

Ocean acidification and its impacts on marine ecosystems

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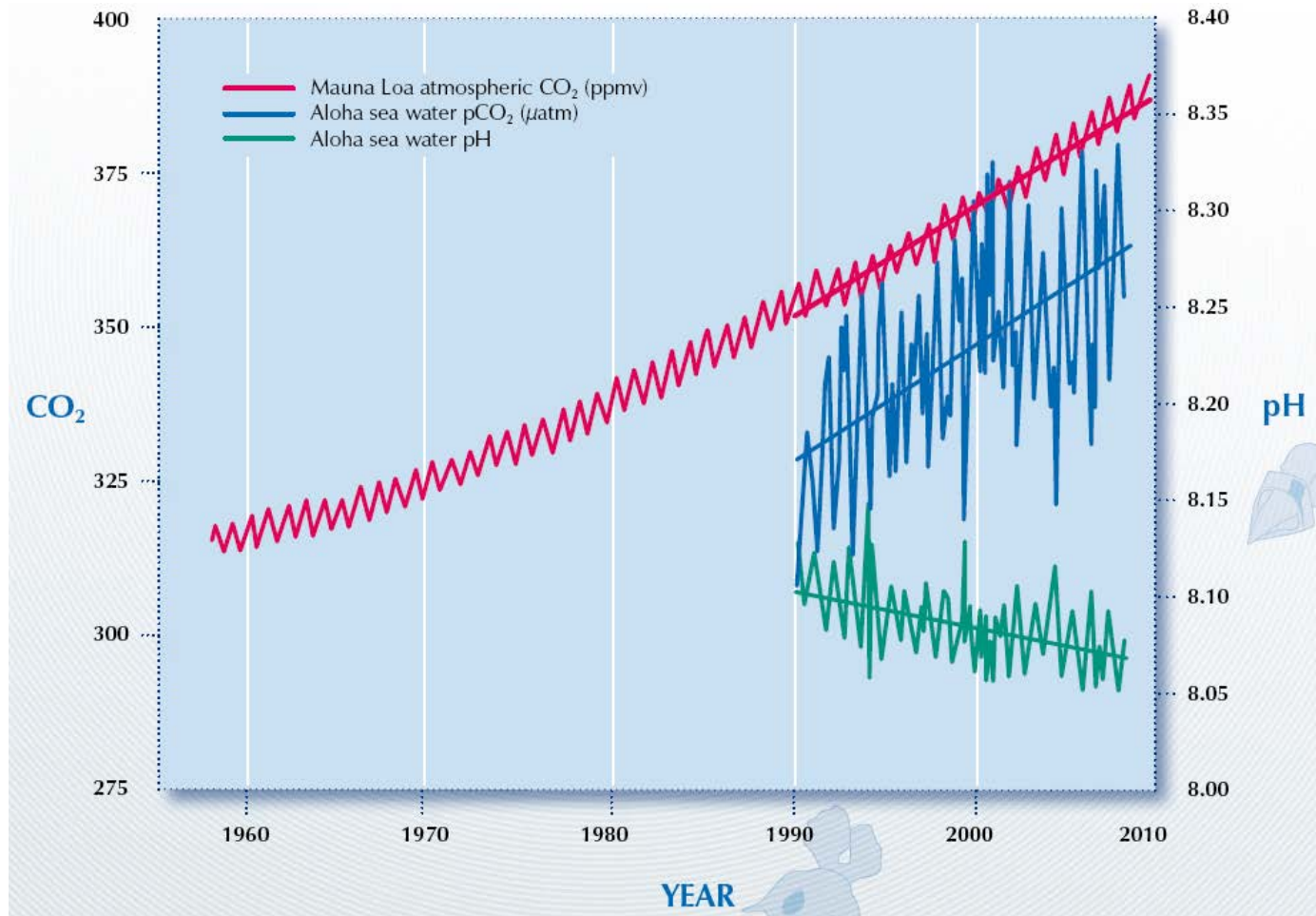
SDG14: Conserve our Oceans



- Largest ecosystem on the planet and crucial to all life on earth.
- Regulate the climate.
- Produces a sixth of all animal protein we consume.
- Provides livelihoods for ~ 3 billion people worldwide.
- Worth an estimated \$US 3 trillion - \$US 6 trillion to the global economy.



The ocean is changing at an unprecedented rate.



The ocean acidification process

Atmospheric
 CO_2



CO_2 dissolves in
water

CO_2 (aq)

Forms Carbonic
Acid

H_2CO_3

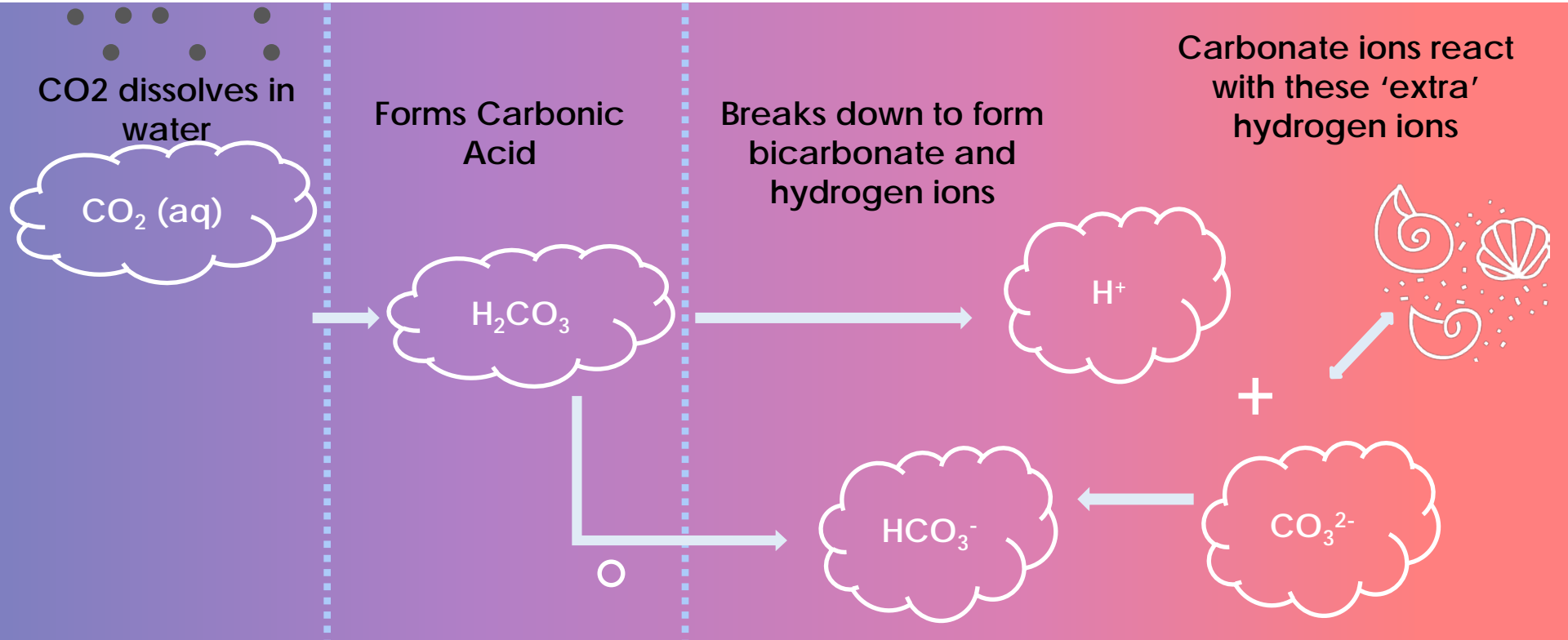
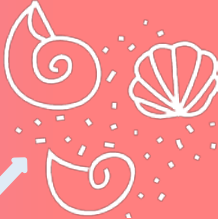
Breaks down to form
bicarbonate and
hydrogen ions

H^+

HCO_3^-

CO_3^{2-}

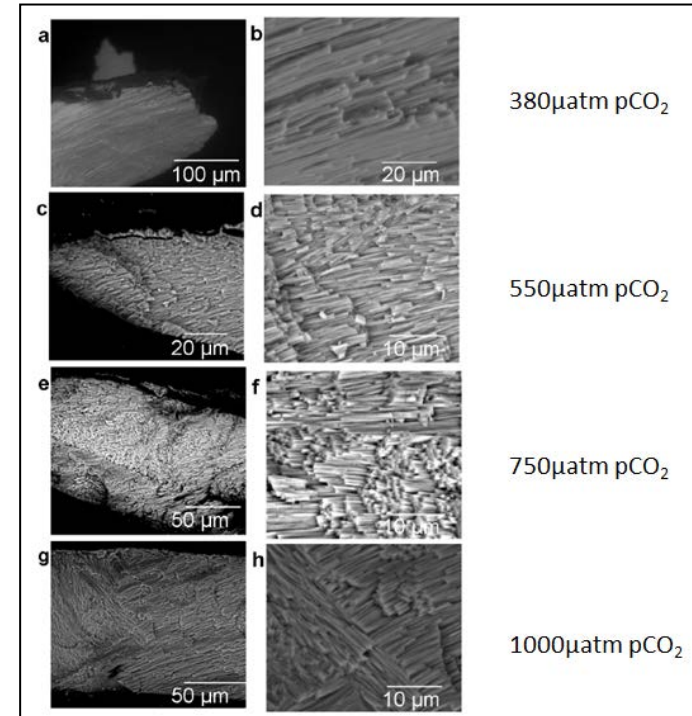
Carbonate ions react
with these 'extra'
hydrogen ions



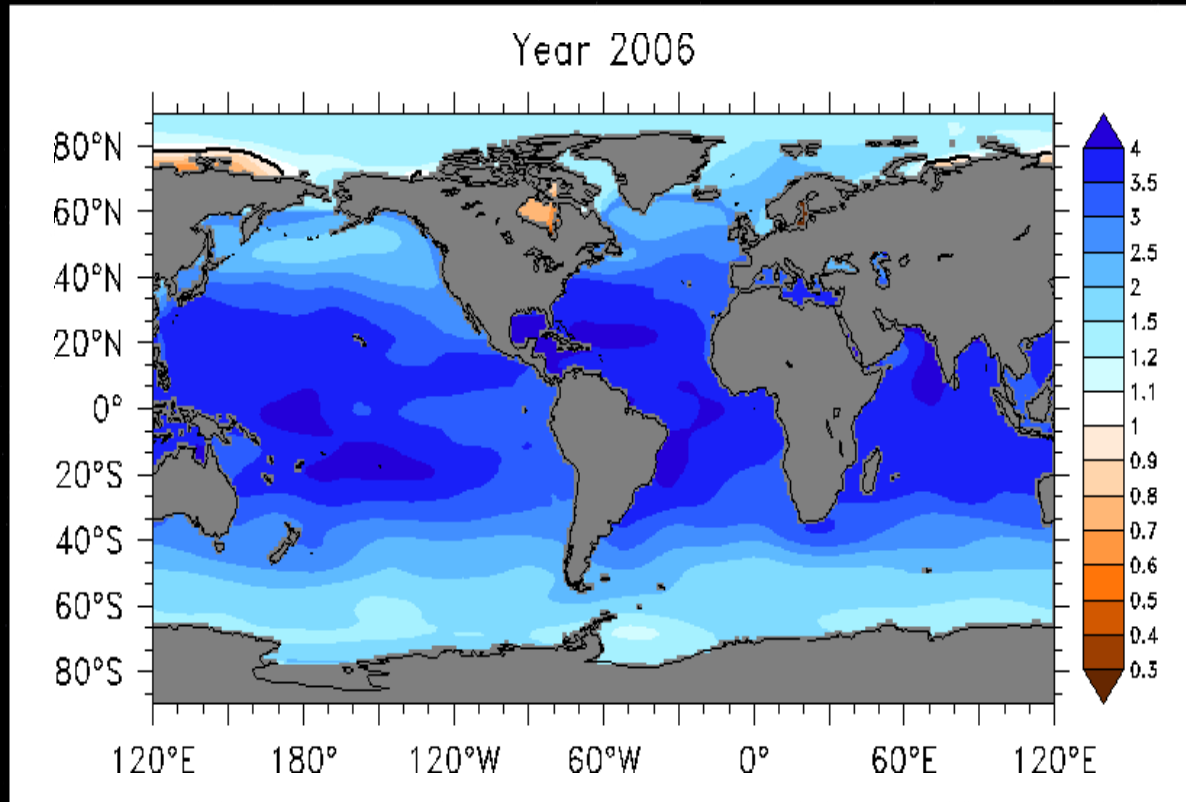
Ocean acidification affects calcification



$$\text{CaCO}_3 \text{ saturation state } (\Omega) = \frac{[\text{Ca}^{2+}][\text{CO}_3^{2-}]}{K_{sp}}$$



Polar oceans will become corrosive to shell material within decades.



Corrosivity of
waters to aragonite

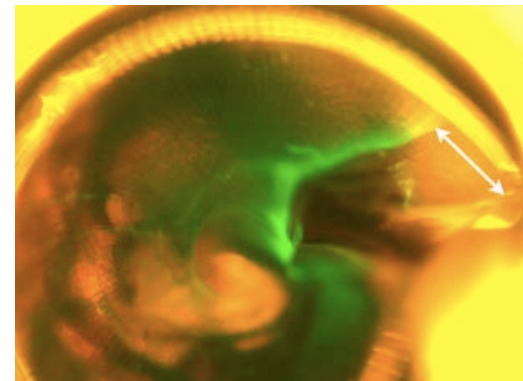
(when < 1, aragonite dissolves)

Models project that cold waters soon become corrosive to aragonite, a (CaCO_3) mineral in some marine shells & skeletons. **Latest model projections (IPCC AR5 WG1, 2013)**

Ocean acidification is happening first and fastest in the Arctic



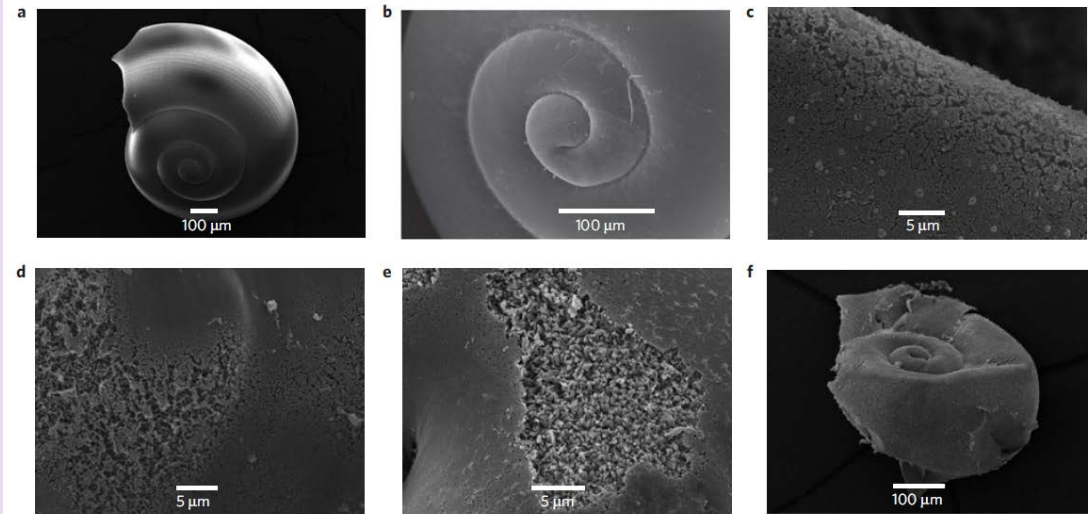
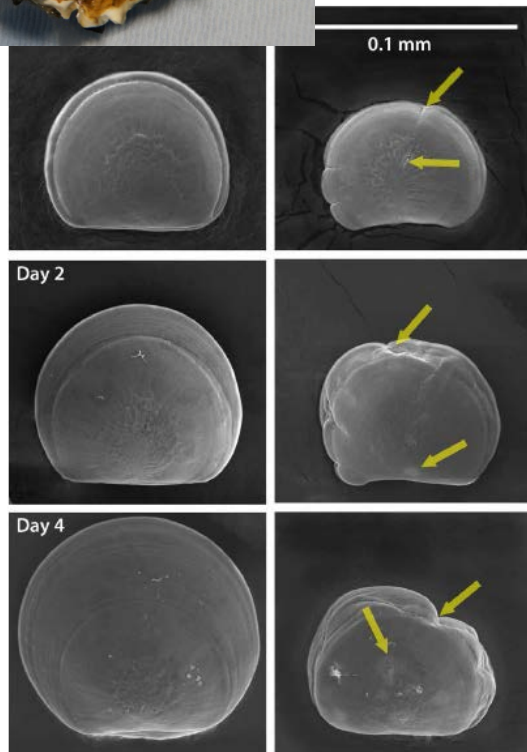
Over much of the Arctic, the pteropod *Limacina helicina* will become unable to precipitate CaCO_3 by the end of the century under the RCP 8.5 scenario.



Ocean acidification affects already visible



The US west coast shellfish industry is seeing unprecedented levels of larval mortality in commercial hatcheries— linked to lower $\Omega_{\text{aragonite}}$.

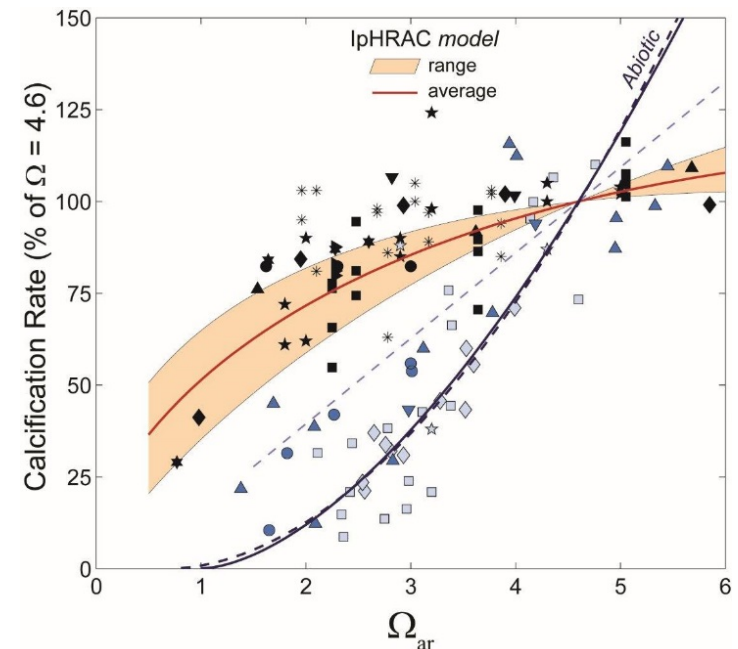


Dissolution of pteropod shells already observable in the Southern Ocean and the Californian upwelling.

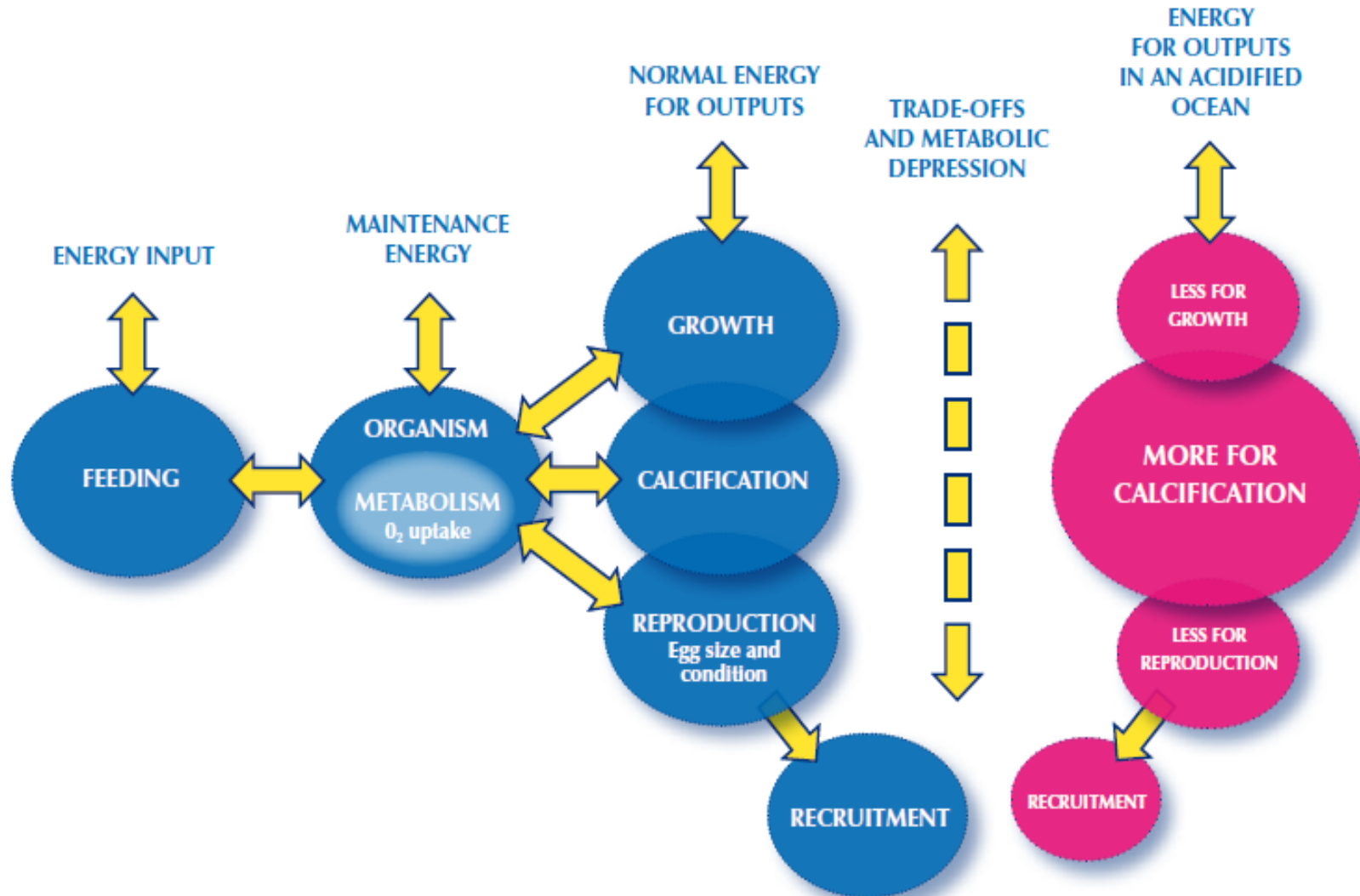
OA affects on corals - a particular concern.



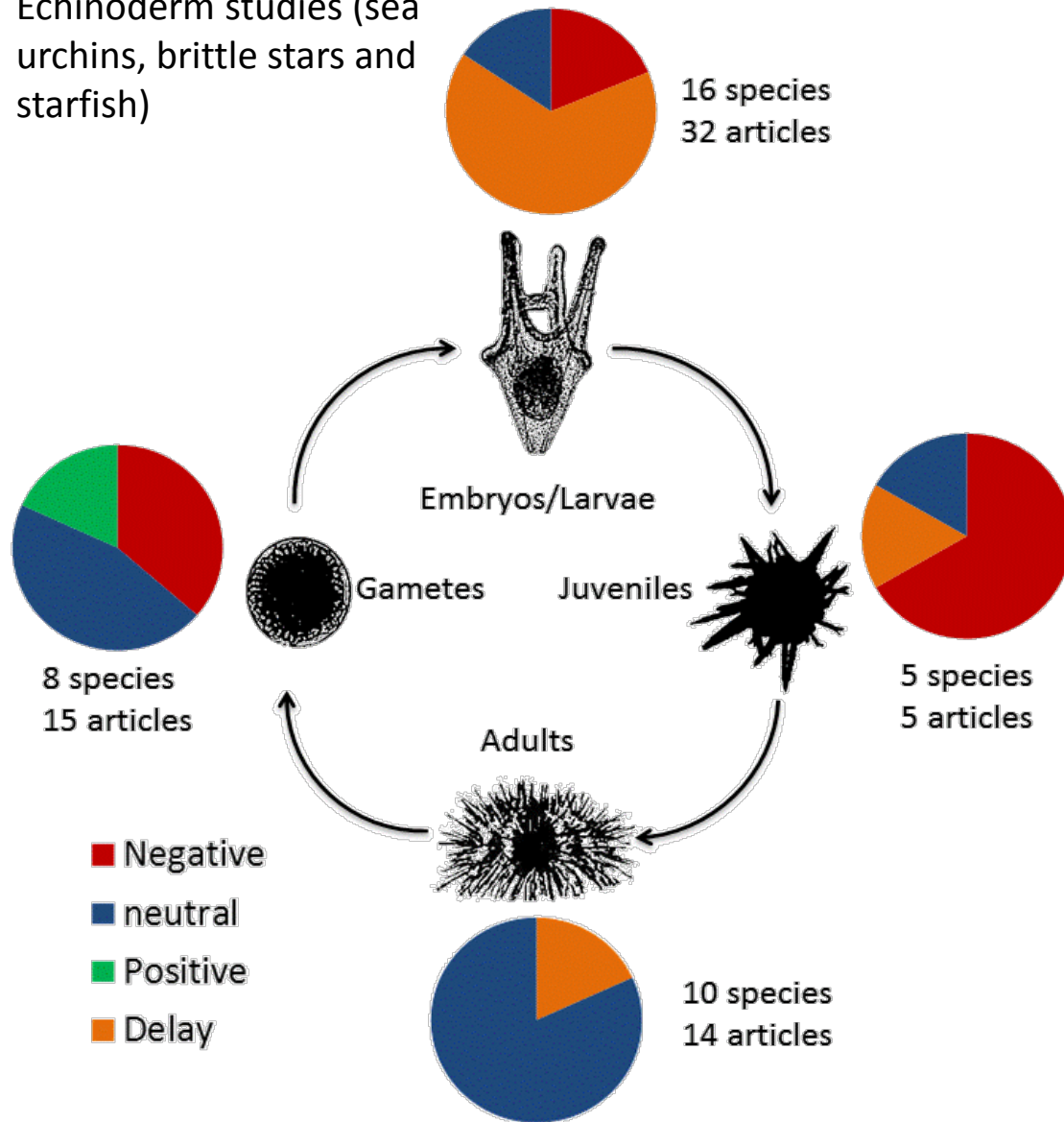
- Coral reefs cover 0.1% of the ocean but house over 25% of marine biodiversity (> million species).
- Warm-water coral reefs are already under stress, with >50% currently in poor health.
- OA slows calcification, and hence recovery from bleaching.



Energetic cost of ocean acidification.

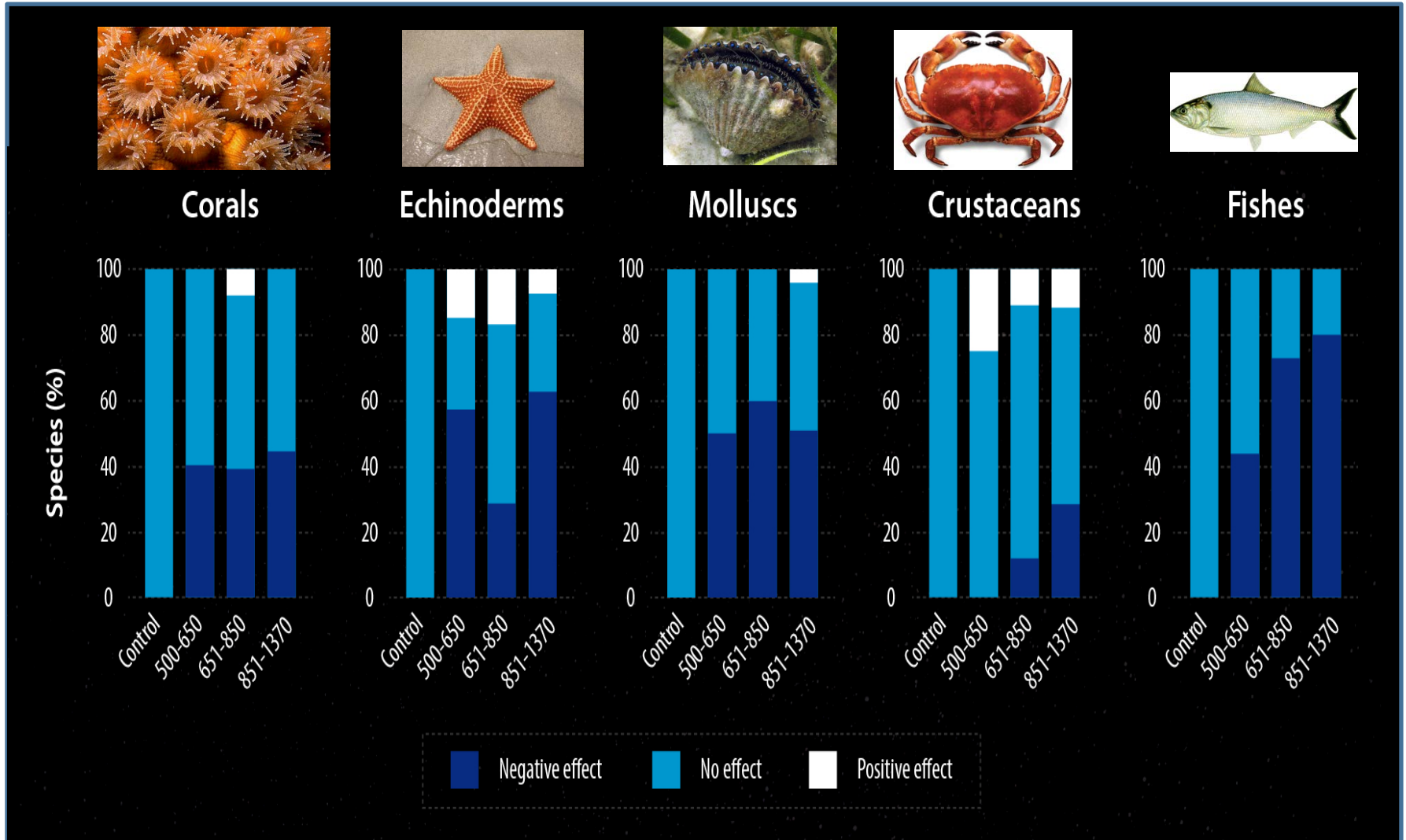


Echinoderm studies (sea urchins, brittle stars and starfish)



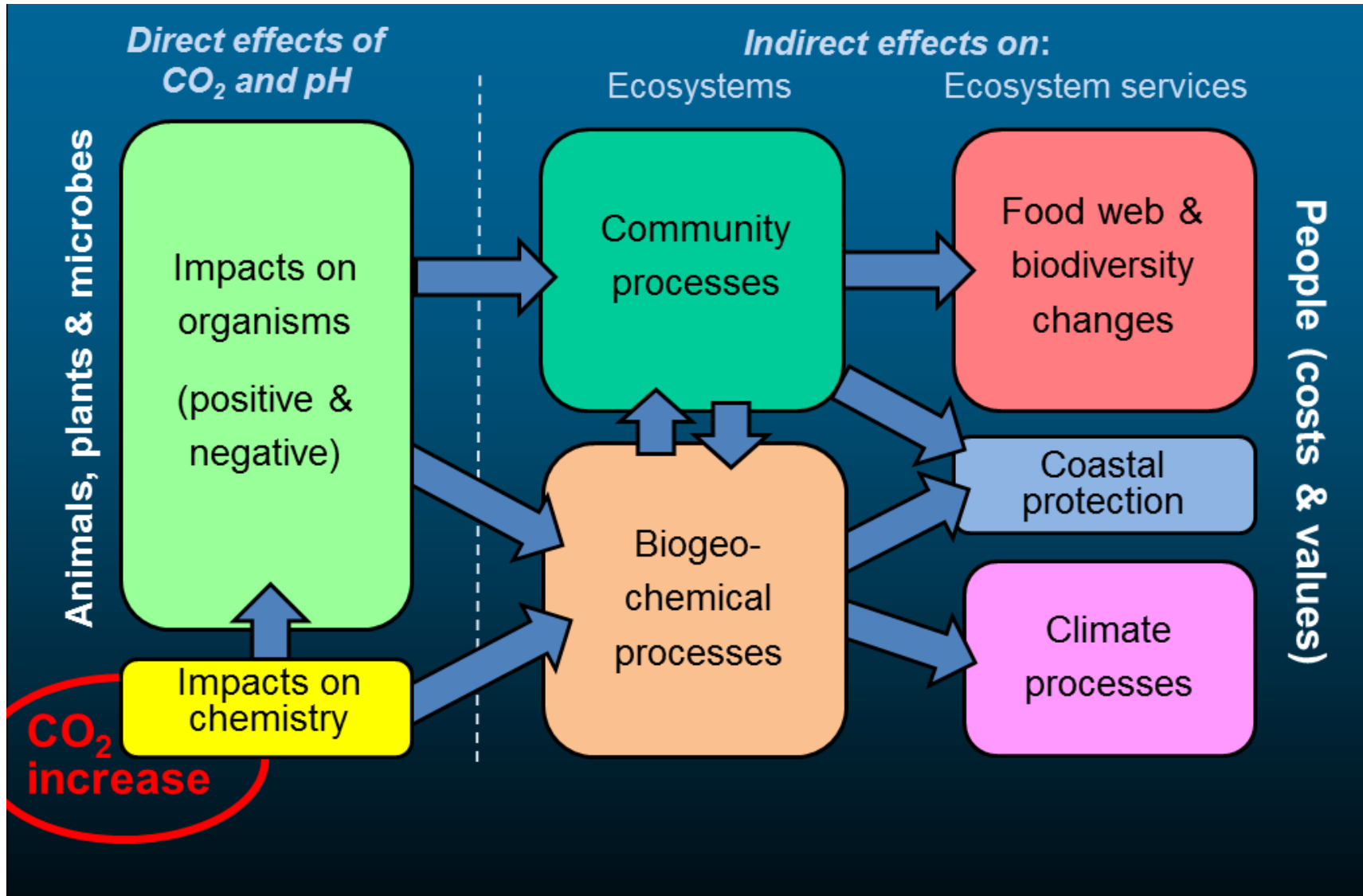
Early life stages – embryos, larvae and juveniles – may be much more sensitive to OA than adults

Over 50% benthic invertebrates and fish species studied to date at risk.

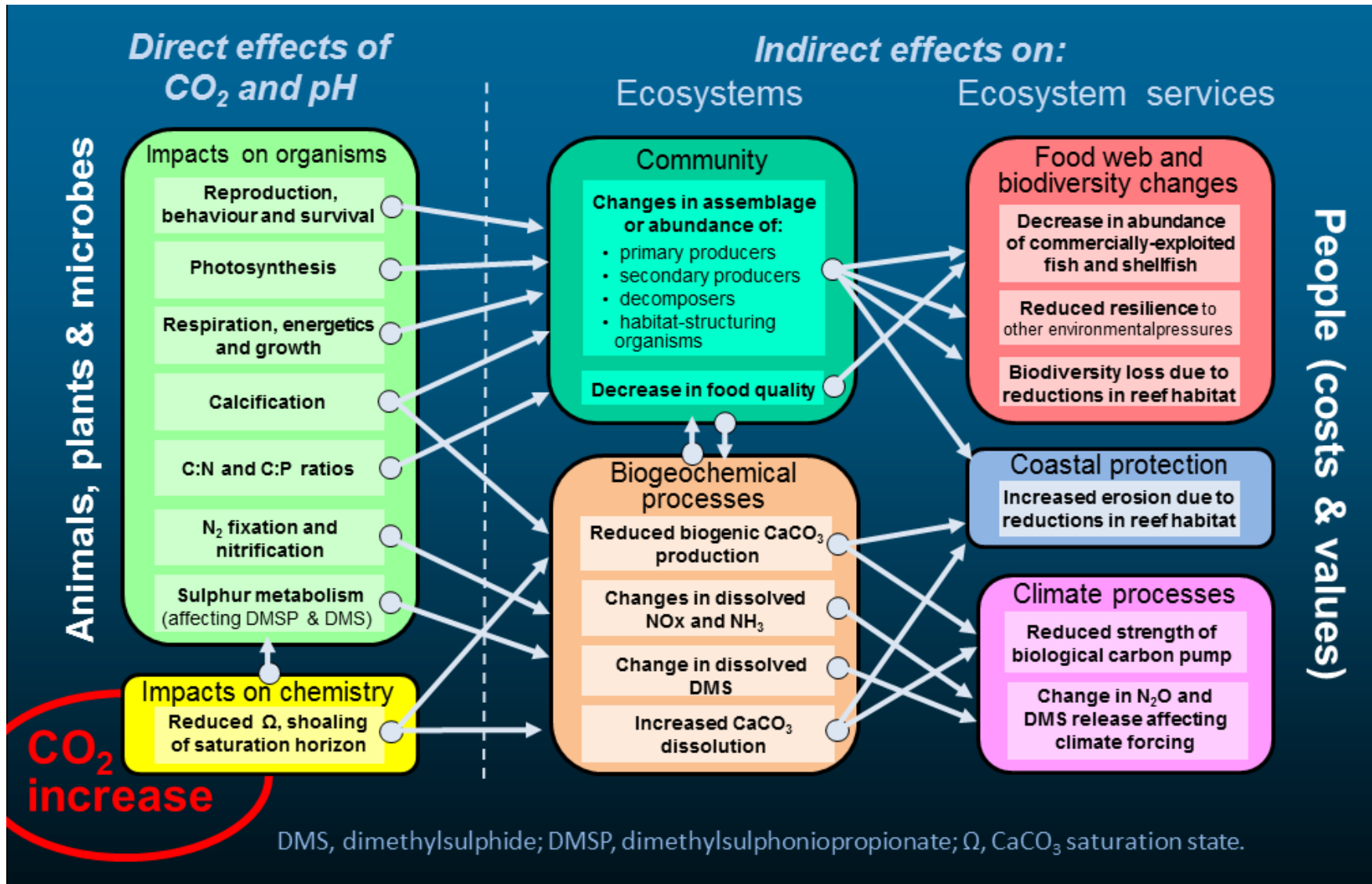


Whitmann and Pörtner (2013)

These invertebrates play key roles in marine ecosystem functioning.



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OA interacts with other stressors



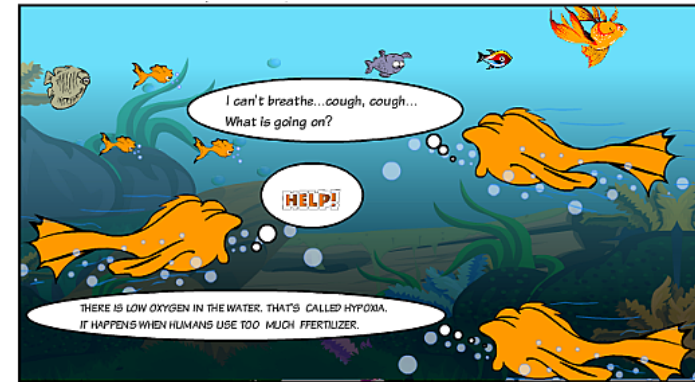
Warming



Pollution

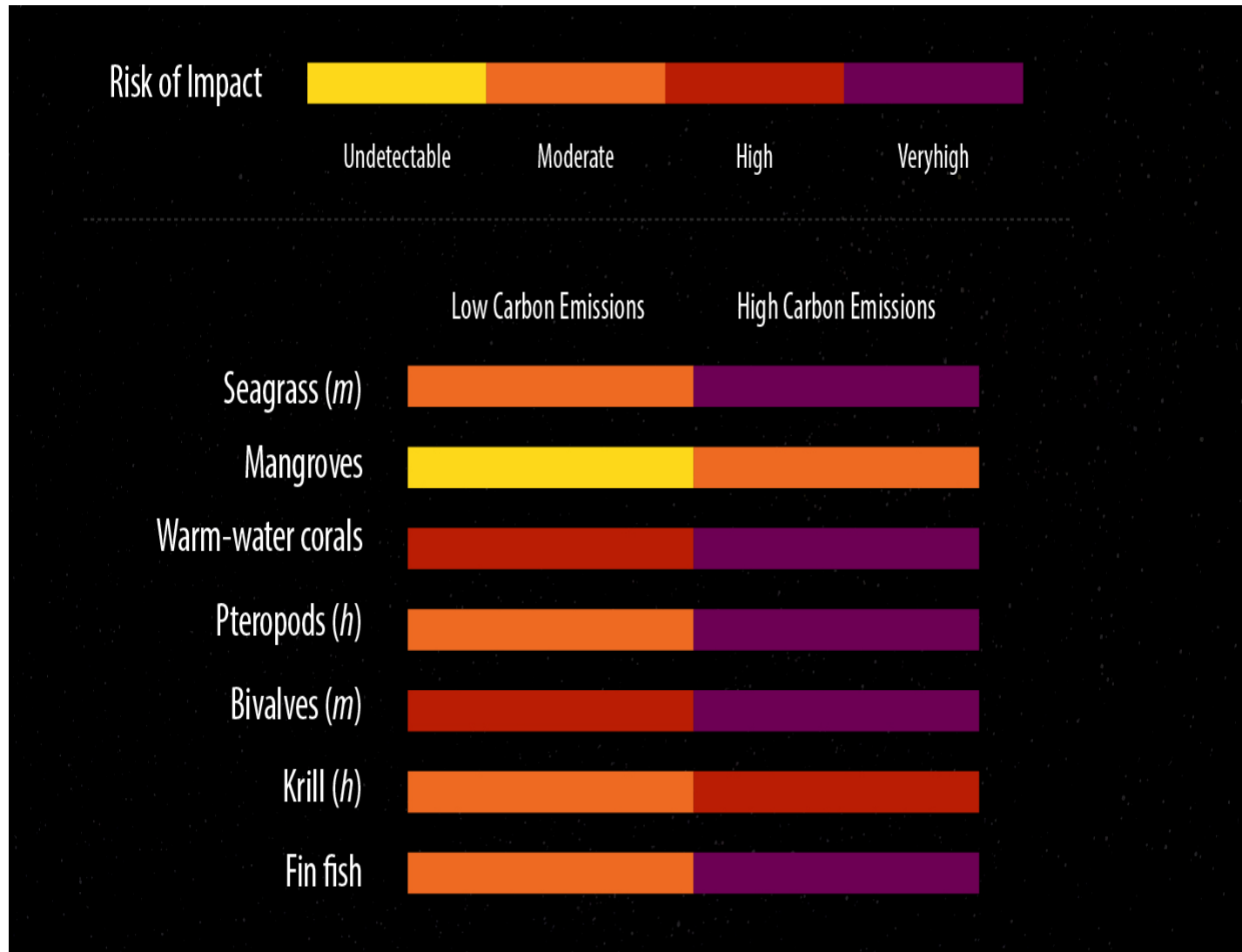


Hypoxia

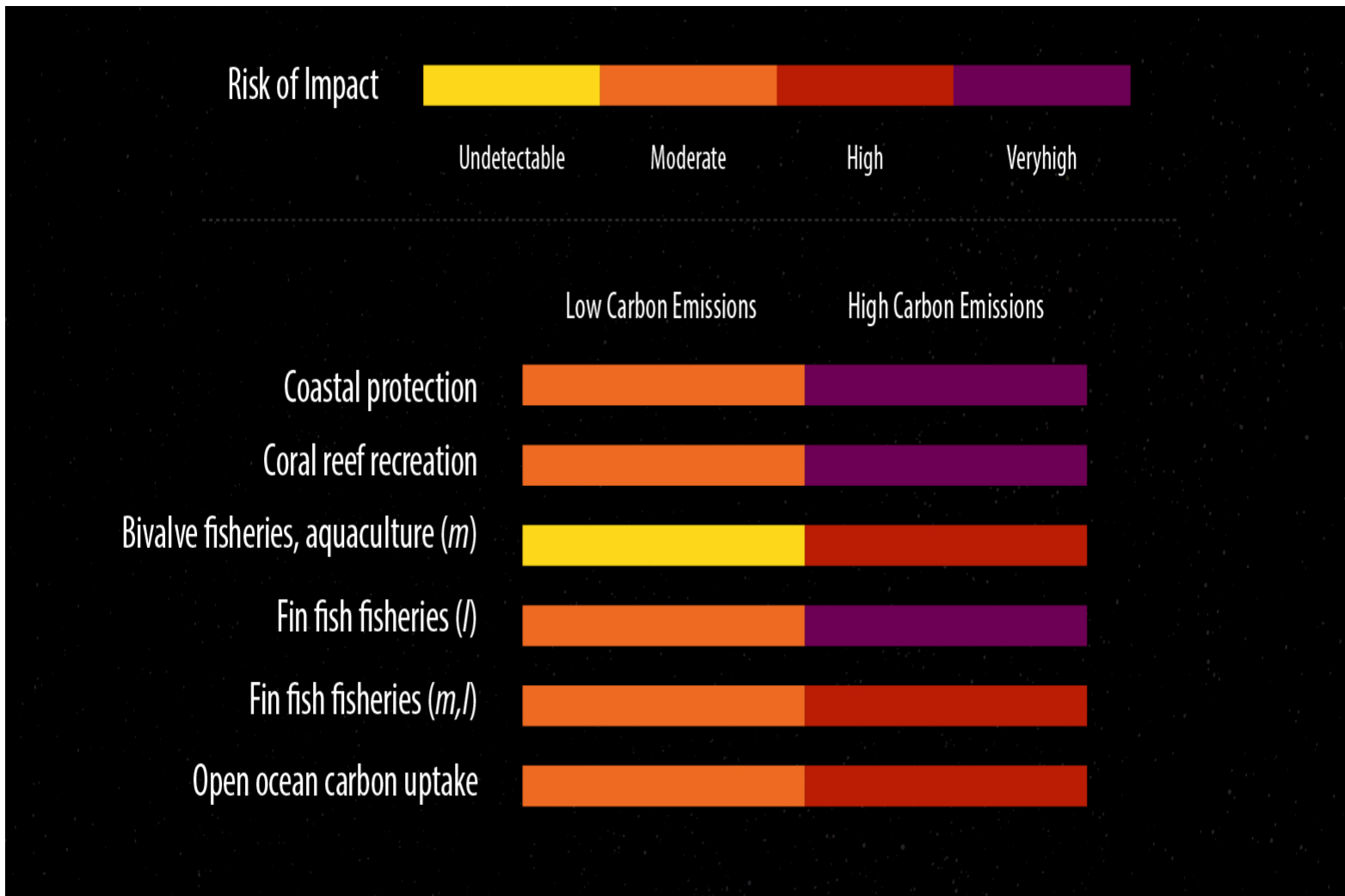


Synergistic interactions (greater than the sum of effects) have been found in over 66% of studies looking at OA-multi-stressors effects.

Risk to ecosystems very high without reduced carbon emissions:



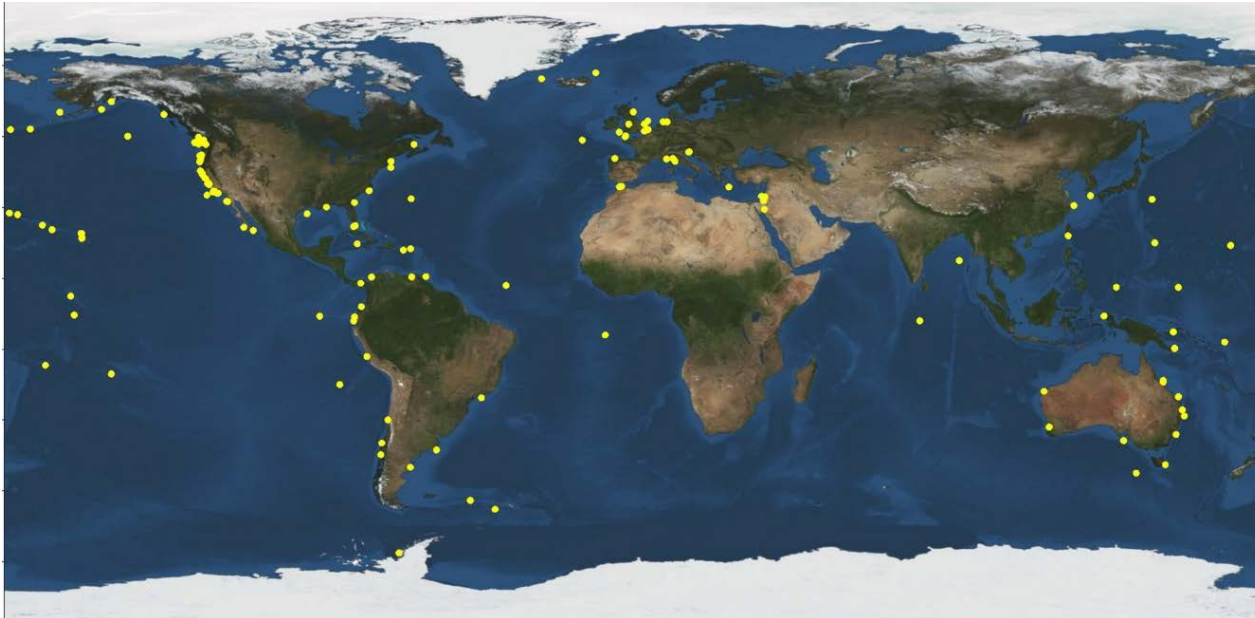
Risks to goods and services reduced by lowered carbon emissions:



Global OA Observation Network



Sites in Global OA Observing network – mostly chemistry only: www.goa-on.org



A global OA observing network is being developed to relate chemical and biological changes, but there are currently many gaps in coverage .

Strong exiting EU ocean acidification expertise from past programmes and initiatives:

