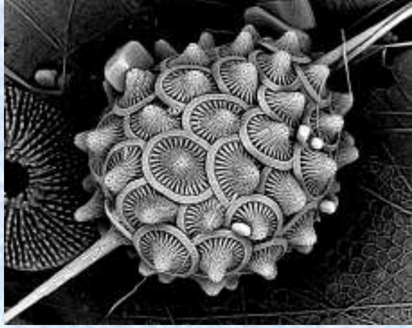


Ocean acidification in NZ offshore waters

Cliff Law
NIWA

- Review susceptible groups in NZ offshore waters
- Examples from international research of responses
- Identify potential impacts in the NZ EEZ

NIWA
Taihoro Nukurangi

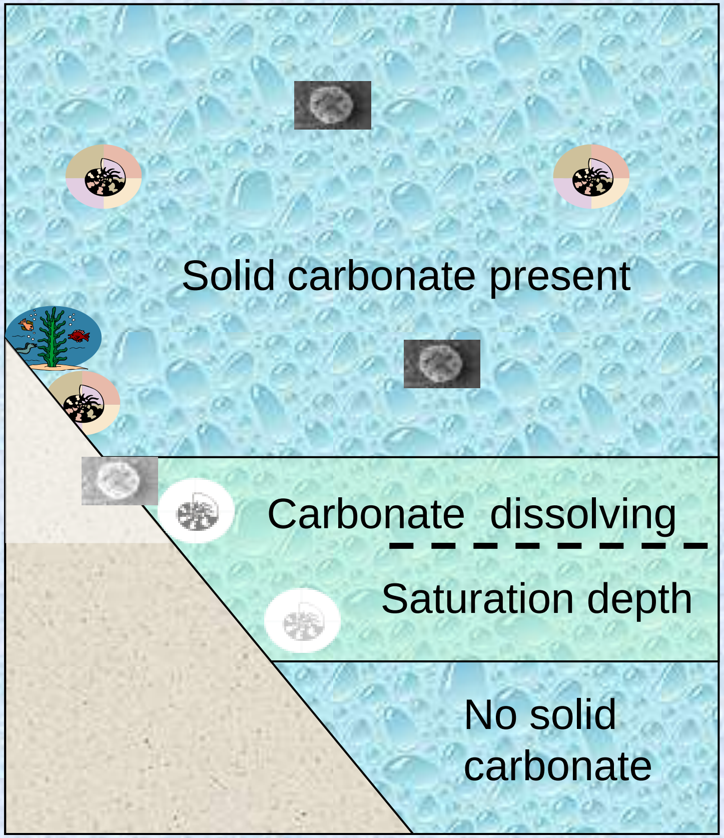
Ministry of
Fisheries
Te Tautiaki i nga tini a Tangaroa

Plankton with carbonate shells will be affected by elevated CO_2

Coccolithophores
Phytoplankton
(Calcite)

Pteropods
Zooplankton
(Aragonite)

- Carbonate becomes more soluble at lower temperature and higher pressure
- As CO_2 increases, saturation depth shoals
- Type of carbonate is important – Aragonite shells will be more susceptible than Calcite shells



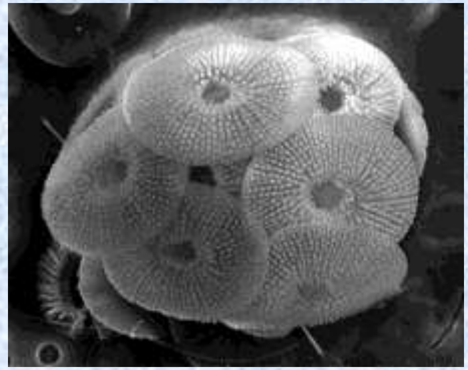
Coccolithophores are an important component of the NZ EEZ plankton

January 3, 2008, NASA Terra-MODIS

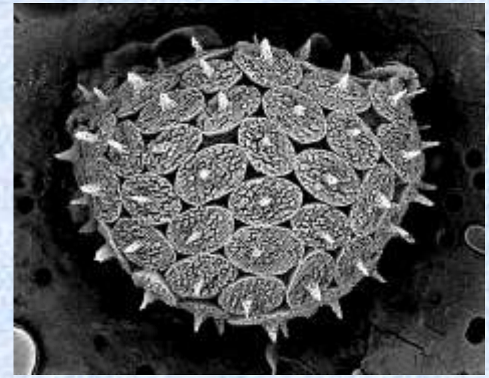
- high cell densities (~10^4-10^6 cells/m^3)
- important in food chain
- affect ocean albedo and chemistry
- dominate biogenic carbonates in deep-sea sediments

Coccolithophores from the Chatham Rise (January 2009)

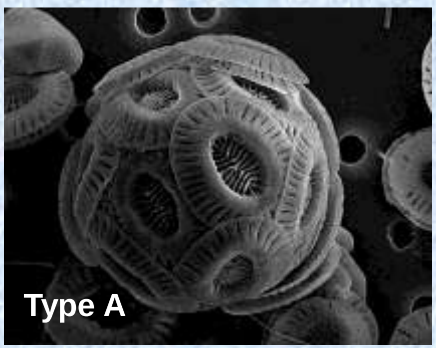
Acanthoica

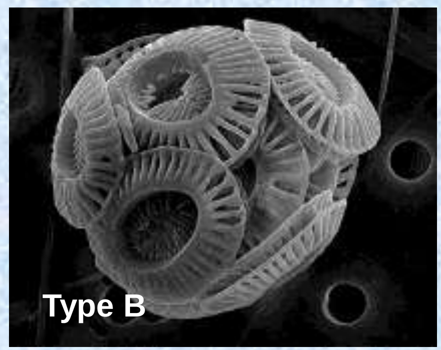


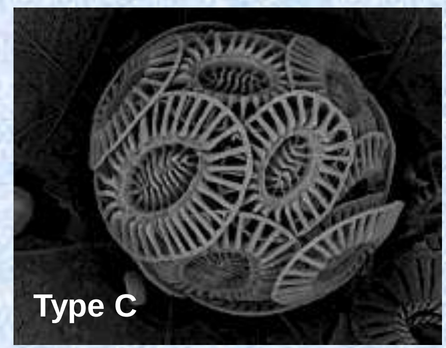
Umbellosphaera



Helicosphaera







Emiliania huxleyi

Helladosphaera

Gephyrocapsa

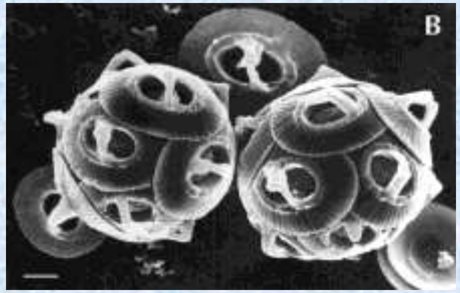
Syracosphaera

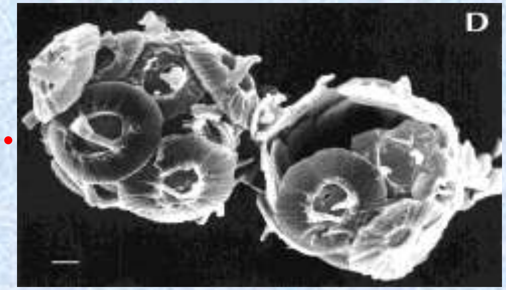
H. Chang, NIWA

Response to high CO_2 may vary between species & within species

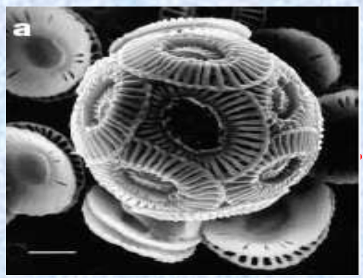
Current CO_2 / Elevated CO_2 (580-915 ppm)

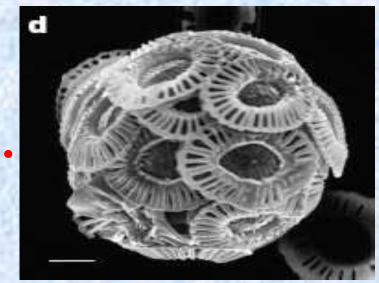
G. oceanica



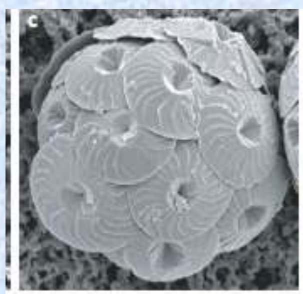


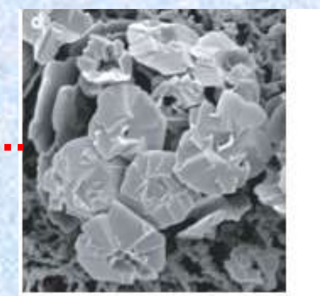
E. huxleyi





C. leptoporus

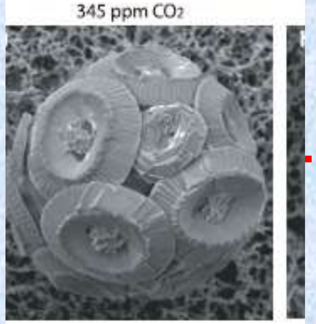


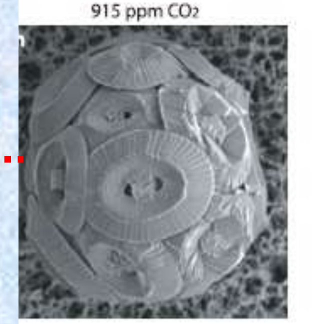


345 ppm CO_2

915 ppm CO_2

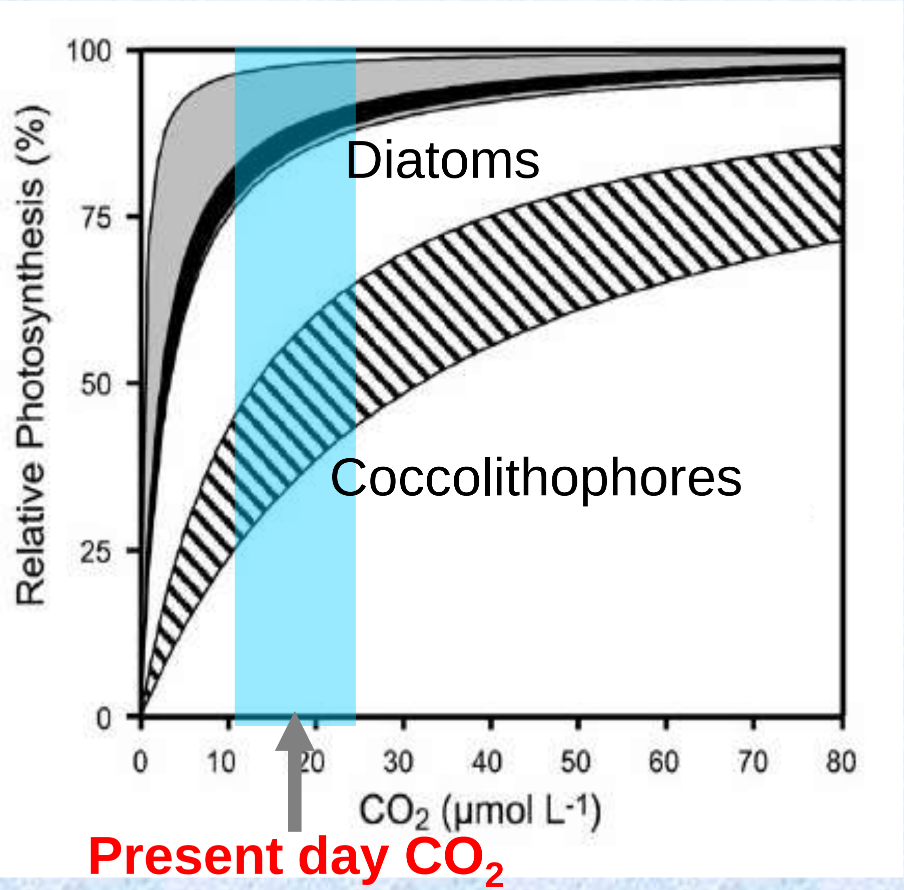
C. pelagicus





Riebesell et al. 2000;
Zonderaven et al, 2001, 2002
Langer et al, 2006

Phytoplankton production may increase under high CO_2



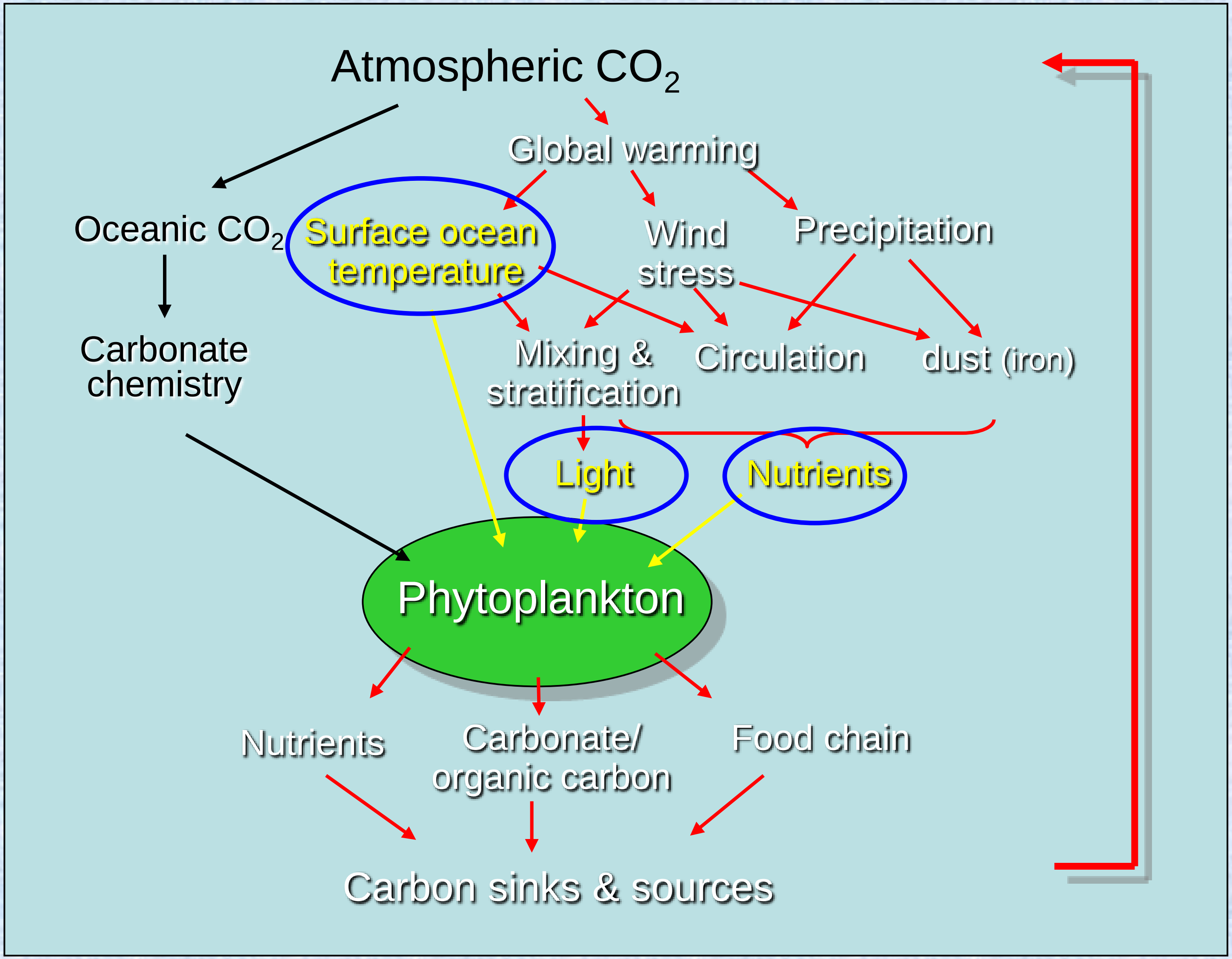
Photosynthetic carbon fixation by diatoms saturated at current CO_2

Coccolithophores well below saturation at current CO_2

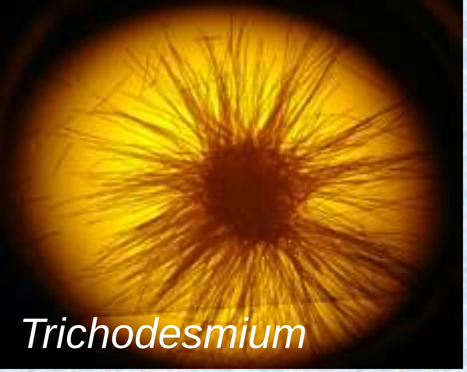
Will coccolithophores benefit from increasing atmospheric CO_2?

Riebesell *et al*., 2000: Burkhardt *et al*., 1999, 2001; Rost *et al*., 2003

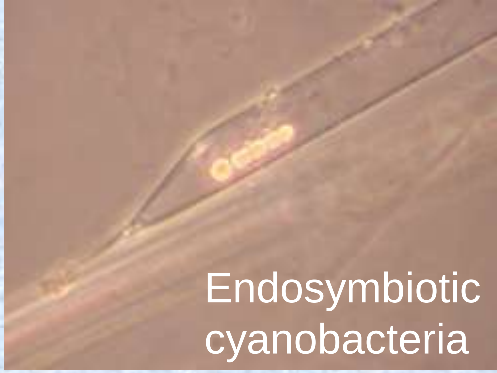
Predicting phytoplankton response to high CO_2 is difficult



Adapted from Ulf Riebesell



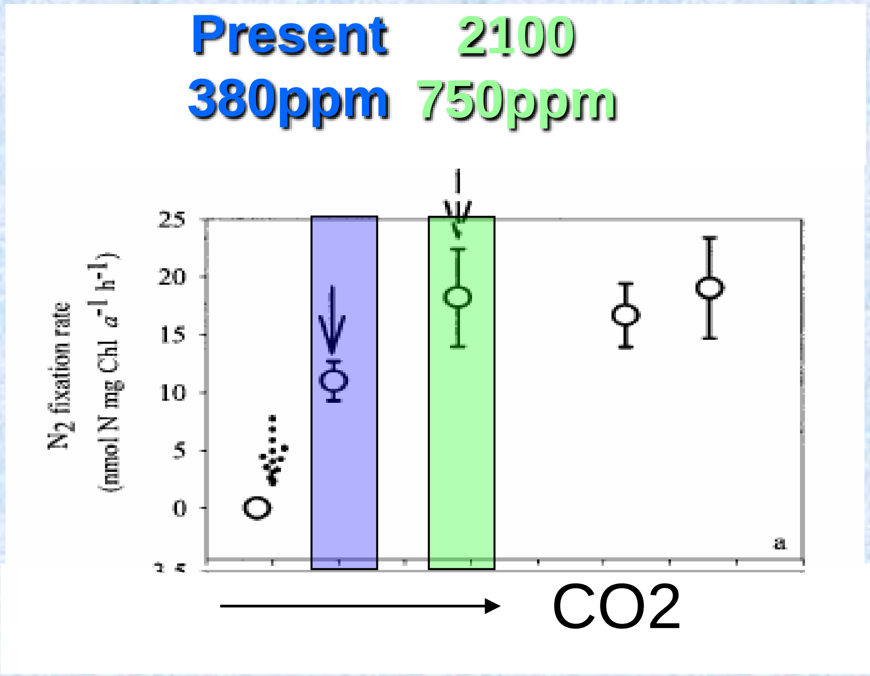
Nitrogen-fixing phytoplankton may benefit from high CO_2



- Sub-tropical nutrient-poor waters
- important source of new nitrogen

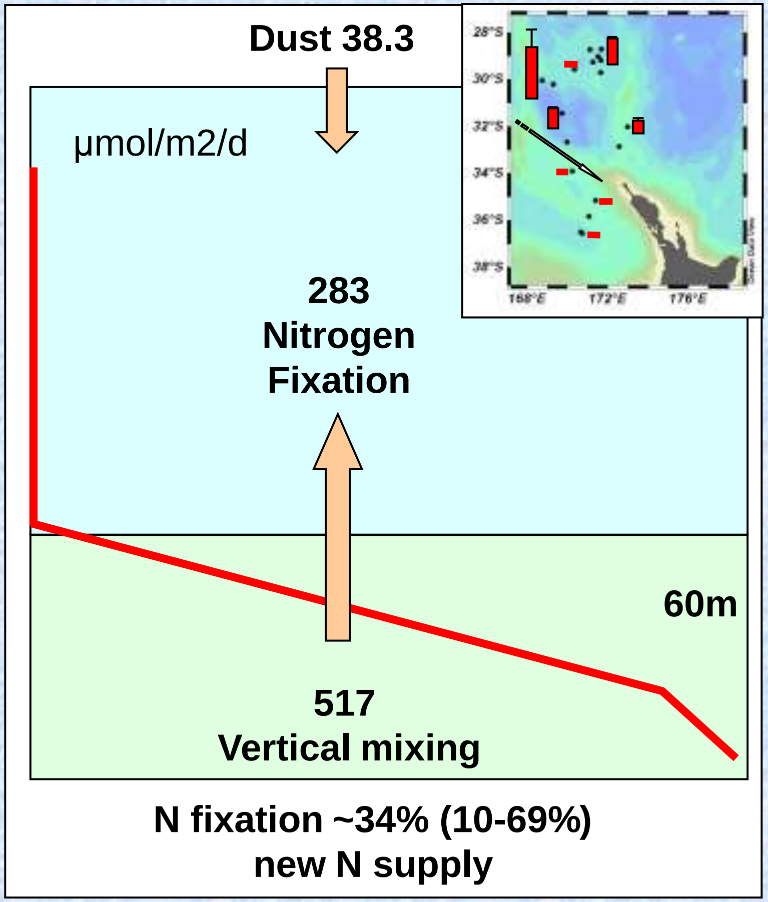
Trichodesmium response to high CO_2

- Nitrogen fixation increase 63%
- Carbon fixation increase 54%



Hutchins et al, 2007

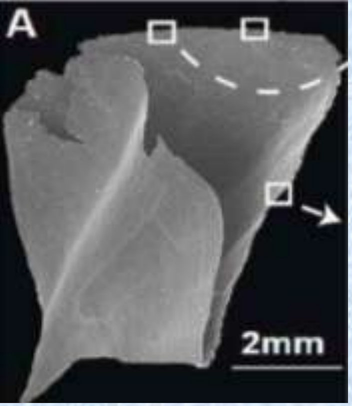
Nitrogen fixation is a significant nitrogen source in NZ sub-tropical waters



Surface blooms of *Trichodesmium*

Surface *Trichodesmium* blooms support plankton biomass in excess of own biomass

Will increased CO_2 enhance productivity in nutrient-poor waters of the EEZ?

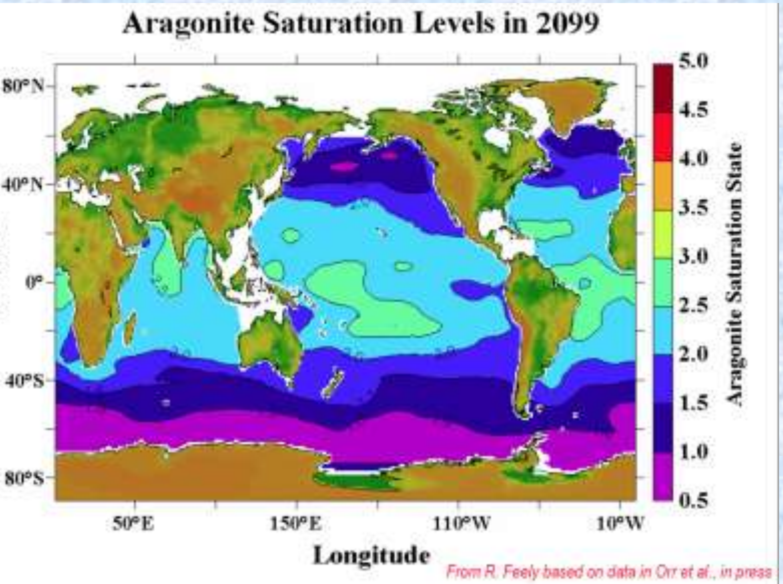


Clio pryimidata
(Orr et al, 2005)

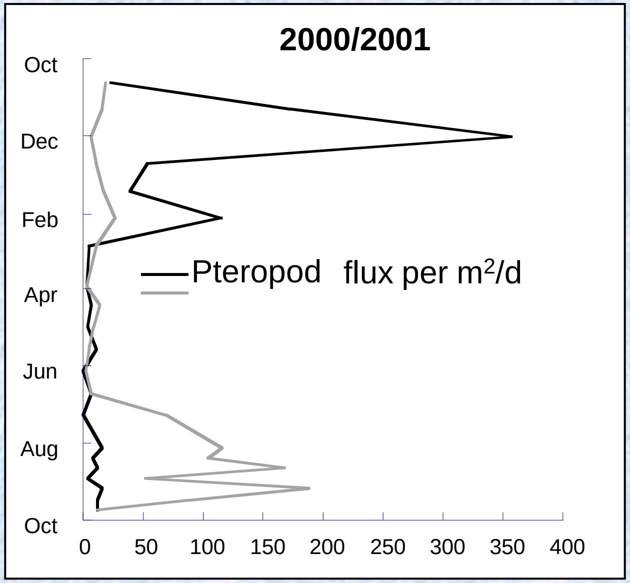
Zooplankton (Pteropods) may suffer under elevated CO_2

Limacina inflata

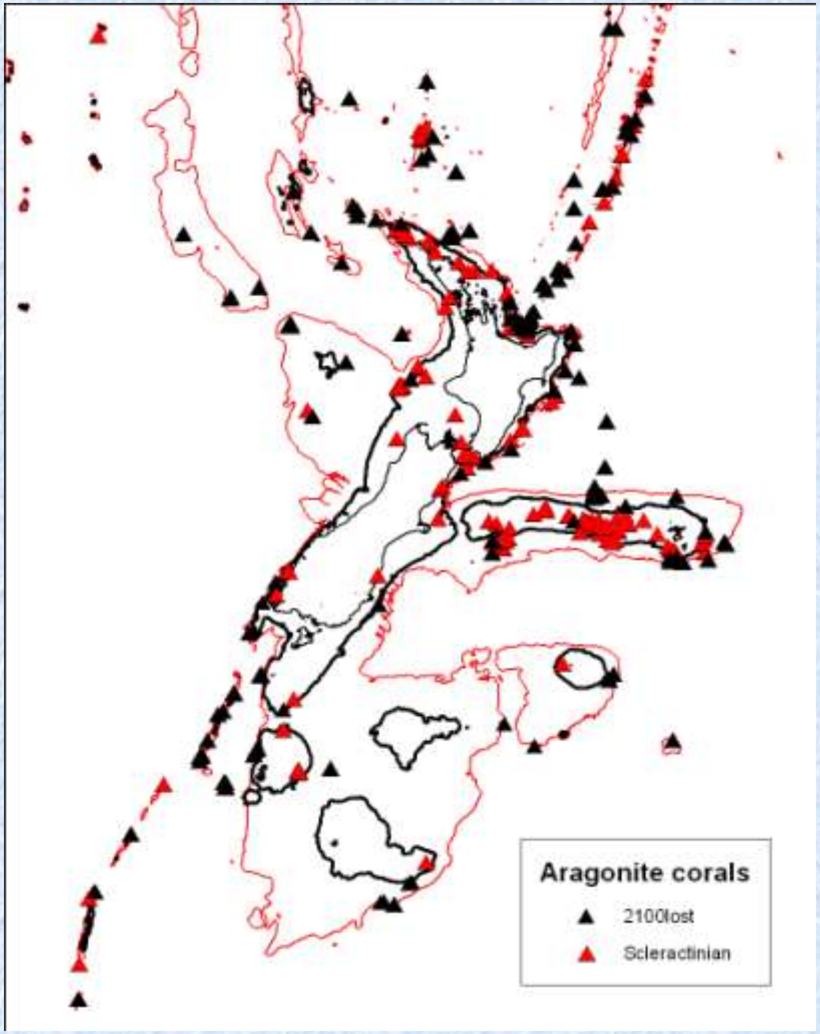
- More abundant than krill in the Ross Sea
- Major diet component of carnivorous zooplankton & fish
- Shells dissolve within 48hrs at predicted aragonite saturation for 2100



High density of *L. inflata* in summer in Sub-Antarctic waters



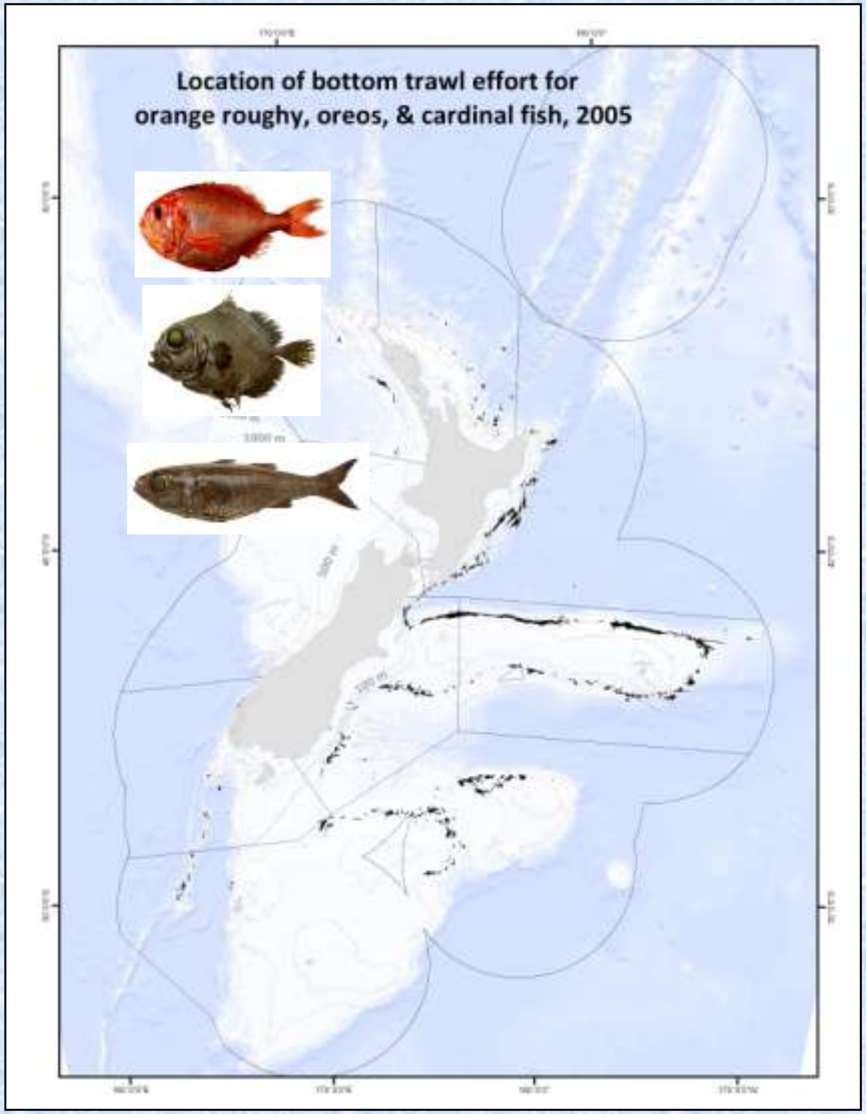
Cold water corals may be the first casualties of ocean acidification in EEZ waters



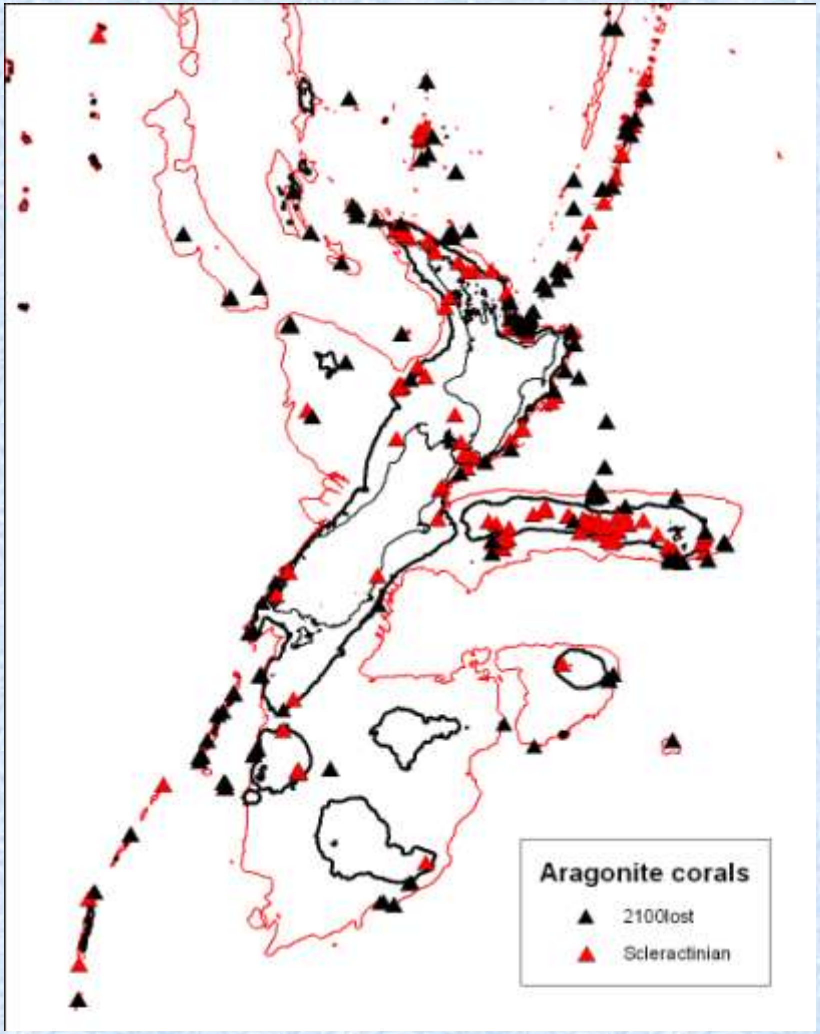
- Major ecosystem role as nursery areas and habitat for invertebrates, fish & sponges
- Disappearance from deeper areas as the aragonite saturation horizon shoals

D. Tracey, H. Bostock, K. Currie, H. Neil, NIWA

Loss of cold water corals may affect commercial fish stocks



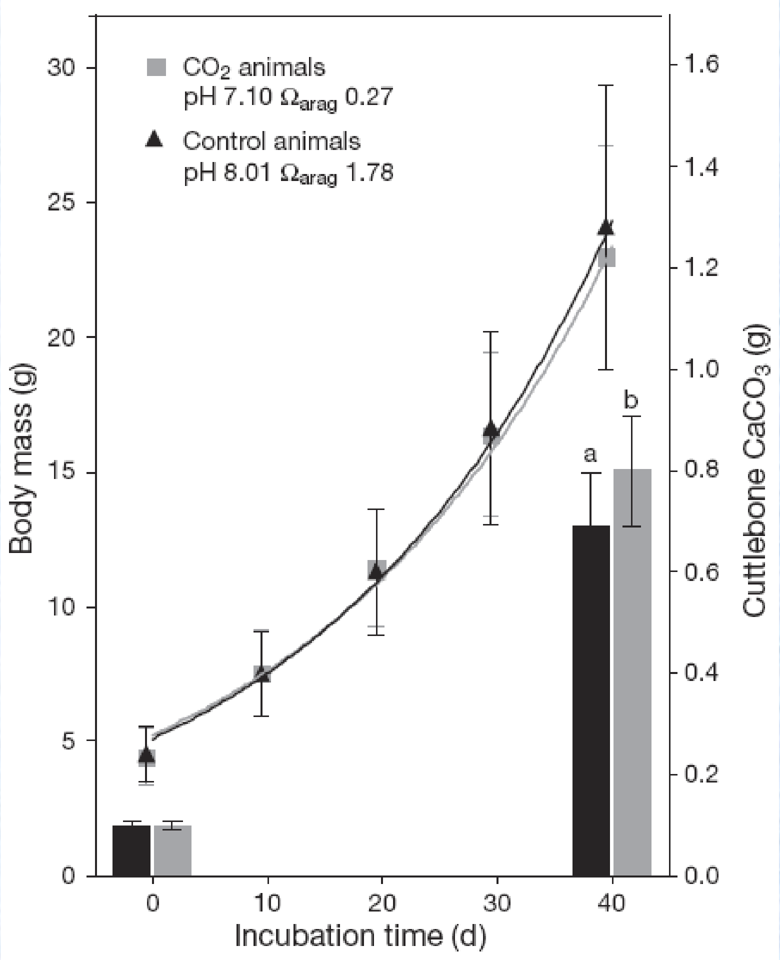
Effort plot from Baird et al. (data source MFish)



Tracey et al (data source *trawl* ,*COD* , *Specify* databases; funding MFISH, DoC, FRST programmes)

Higher organisms may be less directly affected by elevated CO_2

- May reduce blood oxygen-carrying capacity
- Potential reduced feeding, growth and reproduction, particularly in active organisms
- Current research on squid suggests no impact



Sepia officinalis growth under ~6000 ppm CO_2 (grey) and control conditions (black) (Gutowska et al, 2009)

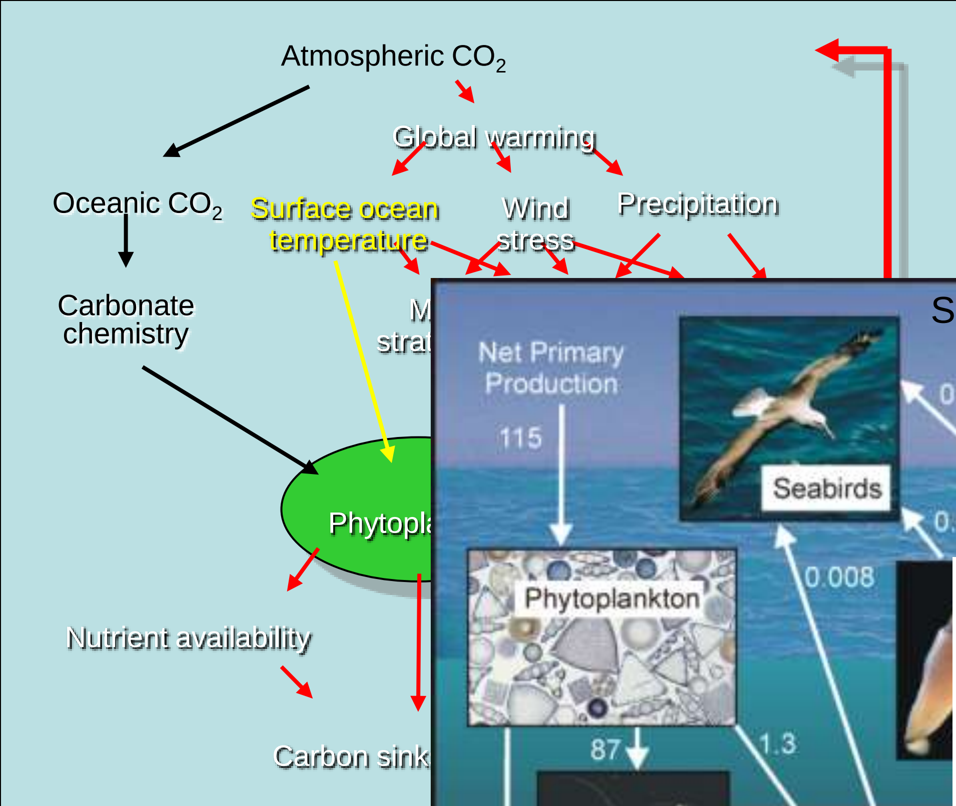
Indirect effects (food & habitat reduction) may have equal or greater impact than direct effects on fish physiology

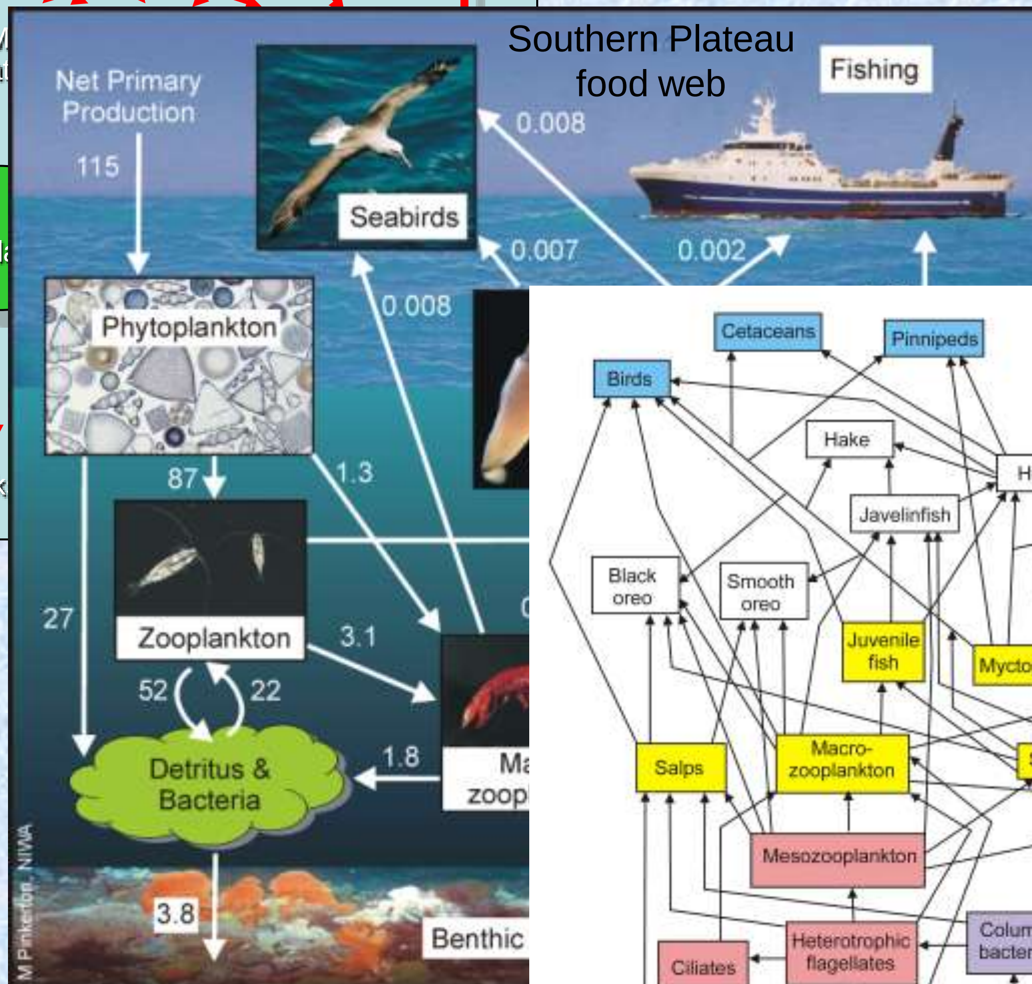
- Fish maintain O_2 consumption under high CO_2 but use more energy on ventilation
- Potential physiological cost, but body weight is unaffected in high CO_2 studies
- Little information on effects on reproduction, growth & behaviour
- Research required at susceptible stages such as egg and larvae

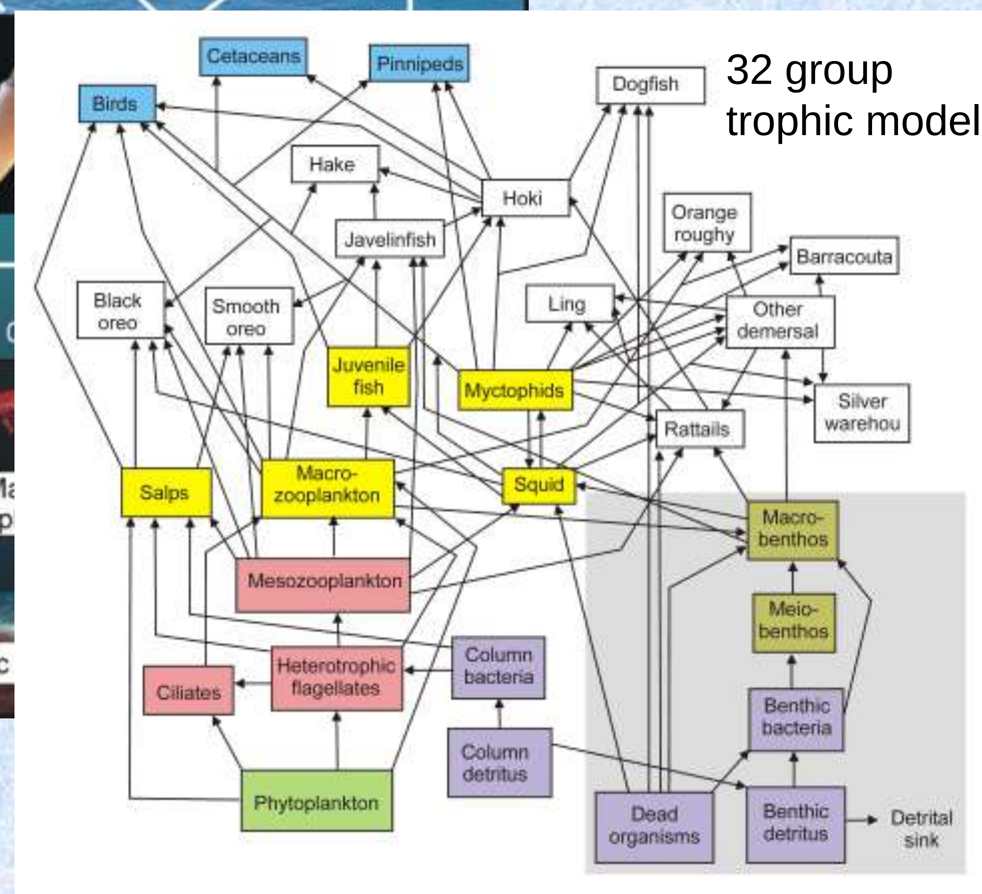
P. Grimes, NIWA

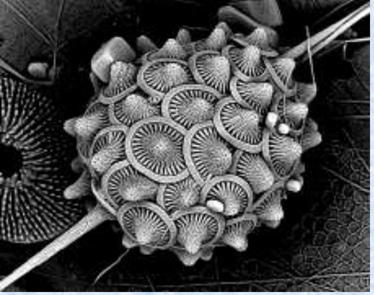
A. Blacklock, NIWA

Predicting the response of fisheries to high CO_2 is difficult









Summary

- Plankton biodiversity may decrease

- Phytoplankton productivity may increase in some regions

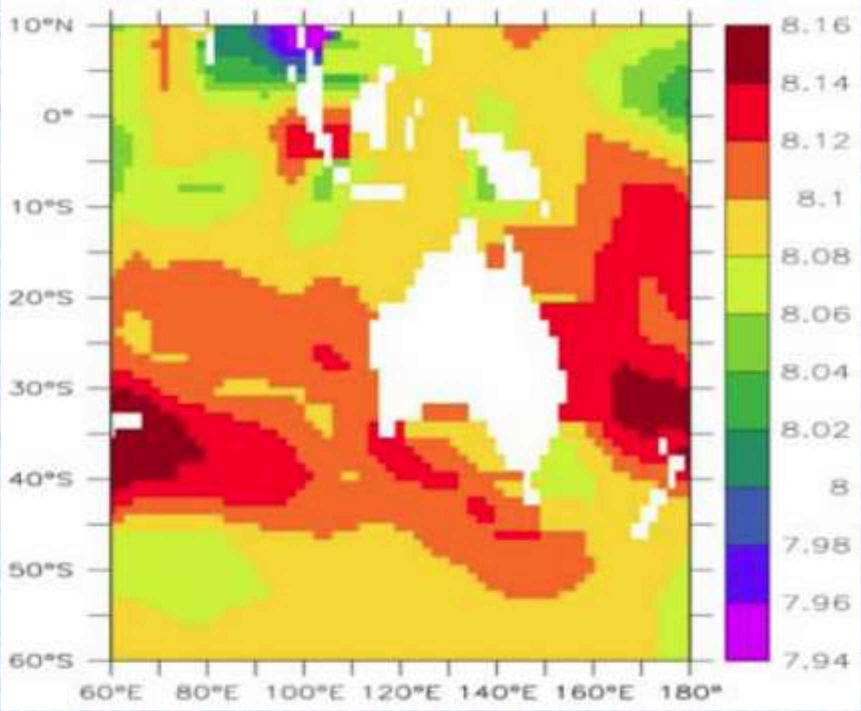
- Cold water corals are under threat, resulting in habitat loss

- Squid and fish may cope physiologically, but habitat and prey reduction may impact, and early life stages may be susceptible

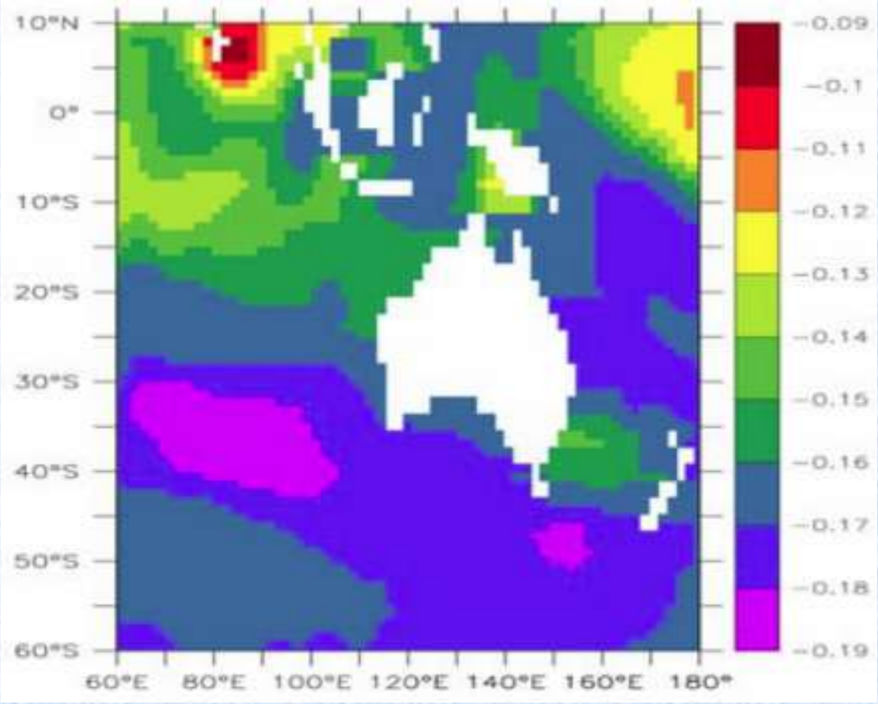
- Baseline information on susceptible groups is limited

- Cannot extrapolate species or ecosystem responses observed elsewhere to NZ waters

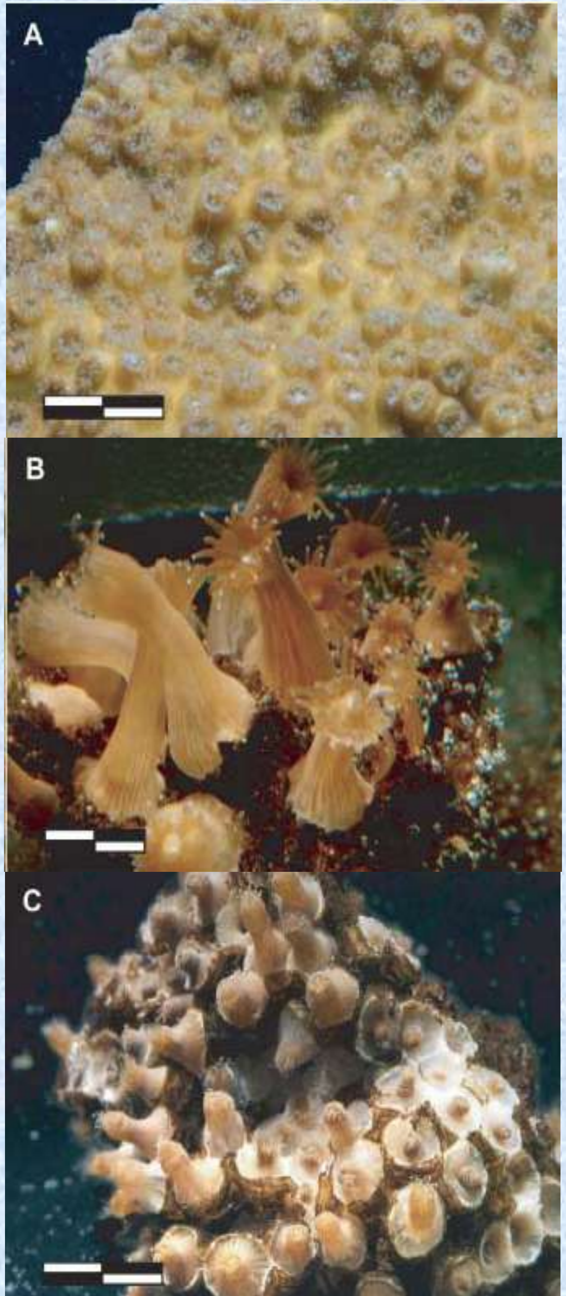
Average pH for the 1990s



Projected change in pH between 1990s and 2070.



Source: Hobday et al, 2006. Impacts of Climate Change on Australian Marine Life. CSIRO Marine and Atmospheric Research report to the Department of the Environment and Heritage



Can corals survive without carbonate ?

Scleractinian sp. *Oculina patagonica* (Mediterranean)

• pH 7.3-7.6, polyp elongation and skeleton dissolution

• Polyp biomass 3 x control

• Polyps calcified and reformed, when transferred to ambient pH after 12 months

Corals might survive major environmental change but decalcificationmay cause major changes to structure and function of reef ecosystems

Fine and Tchernov, 2007