Understanding Blue Carbon and Ocean Acidification

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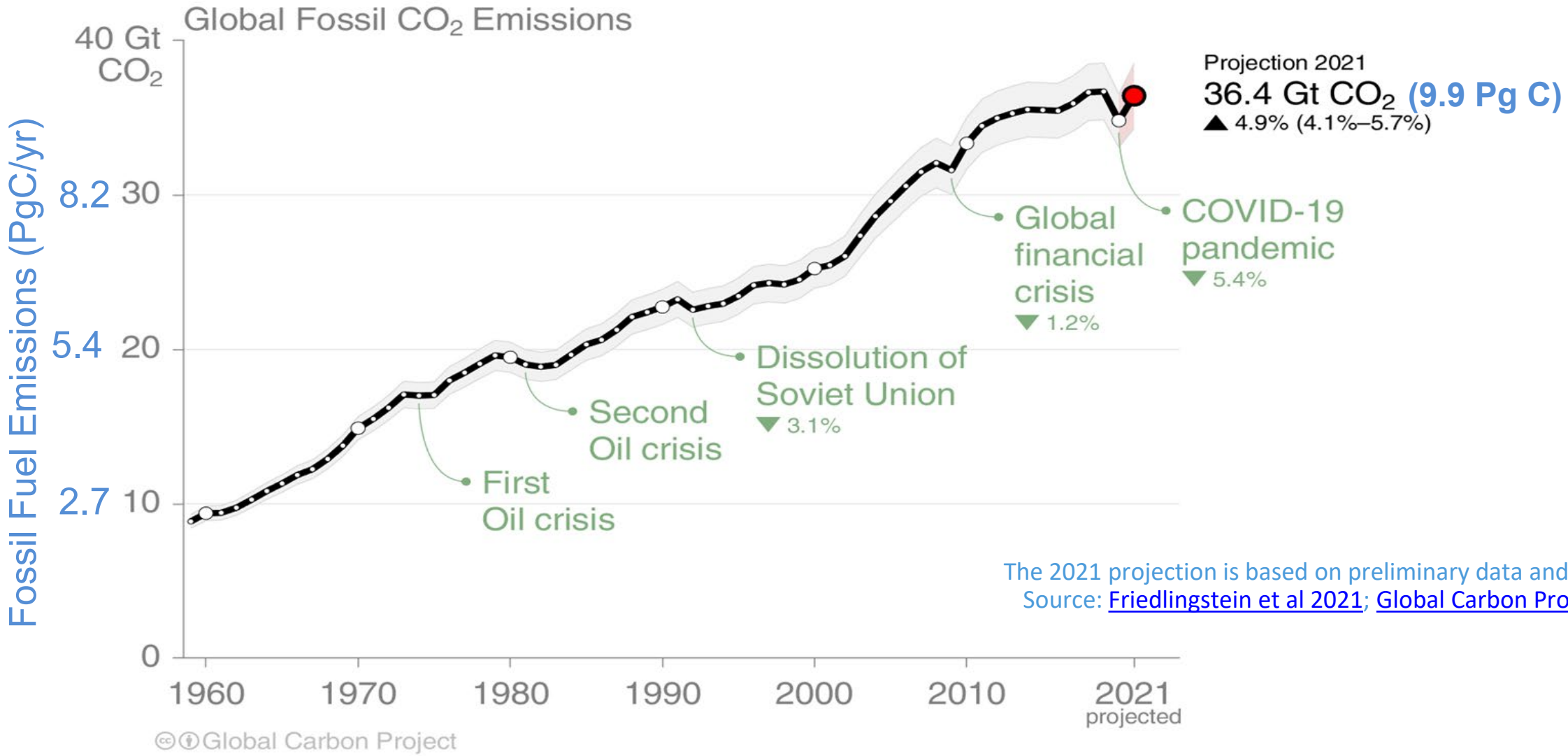
Global Fossil CO_2 Emissions

Global fossil CO_2 emissions have risen steadily over the last decades.
Emissions in 2021 are set to rebound towards their pre-COVID-19 levels after an unprecedented drop in 2020.



The 2021 projection is based on preliminary data and modelling.
Source: Friedlingstein et al 2021; Global Carbon Project 2021

Fate of anthropogenic CO_2 emissions (2011–2020)

Sources

Fossil Fuels and Industry

90%

9.6 PgC/yr

Land Use Change

10%

1.1 PgC/yr

Source: Friedlingstein et al 2021; Global Carbon Project 2021

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Atmospheric Accumulation

Sinks

47%

5 PgC/yr

Source: Friedlingstein et al 2021; Global Carbon Project 2021

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Atmospheric Accumulation

47%

5 PgC/yr

Forest Regrowth

28%

3 PgC/yr

Ocean Uptake

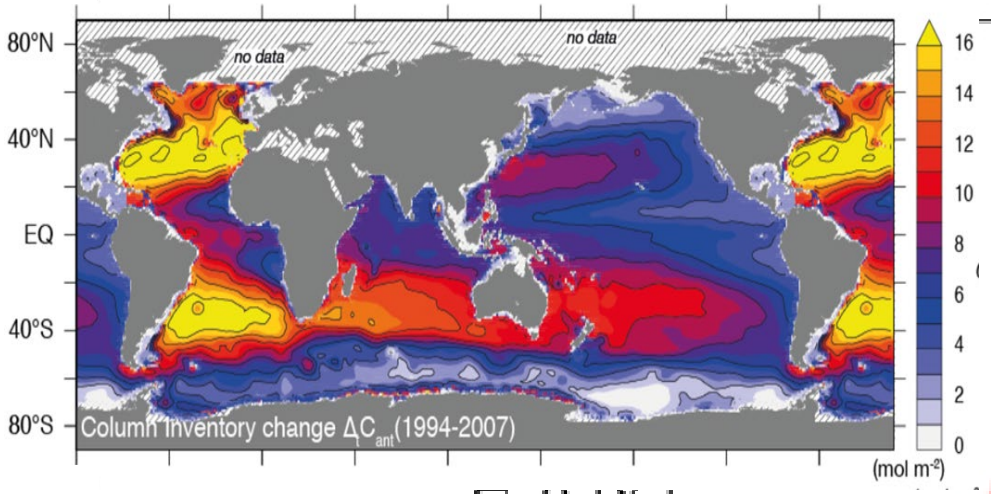
25%

2.7 PgC/yr

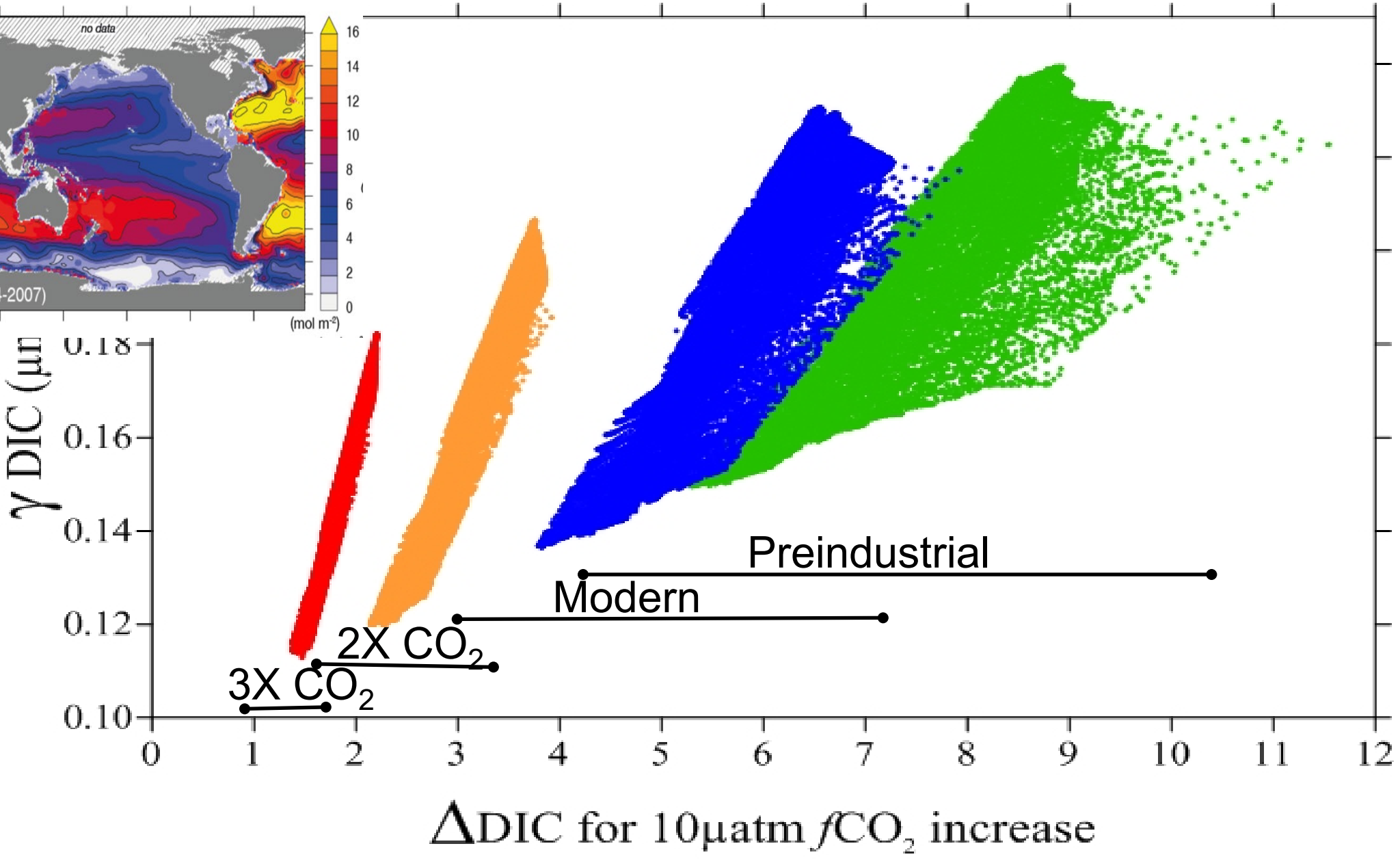
Sinks

Source: Friedlingstein et al 2021; Global Carbon Project 2021

190 billion metric tons of human-derived carbon is stored in the ocean



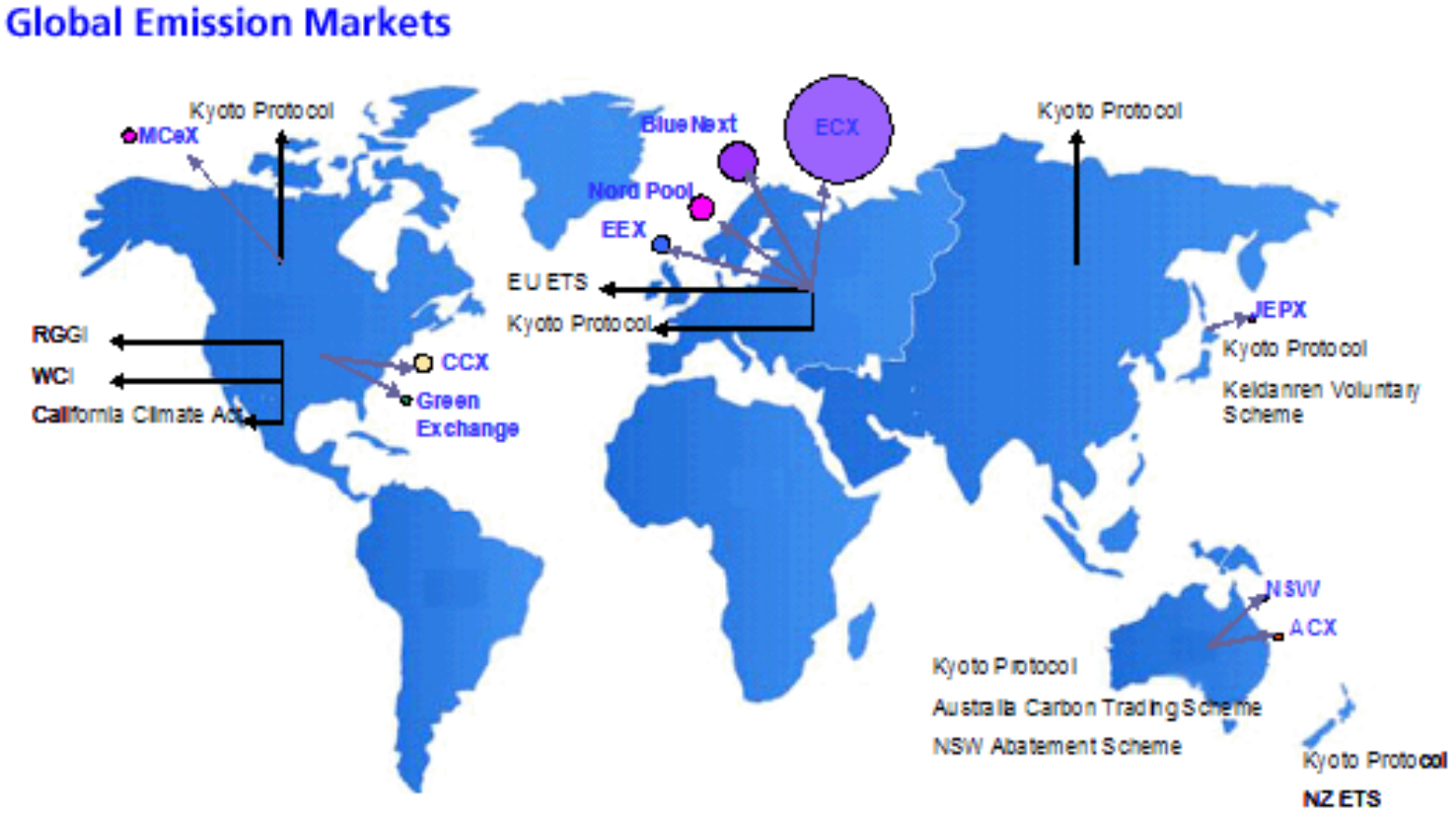
75% drop in uptake by the end of this century



Carbon Trading was a key component of the 1997 Kyoto Protocol

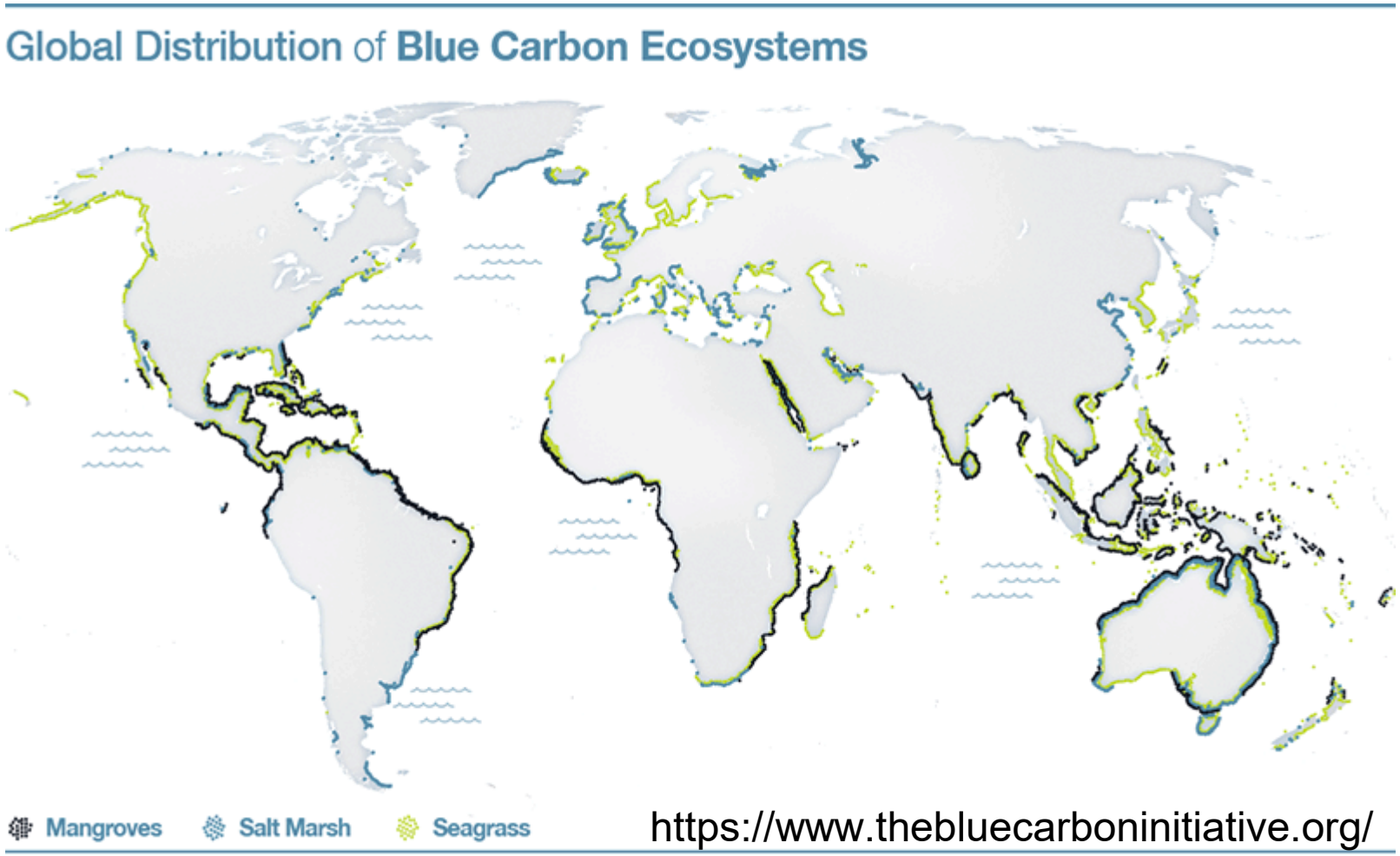
Recognizing that the ocean is such a large sink for CO_2, governments in the early 2000s were asking how to get carbon credits for the ocean uptake.

Blue carbon is the carbon stored in coastal and marine ecosystems. The Blue Carbon Initiative currently focuses on carbon in coastal ecosystems - mangroves, tidal marshes and seagrasses.



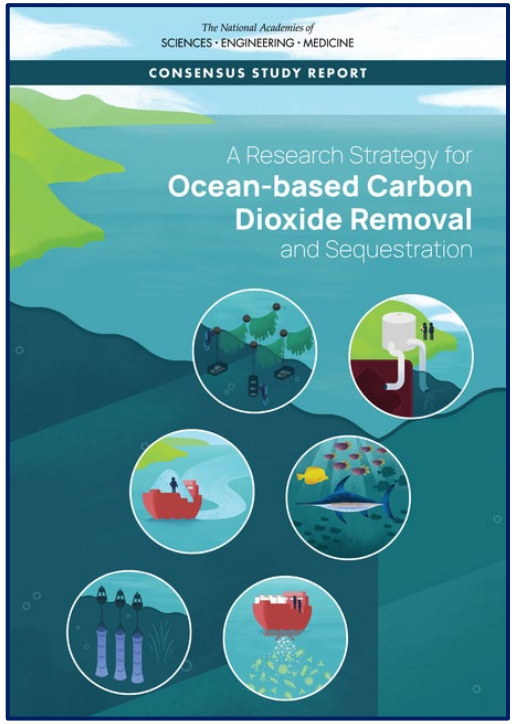
Blue Carbon was developed for the carbon trading market

Carbon Trading is not strictly a part of the Paris agreement, so governments today seem to be less interested in Blue Carbon, but there are a number of other entities that are still promoting Blue Carbon as a smart way to sequester carbon while also helping with local environmental issues.



https://www.thebluecarboninitiative.org/

3 Basic Approaches to Ocean Carbon Capture and Storage



December 2021
National Academies Report

1) Direct injection of CO_2 in the ocean

Largely dismissed because it would exacerbate ocean acidification

2) Enhanced Biological Uptake

Blue carbon, seaweed cultivation, artificial upwelling, ecosystem recovery, nutrient fertilization

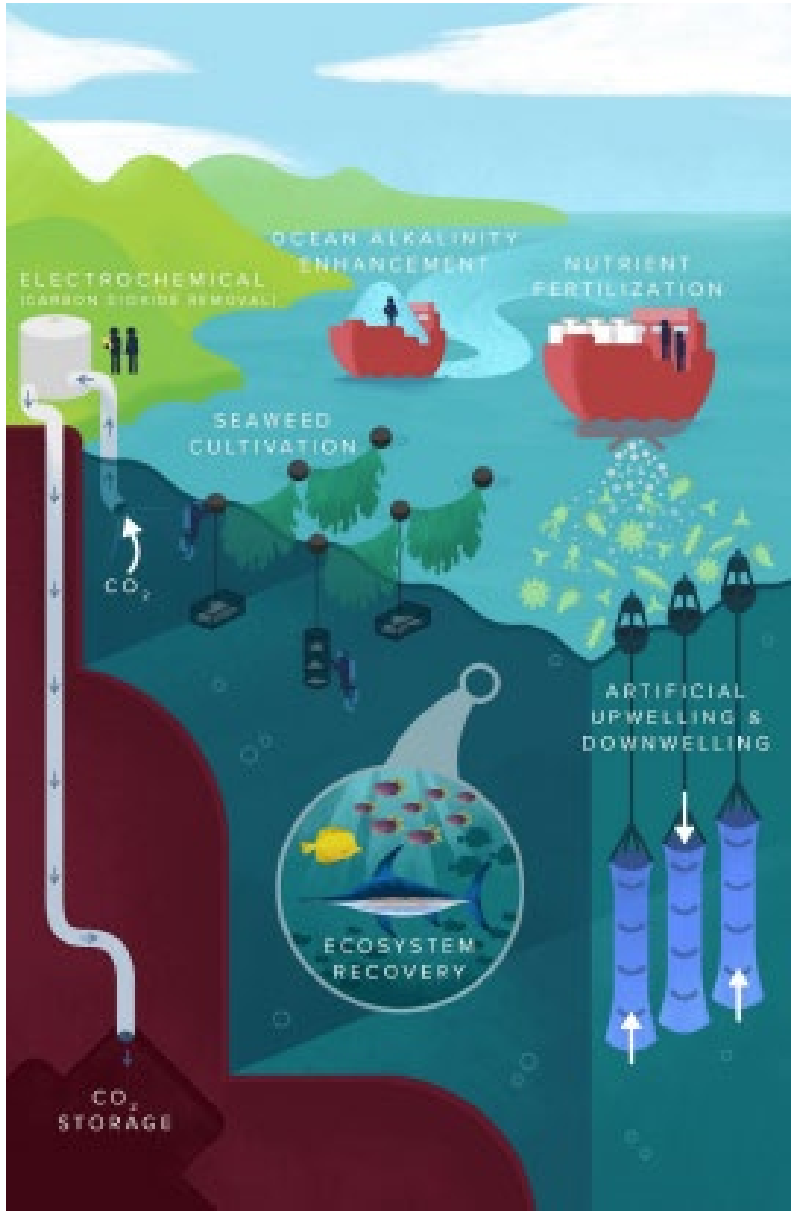
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

3) Alkalinity Enhancement

Carbonate weathering, silicate weathering, electrochemical

$$CaCO_3 + H_2O + CO_2 = Ca^{+2} + 2HCO^-_3$$

$$Mg_2SiO_4 + 4CO_2 + 4H_2O = 2Mg^{+2} + 4HCO_3^- + H_4SIO_4$$



Ocean Acidification: the other CO_2 problem

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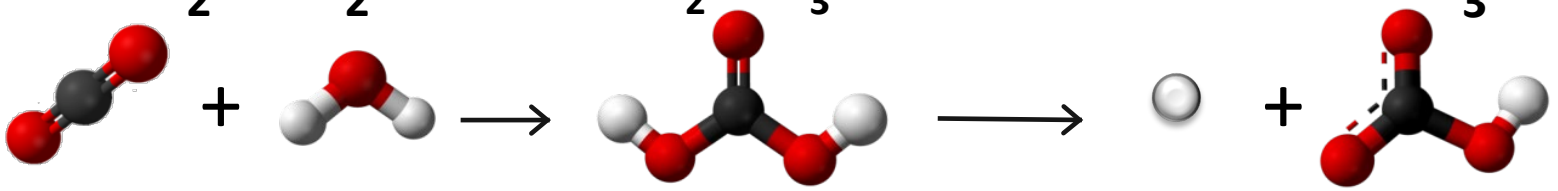
Climate change

Carbon Dioxide (CO_2)

Ocean acidification

CO_2 is an acid gas… it reacts with water to form carbonic acid.

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$



carbon dioxide + water → carbonic acid → hydrogen ion + bicarbonate ion

Concern for Marine Organisms and Ecosystems

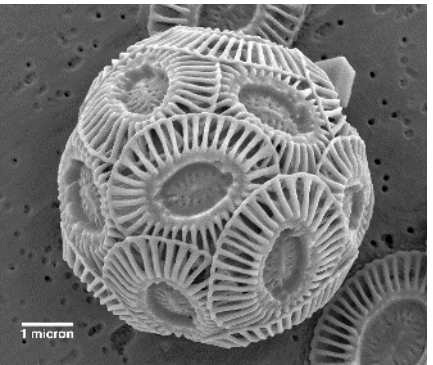
- Reduced calcification rates
- Increased photosynthesis and nitrogen fixation
- Reduced growth, production and life span of adults, juveniles & larvae
- Reduced tolerance to other environmental fluctuations
- Significant shift in key nutrient and trace element speciation

Changes to:

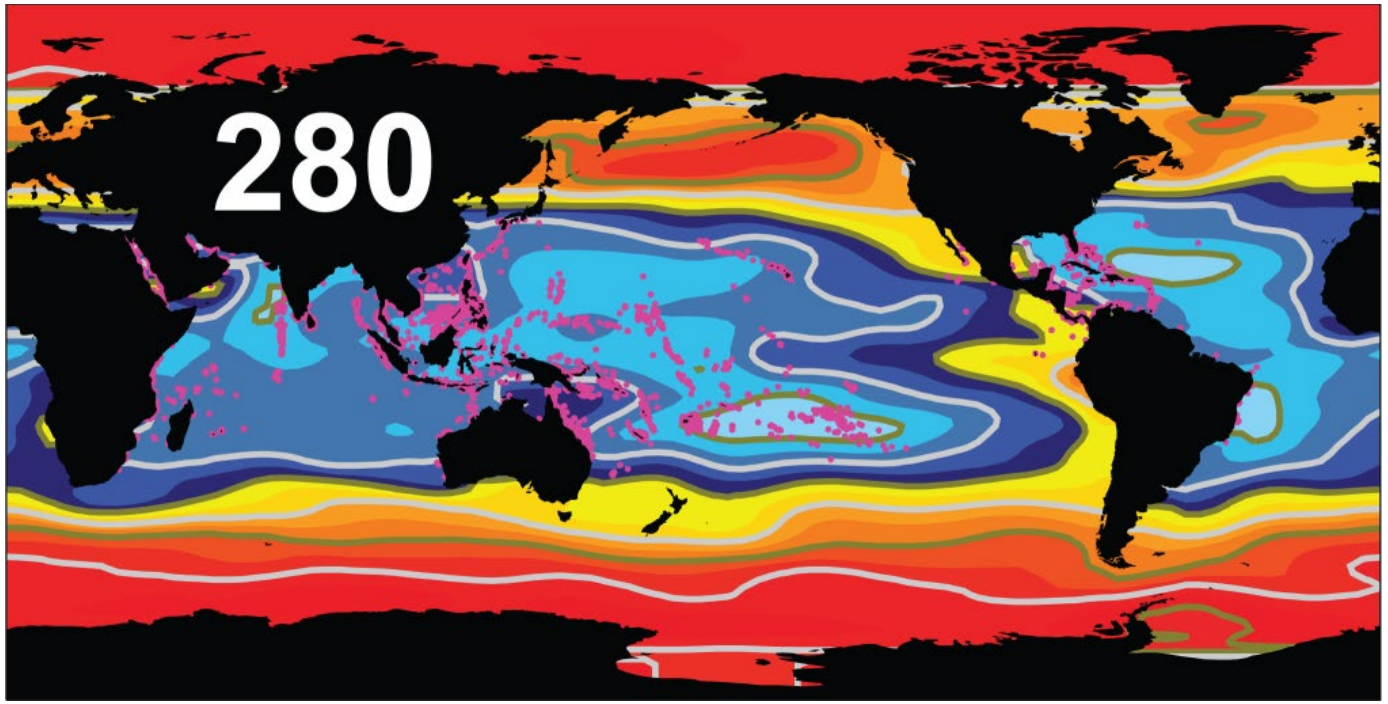
- Fitness and survival
- Species biogeography
- Key biogeochemical cycles
- Food webs

Reduced:

- Sound Absorption
- Homing Ability
- Recruitment and Settlement

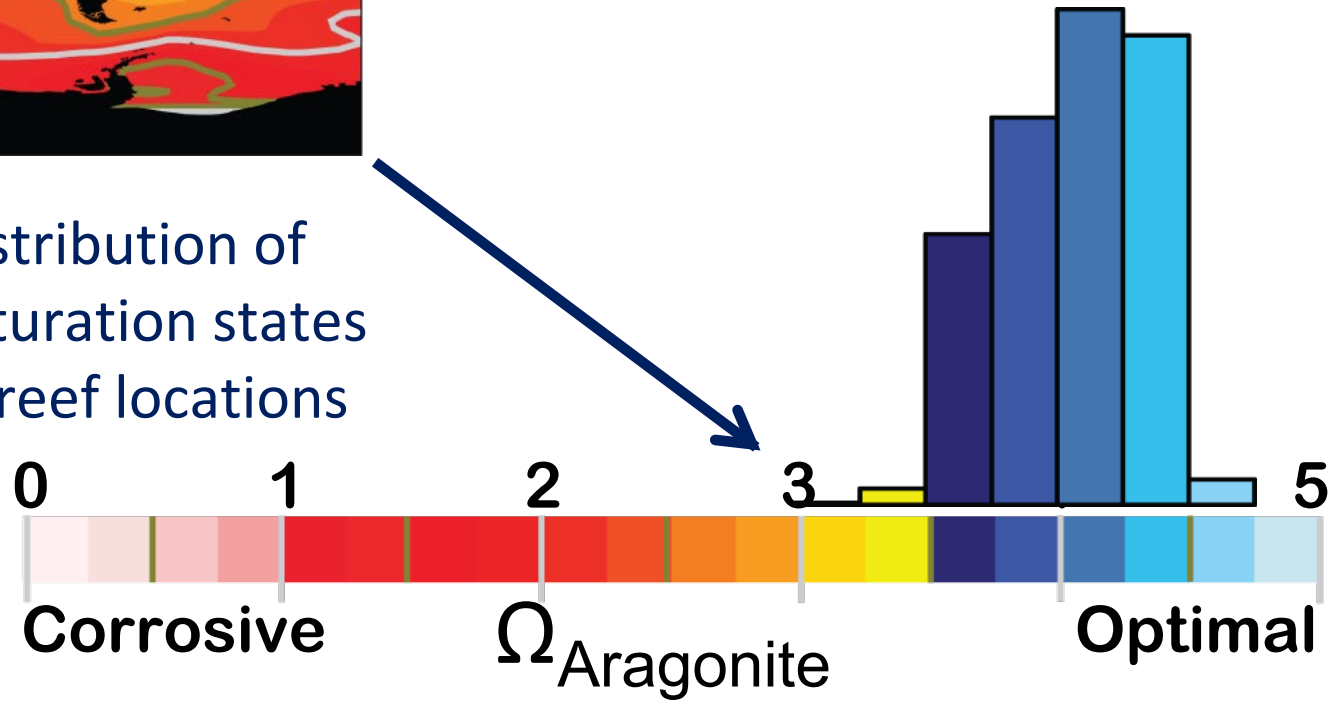


Surface Water Aragonite Saturation States with 280 ppm CO_2



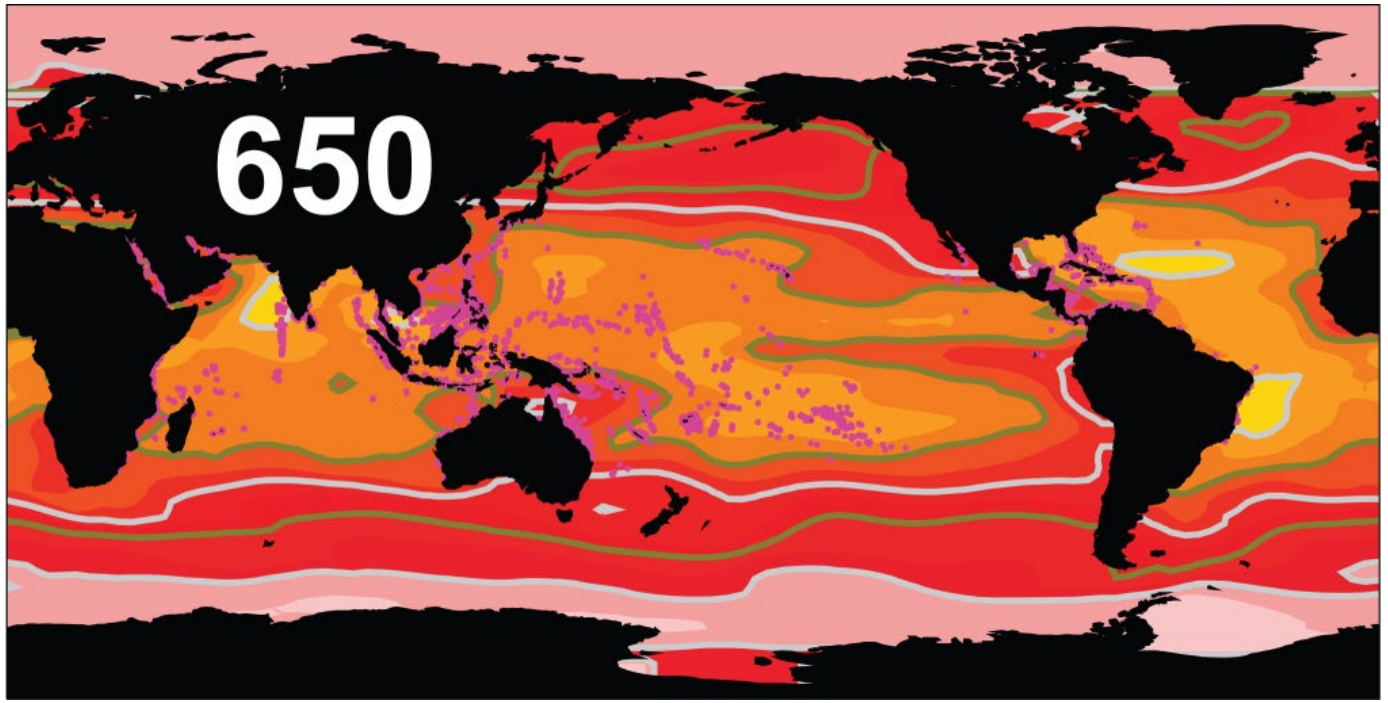
Some think that the impacts are only related to warming temperatures, but increasing CO_2 is having direct impacts

Distribution of saturation states in reef locations



Cao and Caldeira, 2008

Surface Water Aragonite Saturation States with 650 ppm CO_2



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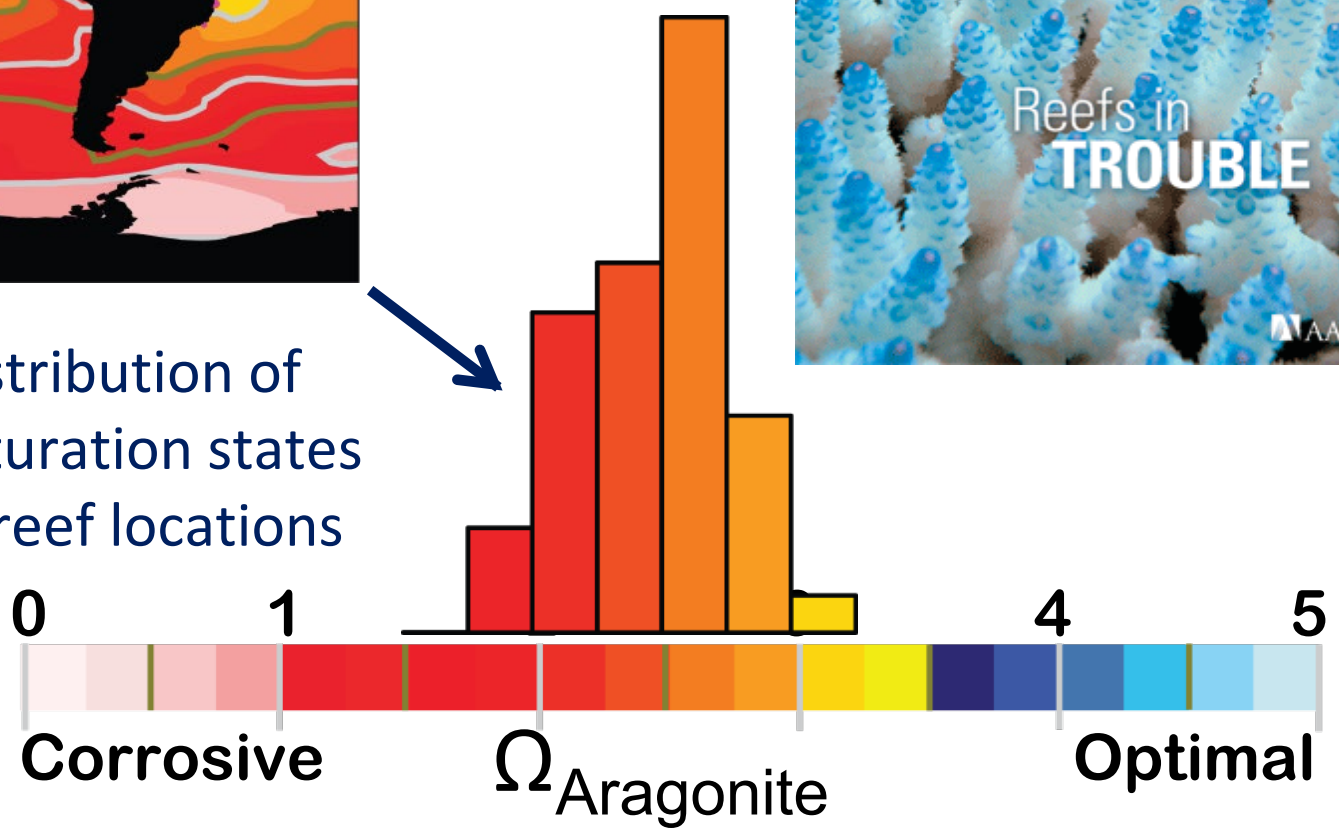

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