

Warren Joubert

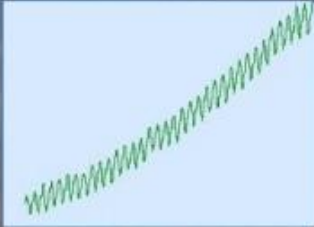
Ocean Acidification



South African
Weather Service

ISO 9001 Certified Organisation

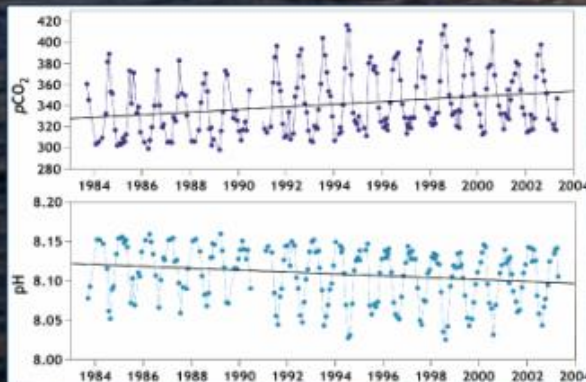
What is Ocean Acidification?



This is resulting in increased carbon dioxide (CO_2) in the atmosphere causing global warming

Mankind is burning fossil fuel

Oceans are vast and are taking up the CO_2



When CO_2 is added to water it becomes an acid...











...so the oceans have become 30% more acidic, lowering the pH of seawater

...by 2060 the oceans could become 120% more acidic

Ocean acidification chemistry



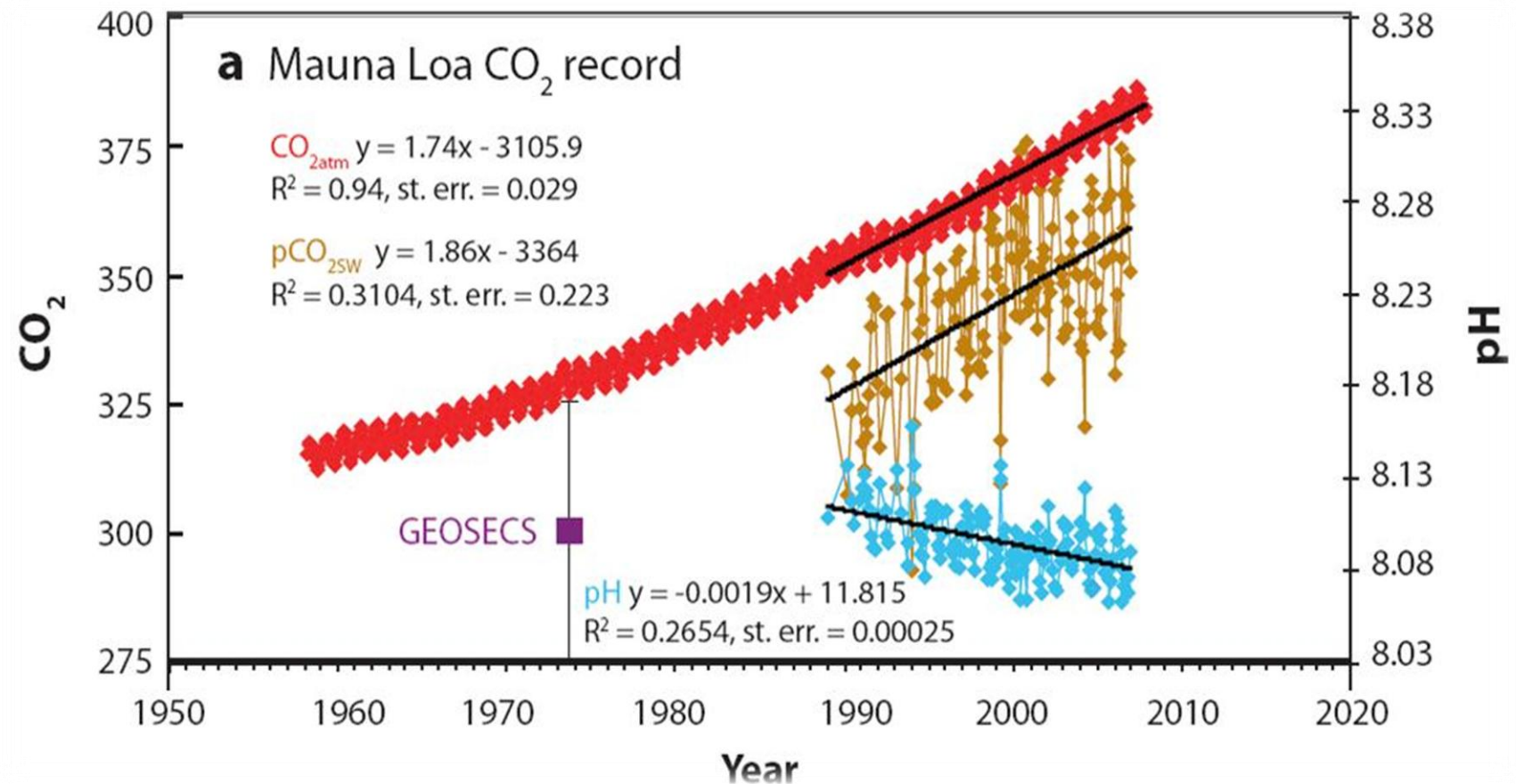
OA impacts

Taxa	Response	Mean Effect	
 Calcifying algae	Survival		Not tested or too few studies
	Calcification		Enhanced <25%
	Growth		95% CI overlaps 0
	Photosynthesis	-28%	Reduced <25%
 Corals	Abundance	-80%	Reduced >25%
	Survival		
	Calcification	-32%	Reduced <25%
	Growth		95% CI overlaps 0
 Coccolithophores	Photosynthesis		
	Abundance		
	Survival		
	Calcification	-23%	Reduced <25%
 Mollusks	Growth		
	Photosynthesis		
	Abundance		
	Development	-25%	Reduced <25%
 Echinoderms	Survival		
	Calcification		
	Growth	-10%	Reduced <25%
	Development	-11%	Reduced <25%
 Crustaceans	Abundance		
	Survival		
	Calcification		
	Growth		
 Fish	Development		
	Abundance		
	Survival		
	Calcification		
 Fleshy algae	Growth		
	Photosynthesis	+22%	Enhanced <25%
	Abundance		
	Survival		
 Seagrasses	Calcification		
	Growth		
	Photosynthesis		
	Abundance		
 Diatoms	Survival		
	Calcification		
	Growth	+17%	Enhanced <25%
	Photosynthesis	+12%	Enhanced <25%
	Abundance		

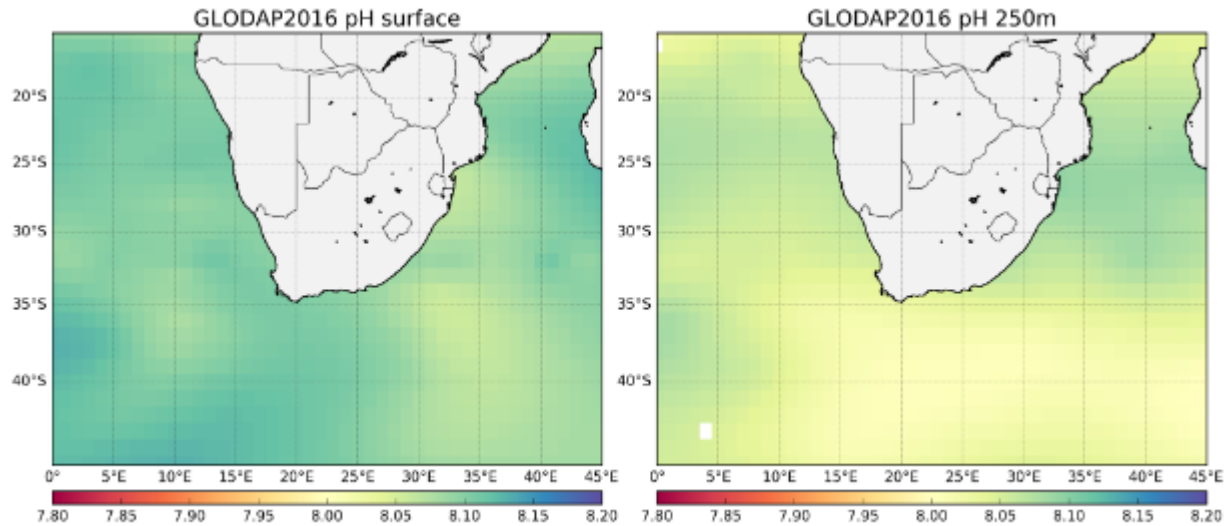
- Single-species experiments
- Big focus on calcification

Fig. 4 Summary of effects of acidification among key taxonomic groups. Effects are represented as either mean percent (+)

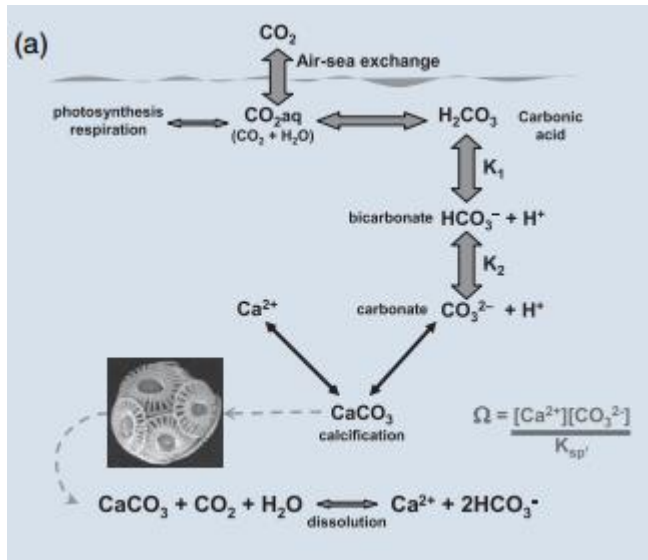
Historic Records for OA



pH climatology South Africa



Mineral Saturation



Saturation State – degree to which seawater is saturated (or not) with relevant ions; provides a measure of the thermodynamic potential for the mineral to form or to dissolve

$\Omega > 1$ Supersaturated with respect to CaCO_3

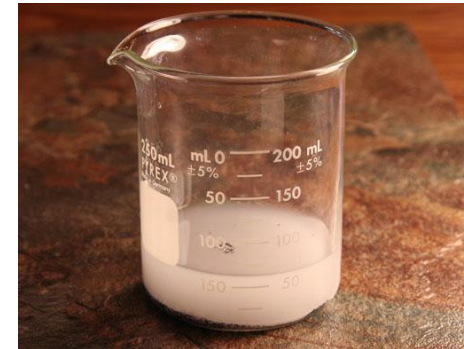
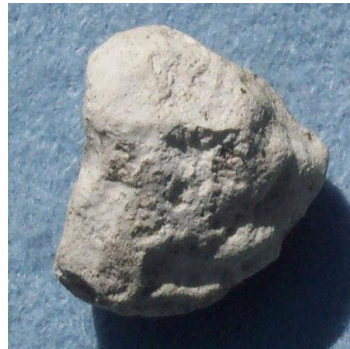
$\Omega < 1$ Undersaturated with respect to CaCO_3 (dissolution)

Equilibrium

Saturation states

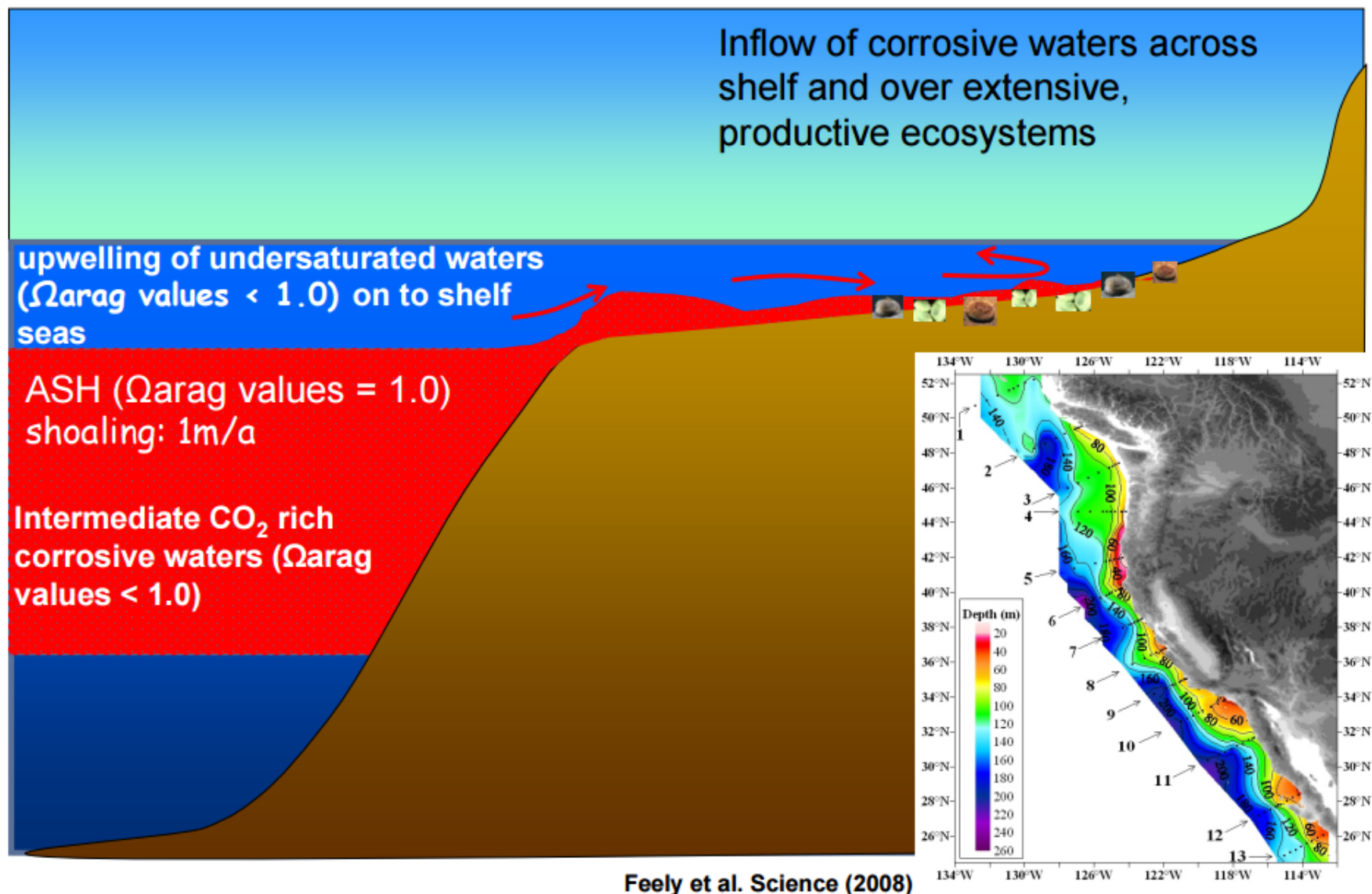


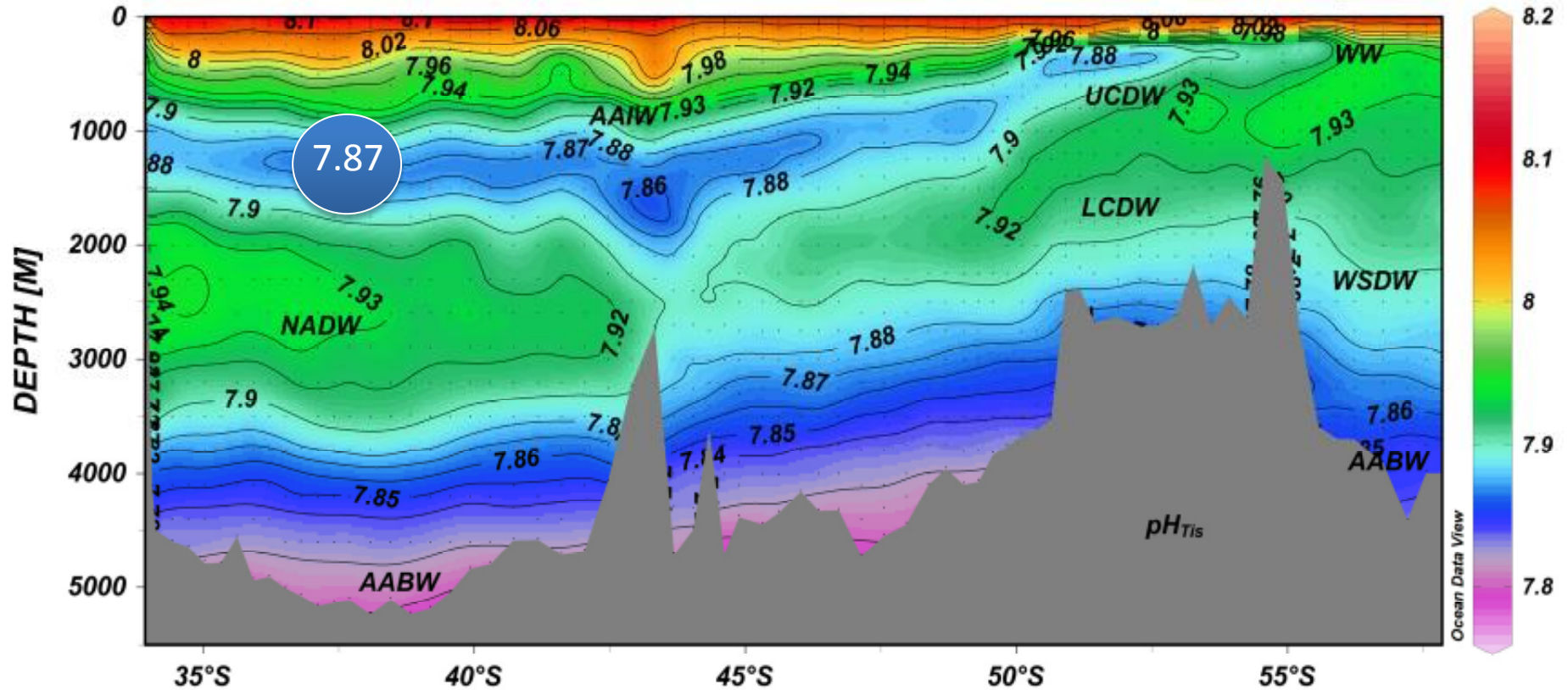
$$\Omega = \frac{[\text{Ca}^{2+}][\text{CO}_3^{2-}]}{K_{sp'}}$$



>1 <1

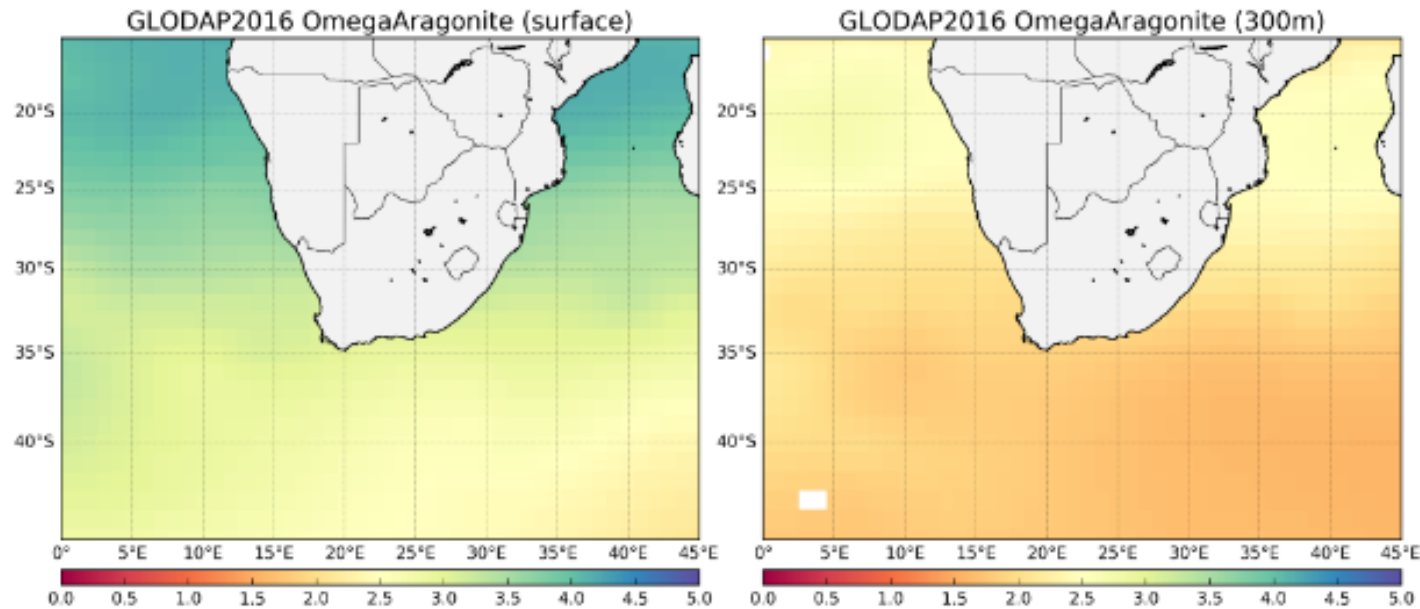
Seasonal Invasion of Corrosive Waters on West Coast North America





M. Gonzalez-Davilla *Biogeosciences*, 8, 2011
Carbonate system of the Southern Ocean, Atlantic Sector

Aragonite Saturation Horizon



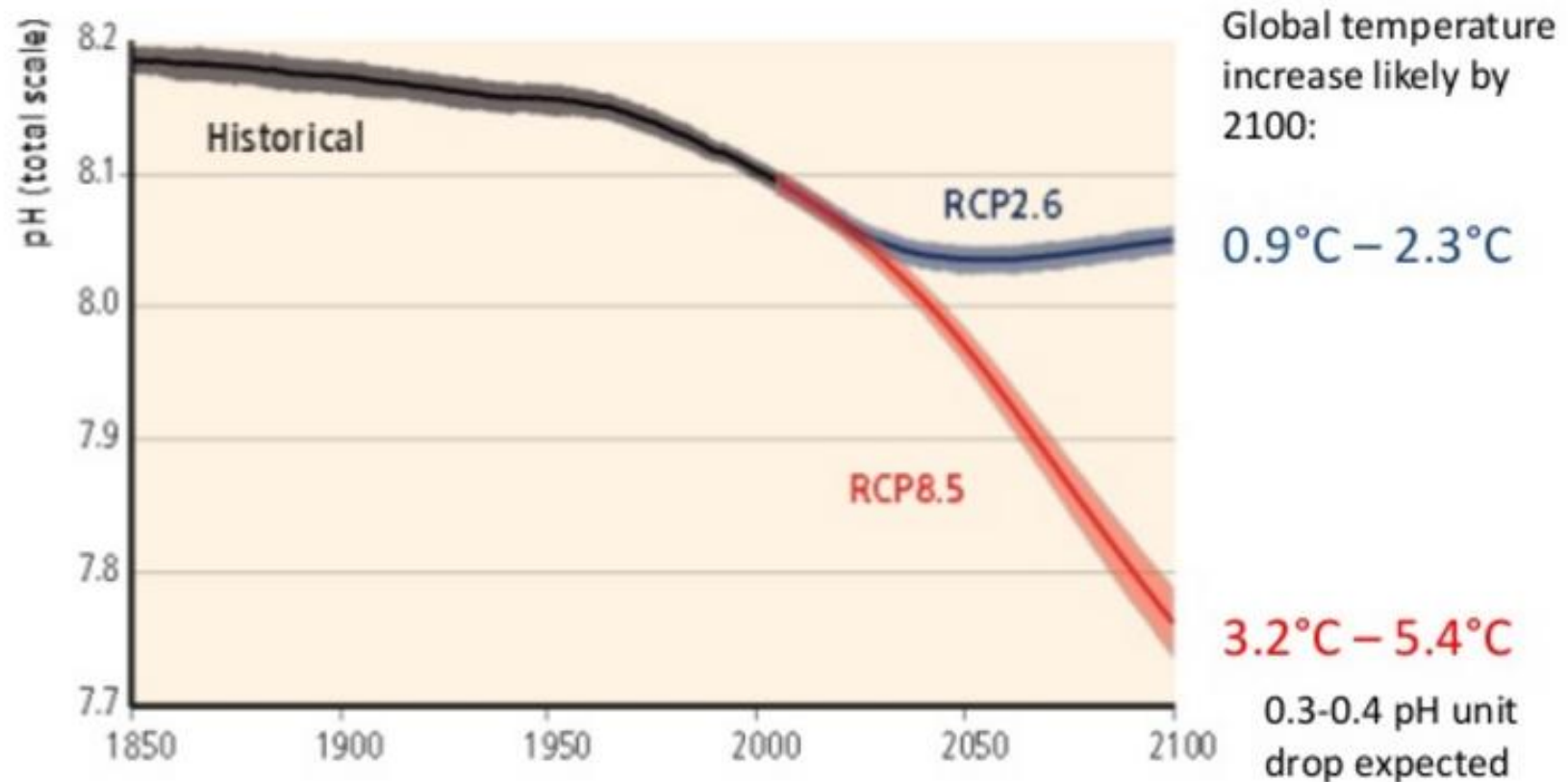
Depth at which Aragonite saturation becomes undersaturated is roughly between 200 – 300m.

Upwelling introduces low pH, undersaturated waters into coastal surface waters.

Shoaling of the Aragonite saturation horizon potential

IPCC Projections for 2100

- Anthropogenic Ocean acidification is currently in progress and its measurable
- Reducing CO₂ emission will slow the process of ocean acidification



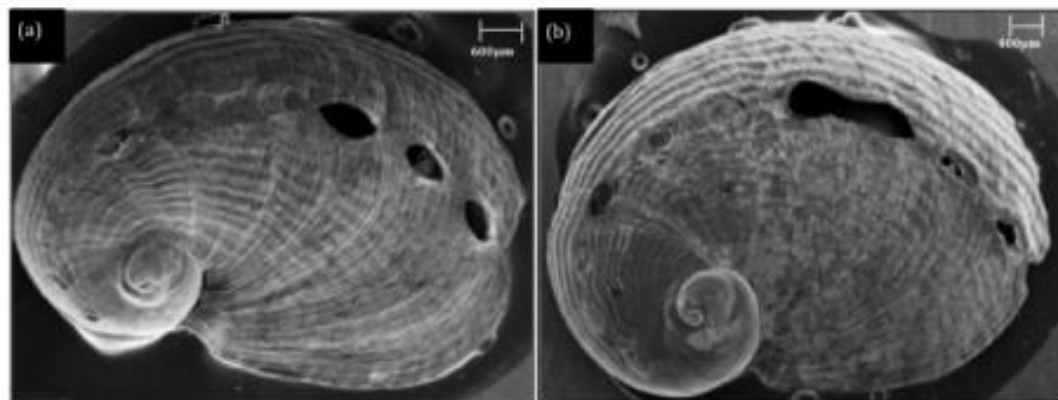
In summary

- Very high certainty that oceans will have lower pH (become more acidic).
- Knowledge of biological impacts are based on single species experiments, and little is known about whole ecosystem responses, multistressors and evolutionary adaptation advantages.
- Impacts of OA on biogeochemical cycles, foodwebs and ecosystems are uncertain
- Propagation of effects through the foodweb, as well as direct effects on commercial species and subsistence fishing
- Socio-Economic impacts are expected but its costs are uncertain

Thank you



Abalone subjected to natural pH variability – but what will be the long term impacts of lower pH and changing SST?



SEM pic showing some shell dissolution at low pH (7.6) after 48 hours (Nina Lester, Mike Lucas)

Project funded by the Abalone Farmers Association of South Africa (AFASA)

Economically important marine species



Acid–base balance and changes in haemolymph properties of the South African rock lobsters, *Jasus lalandii*, a palinurid decapod, during chronic hypercapnia



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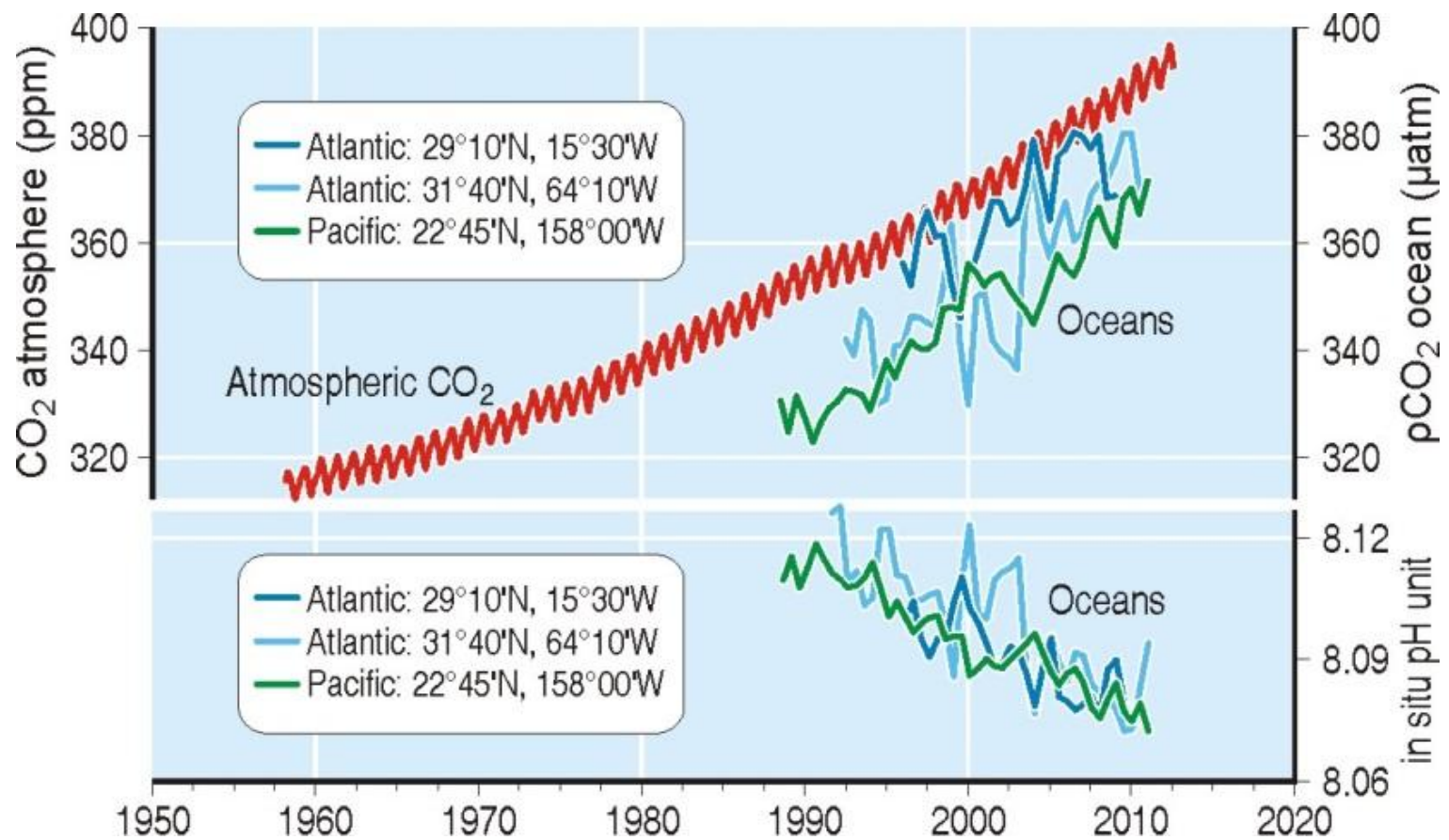
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Physiological responses



Adapted from IPCC 2014