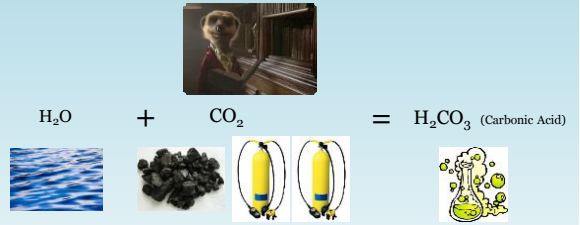


# What should we do about ocean acidification on the South Coast?

Katherine Schmutter  
Fenner School of Environment and Society

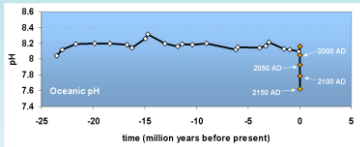


## Understanding what causes ocean acidification is simple



## Very rapid ocean acidification

**H** The ocean is acidifying more rapidly than it has in millions of years [HIGH CONFIDENCE]



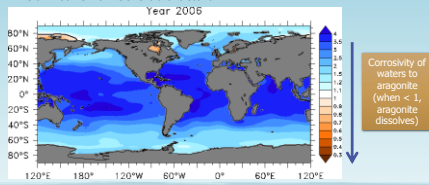
Turley et al., 2006

## Is such a small change in pH significant?

pH		
1	concentrated sulfuric acid	
2	lemon juice	

## Polar oceans become corrosive to shell material within decades

Models project that cold waters soon become corrosive to aragonite, a (CaCO<sub>3</sub>) mineral in some marine shells & skeletons



Animation Copyright James C. Orr

Latest model projections (IPCC AR5 WG1, 2013)

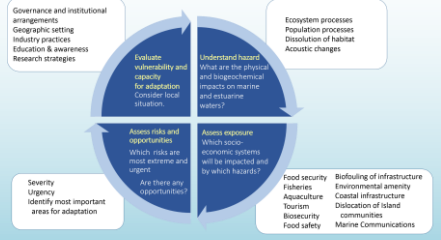
Confirms original warnings: Orr et al. (2005), Caldeira & Wickett (2005), Steinhilber et al. (2009)

see also: Bopp et al. (2013)

## So what can we do about it?

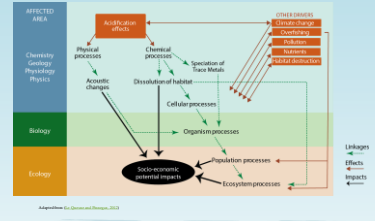
Less CO<sub>2</sub> emissions would be best— but if that doesn't happen

### A framework to evaluate effective responses



### Understanding the Hazard

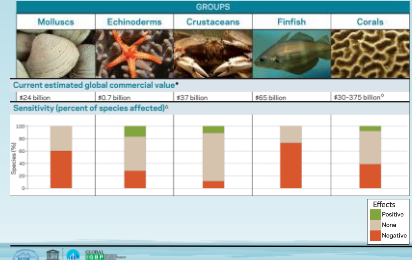
#### Potential effects of ocean acidification on socio-economic systems



### The Four Hazards

- Population processes** – Some organisms will be reduced, some will increase
- Ecosystem processes** – Many changes result in shifts of entire ecosystems
- Dissolution of habitat** – Calcium carbonate reefs and atolls dissolve faster than they grow
- Acoustic changes** - The overall effect is that sea water absorbs less low and mid-frequency sound making these sounds louder at further distances.

### Direct effects on populations



### Indirect effects - ecosystem shifts!

**If species are harmed**  
 Research shows krill could potentially be harmed  
 Krill form the base of the food chain for many marine animals

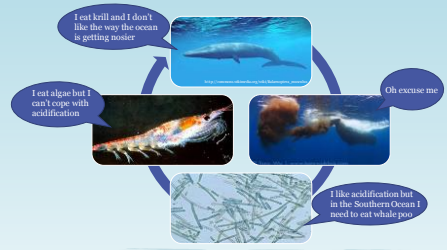
**This could affect many other species like Blue Whales**

*I can't cope*

*Oh no, I only eat krill*

Lab experiments show at increasing levels of acidification larval development was disrupted and no larvae hatched successfully (Kroegelsch et al., 2011)

### Reduce one and reduce them all – indirect effects



Some species grow too much and can damage ecosystems

Too many jelly fish



Thousands of jellyfish wash up onto the beach at Bells Beach on the Redcliffe Peninsula. Photo: Andrew Saltmarsh

Too much algae



If nutrients are present acidic oceans can increase algal blooms. Photo: AFP - Sydney Morning Herald

What might happen in Merimbula?



What already happened in British Columbia Canada?

By Glenda Laymes, The Province February 17, 2015

**B.C.'s shellfish industry is struggling for survival as it deals with rising ocean temperature and acidification.**

Despite insatiable demand, many are concerned B.C.'s once-thriving shellfish industry could be sinking.

"I'd say it's full-scale panic mode (for scallop farmers)," said Rob Saunders, CEO of Qualicum Beach-based Island Scallops.

The company has seen its scallop death rates rise to nearly 95 per cent since 2010, leading to millions of dollars in losses. Ocean acidification — a worldwide problem — is likely to blame.

Saunders said the company's butcheries, which produce scallop, oyster, prawn and sea urchin "seeds," have also had trouble with increased deaths. In order to grow, the B.C. industry must double its seed production.

What might happen to our oysters?

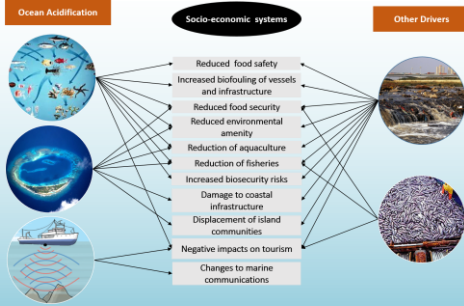


Pacific Oysters *Crassostrea gigas*  
Can out-compete Sydney Rock Oysters *more easily* under high levels of acidification

Organism	Population processes	Ecosystem processes	Potential effect
Oysters	Adults and juveniles have shown reduced calcification, growth and survival rates (Gardner, 2013).  Some species have become locally extinct.  In early stages of acidification will outcompete Sydney Rock oysters due to higher resilience.	Impact of organism on ecosystem Oysters provide habitats for other organism and food for other organisms. If populations of oysters decrease, populations of algae may increase.  Speciation of trace metals may both increase the amount of algae due to increasing nutrients and increase the uptake of metals by algae. This could potentially be toxic to oysters or make consumption oysters toxic to other organisms (Lilland, et al., 2009).  Impact of ecosystem on organism Chen et al. (2011) found that a red tide alga (Phaeocystis globosa) that often forms blooms in or adjacent to coastal waters. Algal blooms can introduce toxins to oysters which can have a negative effects and/or make the organism toxic for human consumption.	Population reduced or extinct, increased toxicity if algal blooms increase and/or trace metals are present. Reduction in habitat and food for other organisms. Reduced water quality due to increased survival of algae.
Sydney Rock Oyster <i>Saxostrea glomerata</i> Also known as <i>Crassostrea glomerata</i>	As pCO <sub>2</sub> increased, fertilization significantly decreased. There was also an effect (negative) of pCO <sub>2</sub> and on embryonic development (Fisher et al., 2009)	A survey of 54 sites revealed elevated levels of metals in areas where industrial or domestic discharges occurred. This oyster exhibits an unusually great capacity to accumulate a range of elements (that could be toxic to humans if ingested) (Phillips, 1973).	Population reduced or extinct, significantly increased toxicity if trace metals are present.

More species <http://lists.ala.org.au/speciesListItem/list/dr217>

Assessing Exposure



Assessing Risk

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Low	High	Extreme	Extreme	Catastrophic
Likely	Low	Moderate	High	Extreme	Catastrophic
Moderate	Low	Moderate	High	Extreme	Extreme
Unlikely	Low	Low	Moderate	High	Extreme
Rare	Low	Low	Moderate	High	High

## Evaluate communities vulnerability and options for adaptation

### What options could we consider for the South Coast?

- Innovation in aquaculture – on land, multi-trophic, genetic modification, different species?
- Changes to regulations for waste water?
- Artificial reefs?

## Strategies to respond to ocean acidification

From Hatchery international January 2015  
Quentin Dod

Taylor Shellfish in Washington state is circumventing the effects of ocean acidification – thanks in part to expanded hatchery facilities in Hawaii. Company spokesperson Bill Dewey told HI that Taylor Shellfish now has three 30-bin flupsies (floating upwelling system) in operation at the Humboldt mill site.



Though the bins in each unit are not large, measuring about .75 metres square and little more than a metre deep, each can be filled with large quantities of seed oysters – if the water conditions are right.

"It can be anywhere from 100,000 to 300,000 oysters in each bin," he said.

## Encourage diversity and profit through multi-trophic aquaculture



Sea cucumbers can help counter the effects of local ocean acidification through their digestive processes and provide nutrients for fish by recycling sea floor sediments. They can be grown in conjunction with abalone or oysters. Dried they sell for \$298 per kilo on e-bay. Current NSW regulations have deterred oyster growers from growing sea cucumbers.

news.warriornationals Geographic.com/04/2013/03/award-wild-eating-habits-of-california-sea-cucumbers-0204031303.jpg

### Lucrative Pacific ocean sea cucumber over-exploited

<http://www.earthtimes.com/2013/03/award-wild-eating-habits-of-california-sea-cucumbers-0204031303.jpg>

## What oyster growers did in Oregon

<https://vimeo.com/72804703>