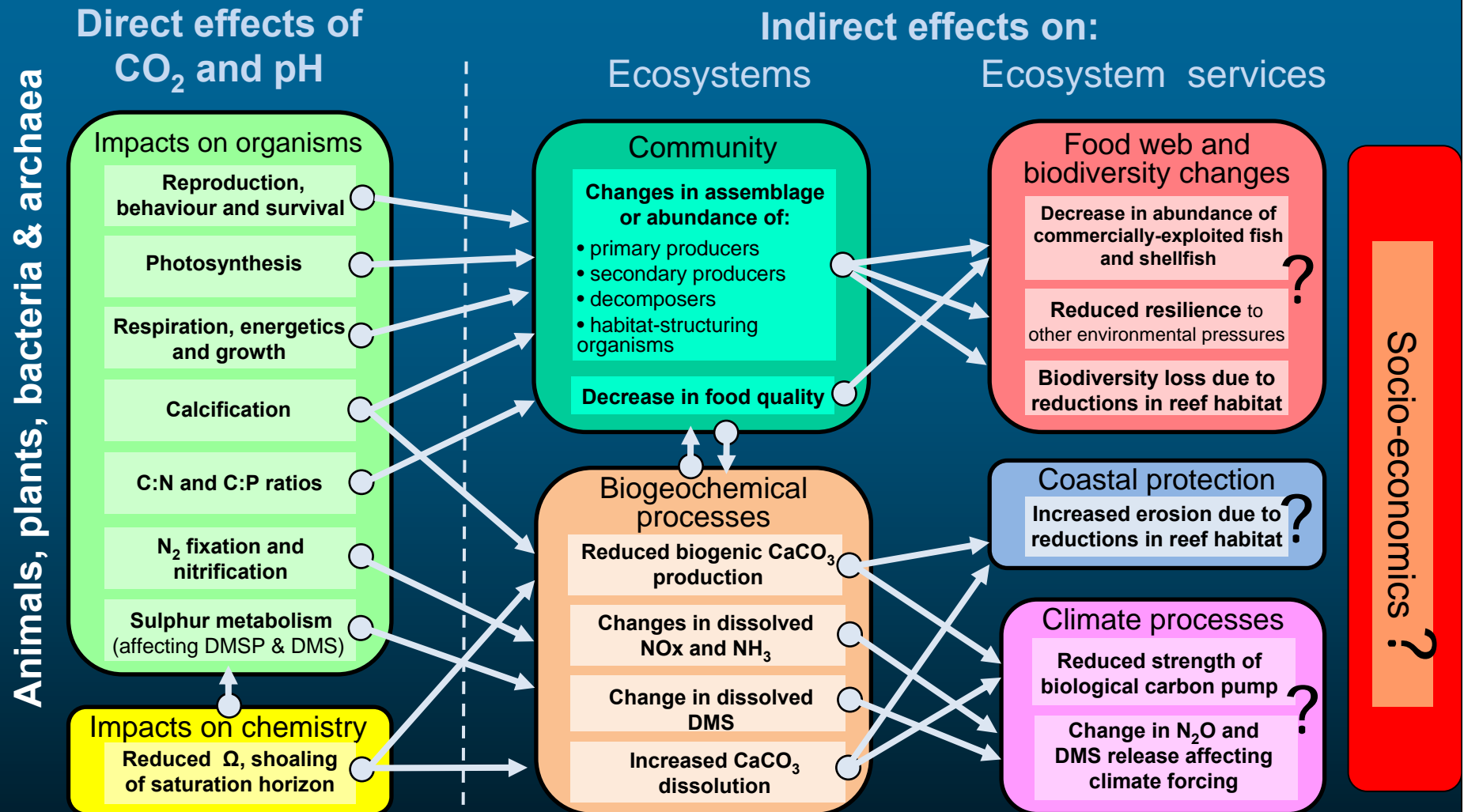


- When should we be concerned?
- What will ocean ecosystems look like in a future high CO₂ world?
- And what will they be able to provide us and what services will they continue to provide?
- What is the economic costs?
- What can we do about it?



Meta-analysis by Kroeker *et al* (2010): impact of 0.4 pH change.
(N) = no of studies

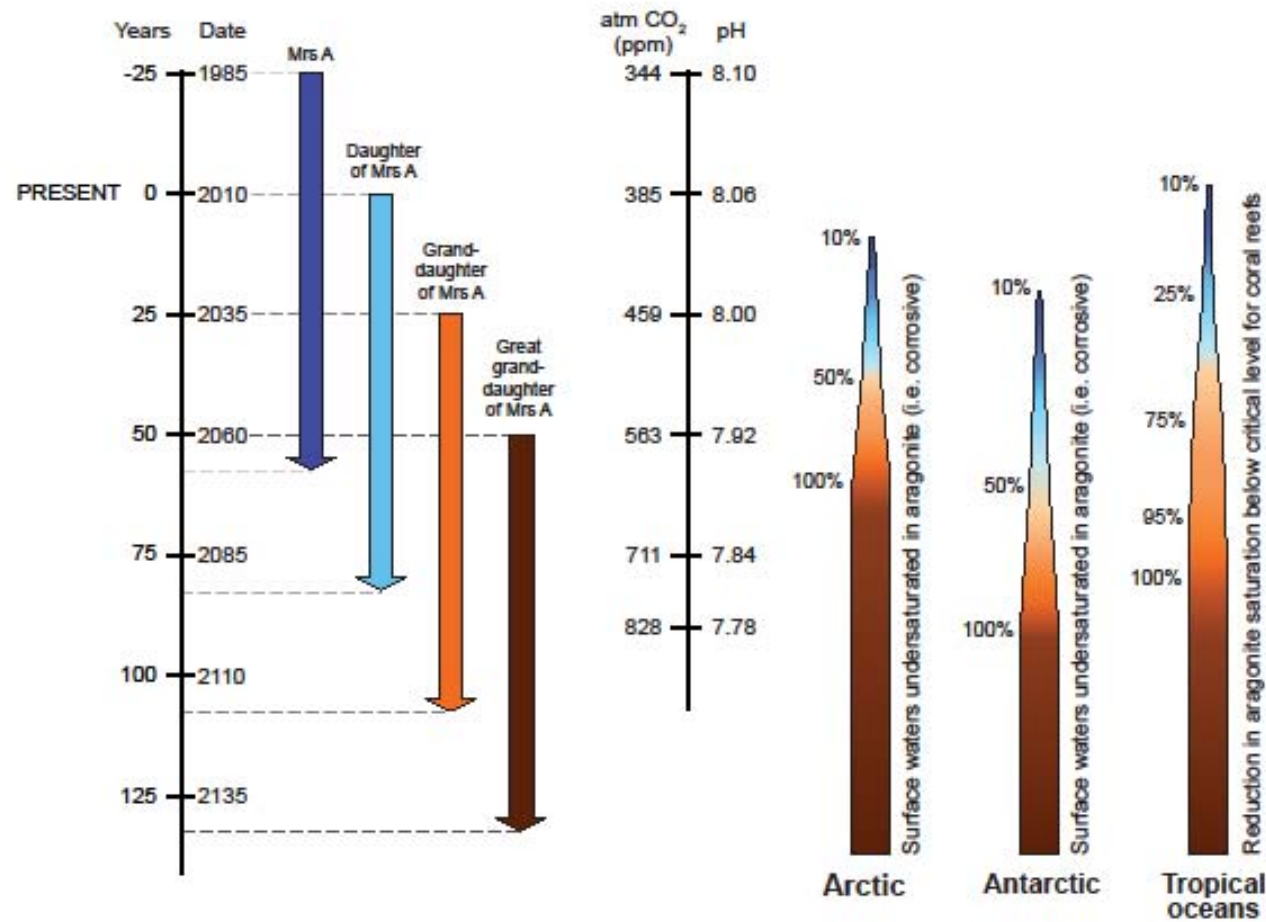
Conceptual Structure of Consequences of OA



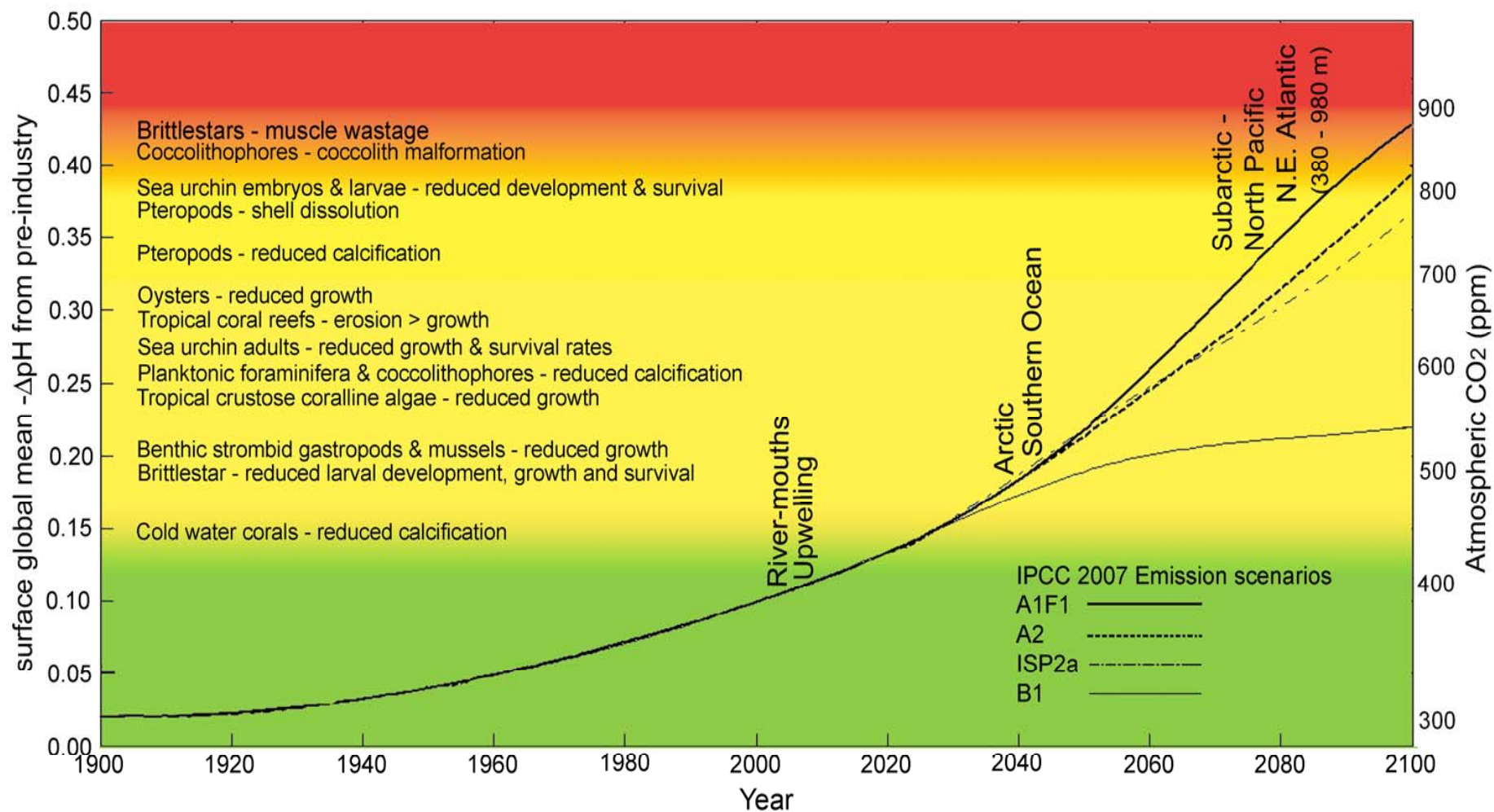
Representation – not comprehensive - of possible OA impacts on planktonic and benthic organisms, with implications for ecosystems and ecosystem services. DMS, dimethylsulphide; DMSP, dimethylsulphoniopropionate; Ω , CaCO₃ saturation state.

Image: Tyrrell Williamson & Turley

When Should We Be Concerned?



Mounting Evidence: some areas could be sensitive this decade

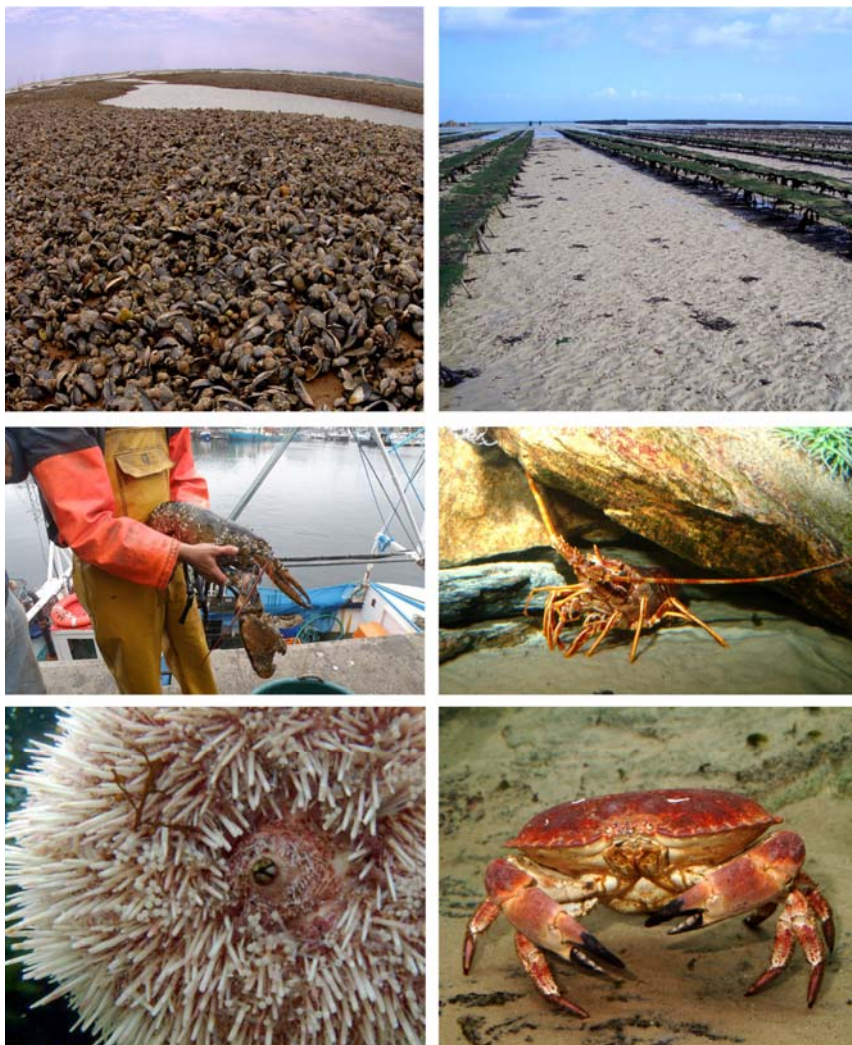


Turley et al. Marine Pollution Bulletin
(2010)

Socio-Economic Impacts of Ocean Acidification



Concern for some Food Providing Organisms

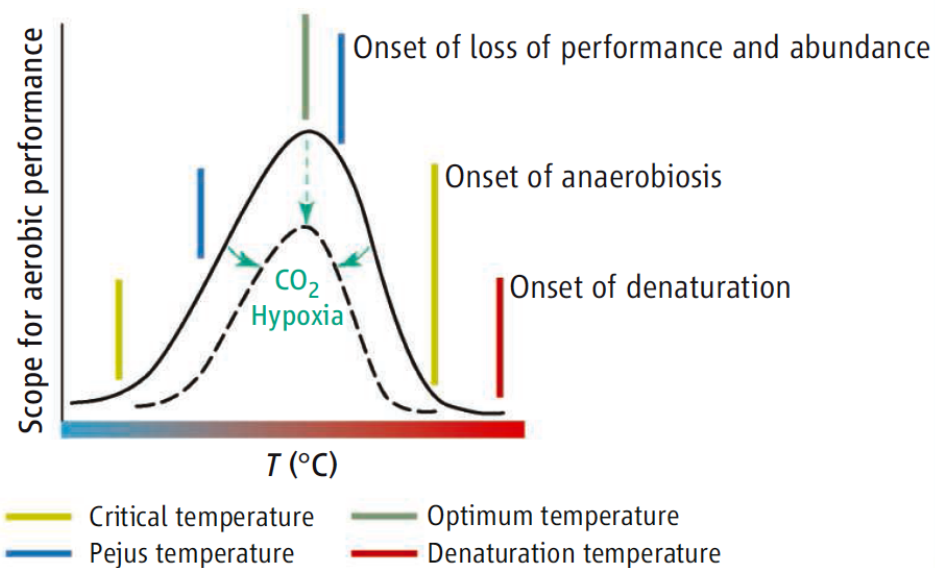


Top left: Mussels beds (Rob Ellis/PML), Top right: Oyster tables (Steve Widdicombe/PML), Mid left: Lobster (Kelly-Marie Davidson/PML), Mid right: Spiny lobster (Kelvin Boot/PML), Bottom left: Sea urchin (Kelvin Boot/PML) and Bottom right: Edible crab (Kelvin Boot/PML)

Some may be sensitive as adults, others at larval or egg development stages or physiology can be effected in others.

In some their ability to withstand warming is reduced

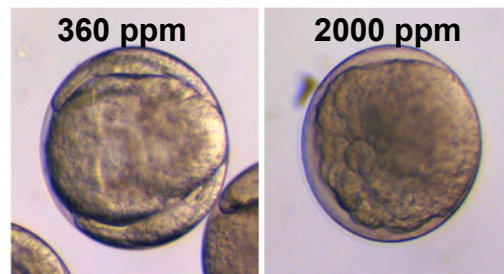
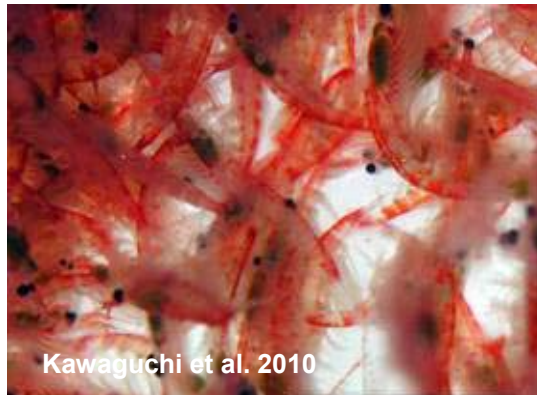
Thermal windows for animals
(may include time dependent shifts through acclimatization)



Pörtner and A.P. Farrell (2008), Pörtner (2010)

Key links in the food chain show vulnerability....

Krill embryo development



Normal krill embryo development

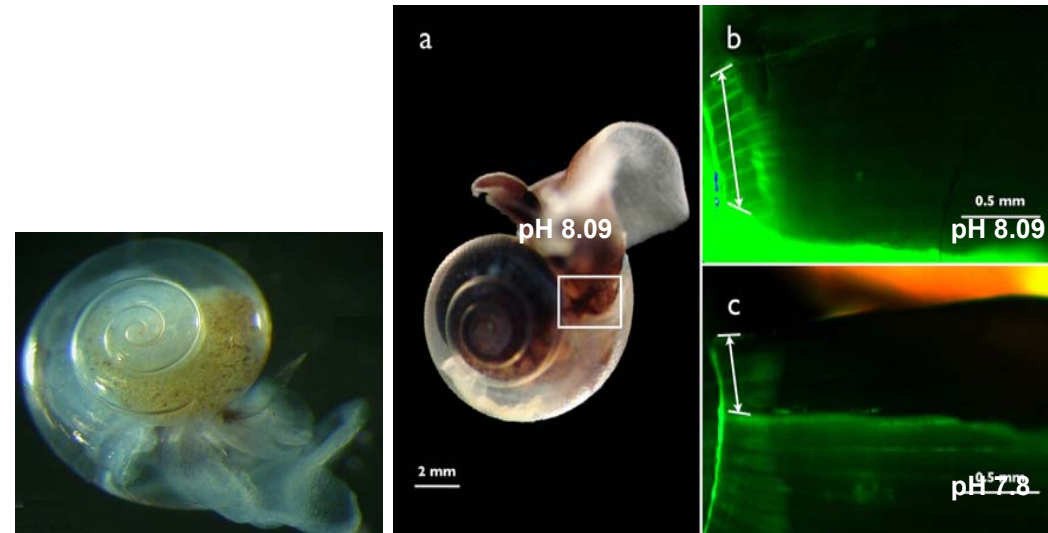
Abnormal krill embryo development

Arm re-growth



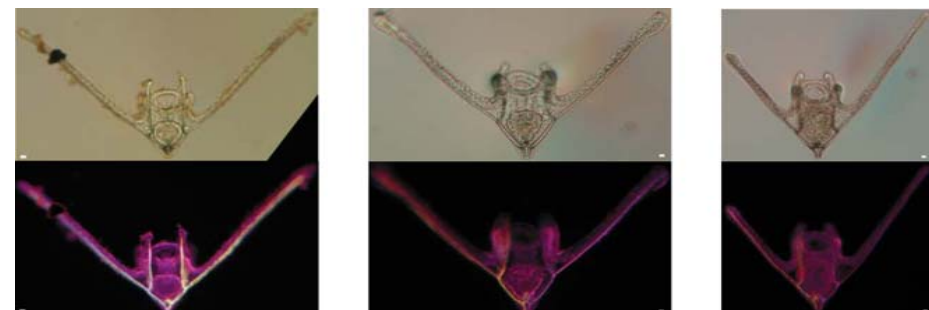
Wood et al. 2008

Pteropods shell growth



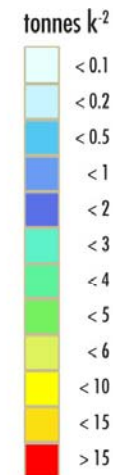
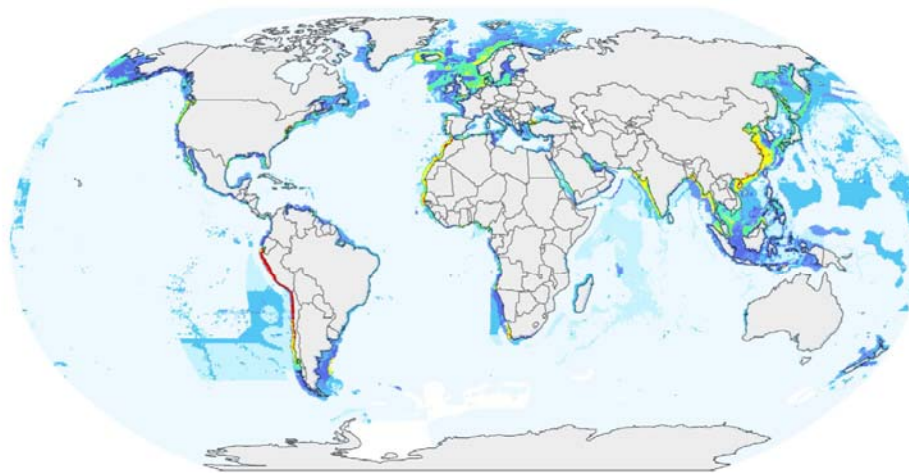
Comeau et al. (2009)

Larval development and survival



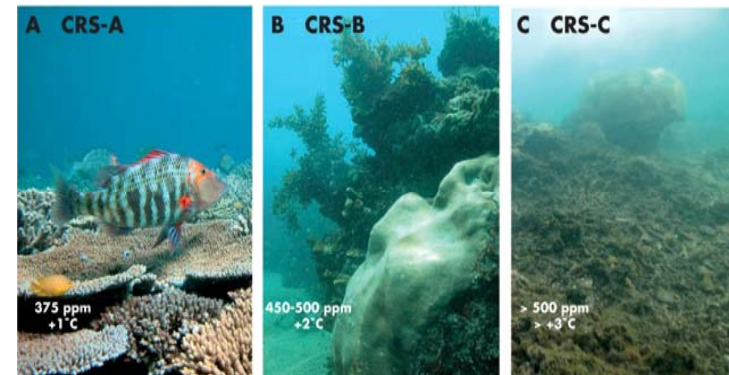
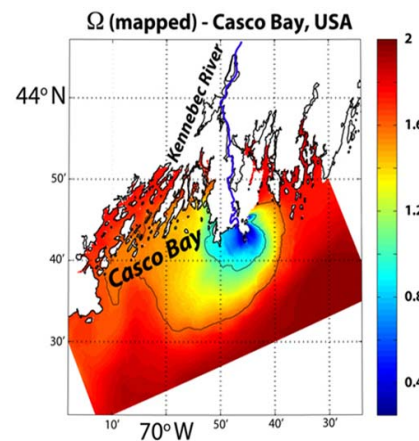
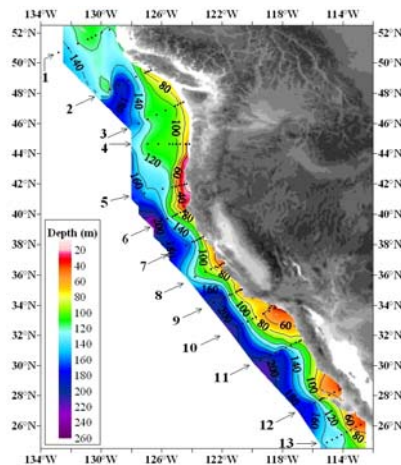
Dupont et al. 2009

World's Fisheries Hotspots



- Strong geographic concurrence of continental shelves, upwelling and the amount of fish caught by fisheries with.....
- Areas vulnerable to early ocean acidification

Data source: Sea Around Us project, (University of British Columbia, <http://www.seaaroundus.org>). Map designed by Dr. Reg Watson (<http://ecomarres.com>). Used with permission.

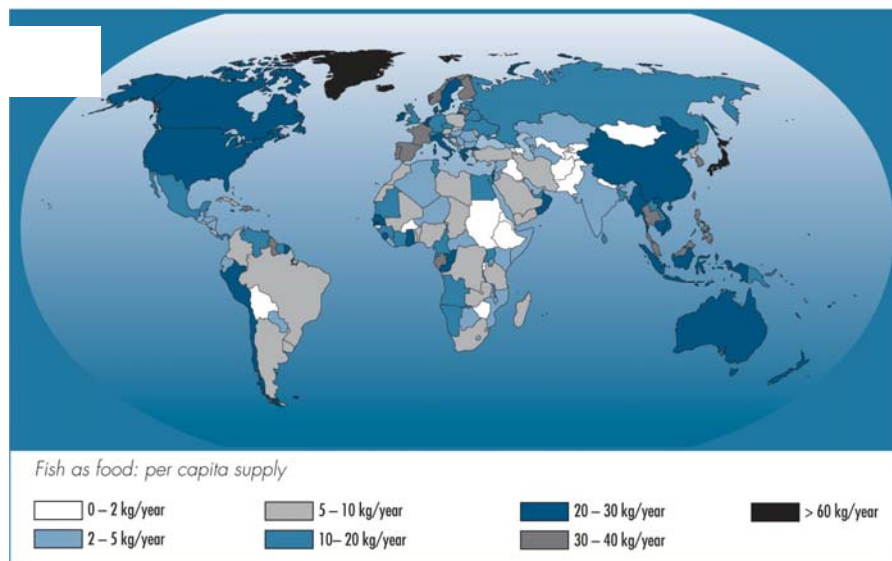


Hoegh-Guldberg *et al.* 2007

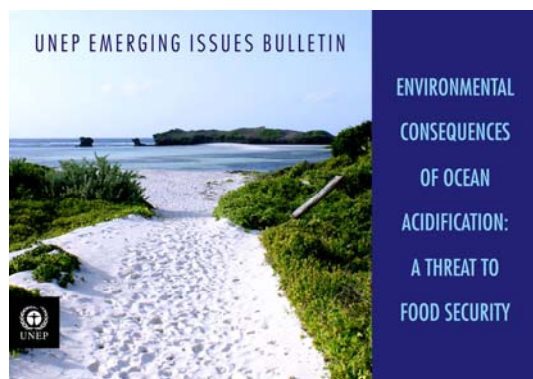
Feely *et al.* Science (2008)

Ocean acidification may impact future food security....

Figure 5: Average per capita fish supply 2003-2005 (in live weight equivalent)



Source: *The State of World Fisheries and Aquaculture, 2008, World Fisheries (FAO22)*



Indirectly through food webs

Directly on food providing organisms

Many countries depend nearly totally on fish as their main protein source

Fish food contribute ~15% of animal protein for 3 billion people worldwide

1 billion depend on fisheries as sole protein source

Aquaculture contribute ~50% of total fish production and rising

Demand for ocean protein anticipated to rise due to increasing world population and growth in coastal populations

Fish stocks already under threat due to over fishing and habitat loss

Ocean acidification is another threat

Economic Valuation of Marine Ecosystems not Easy!

Assessing value of non-market goods and services controversial

Assessing future impact of ocean acidification on goods and services difficult

- Carbon storage
- Coastline & Infrastructure protection
- Tourism
- Extraction of fish & aquaculture
- Health
 - Food security
 - Food quality
 - Harmful algal blooms and toxins

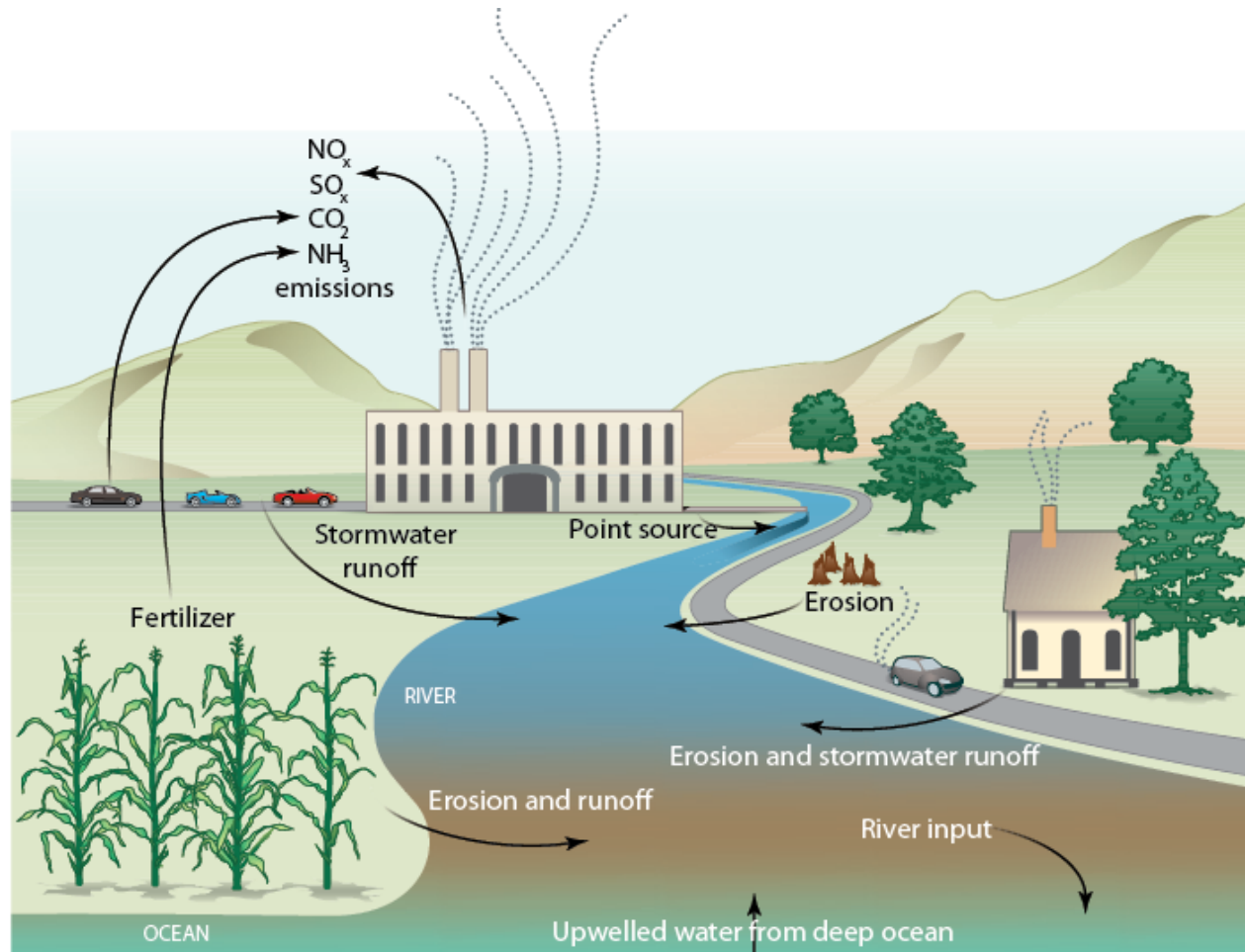
Total Economic Value (TEV) of Hawaiian reefs		
Use values		Non-use values
Direct use values	Indirect use values	Bequest, option and existence values
Extractive (capture fisheries, mariculture, aquarium trade, pharmaceutical). Non extractive (tourism, recreation, research, education, aesthetic)	Biological support to sea bird, turtle, fisheries. Physical protection to other coastal ecosystems, coastline, infrastructure, navigation. Global life-support in terms of carbon storage	Endangered and charismatic species. Threatened reef habitats. Aesthetic reefs. 'Way of life' linked to traditional use

Cesar *et al.* (2002).

What can we do?

- Rapid and substantial *cuts* to man-made CO₂ emissions
- Determine the *vulnerability* to ocean acidification of human communities dependent on marine goods and services
- Identify species that are more *flexible* or *resistant* to change and assess how these may affect ecosystems and food security
- Reduce other *pressures* on ecosystems and food fish stocks
- Embrace the science of ocean acidification into *marine and fisheries management* tools
- *Value* marine ecosystem services
- Increase *awareness* stakeholder engagement

Mitigating Local Ocean Acidification

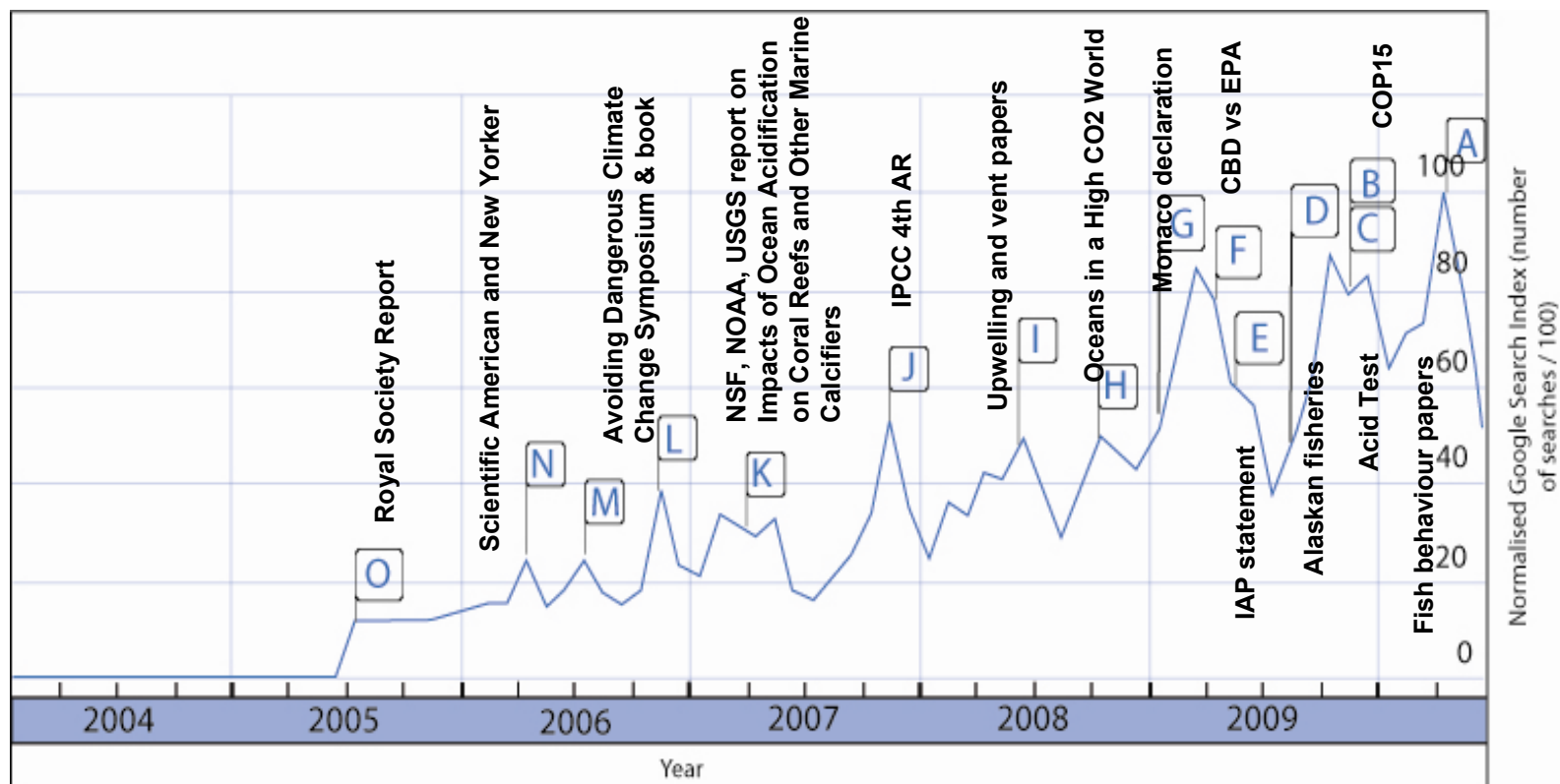


Reduce local sources of acidification where possible..

.. but what are the costs of doing this vs costs of CO_2 emissions reduction?

...and will it work?

Raise Awareness – growing outreach and impact



O= Royal Society Report

N= Scientific American and New Yorker

M and L = Avoiding Dangerous Climate Change Symposium & book

K= NSF, NOAA, USGS report on Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers

J= IPCC 4th Assessment Report on Climate Change

I= Key articles e.g. upwelling of high CO₂ water off the west coast on North America and vulnerability of calcifiers around natural CO₂ vents

H= Oceans in a High CO₂ World symposium,

G= Monaco declaration

F =CBD legal proceedings against the EPA,

E= Interacademy Statement on ocean acidification,

D= threat of high CO₂ waters to Alaskan fisheries,

C= launch of the Film 'Acid Test',

B= Oceans Day and other ocean acidification activities during COP15.

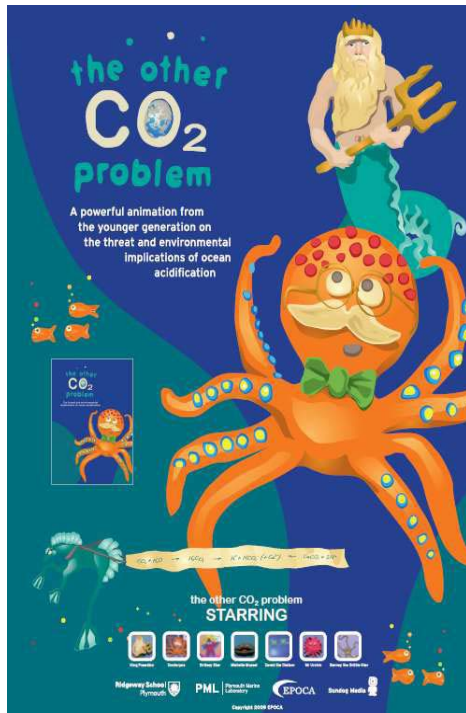
A= Paper on fish behavioural response to predators under high CO₂

The increasing baseline interest in ocean acidification since 2004 will also be in response to the increasing numbers of research publications over this period stimulating increasing 'take-up' by stakeholders.

Turley and Boot (in press) OUP Book on Ocean Acidification (Gattuso and Hansson eds.)

Stakeholder Concern and Engagement

Fishermen and Mariners.....



Ridgeway School,
Plymouth

..... and School Children



Films



Ocean acidification: Connecting science, industry, policy and public <http://www.youtube.com/user/PMLAdministrator?feature=mhee>.



The Ocean in a High-CO₂ World

Ocean Acidification

Third Symposium • Monterey • California • 24-27 September • 2012



**Future: science symposia and research
to include socio-economics
and policy outreach
as well as impacts**



UK Ocean Acidification
Research Programme

