A case study of ocean acidification and South Florida's coral reefs

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Introduction

- Ocean acidification is a result of increased anthropogenic atmospheric carbon dioxide levels being absorbed by the world's oceans
- This results in a lowered pH value of seawater
- The subsequent chemical reaction leads to less carbonate ions being available for calcifying marine organisms to build their skeletons
- In coral reefs this means loss to the following functions:
  - Skeletal density
  - Expansion rate
  - Reproduction
- Coral populations are decreasing along with their necessary ecosystem services

Research Question

How is ocean acidification affecting the coral reef ecosystem in South Florida and what does this imply for the future?

Explanation

Anthropogenic CO2 Levels

About 25% of all carbon dioxide emitted from human activities into the atmosphere is absorbed by the ocean

Carbon dioxide levels are currently increasing at a rate of approximately 2.2 parts per million annually

Carbonate Saturation

CO2 reacts with sea water to produce two positively charged ions, causing a lowered pH

These react with negative bases in the water such as CaCO3- carbonate ions

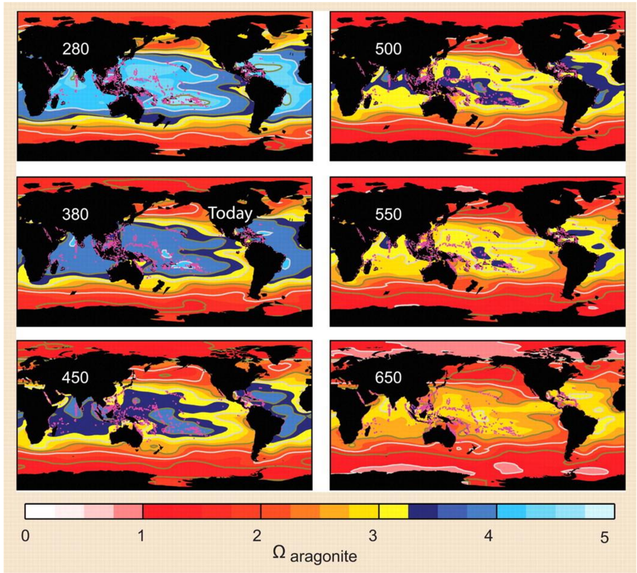
Hydrogen saturation and carbonate saturation have an inverse relationship

Calcification

Calcifying organisms depend on carbonate ions to build their skeletons

As carbonate saturation decreases, calcifying organisms' growth slows until they eventually begin to dissolve

Evidence



(Heogh-Guldberg et al, 2007)

Aragonite is a mineral form of calcium carbonate. This figure shows the changes in ocean water aragonite saturation predicted to occur with increasing levels of ppm of atmospheric CO2 saturation exhibited in white at the top left of each panel. Coral reef locations are shown as pink dots.

Kuffner et al conducted an experiment in the Florida Keys in 2013 to exemplify the negative effects of reduced ability for calcification on coral growth.

- 4 sites were selected and 2 batches of 40 corals were used for 2 runs in the spring of 2009 and the spring of 2011
- Selected coral colonies were attached to concrete blocks with epoxy
- Every 6 months the corals were analyzed for linear expansion and calcification levels
- A positive relationship was determined between calcification levels and increased linear expansion

Langdon et al also conducted an experiment in 2013 in the Florida Keys to explore the effects of increased pCO2 on coral calcification rates.

- 11 corals were attached to cinderblocks with sensors recording environmental data such as temperature and ocean water pH levels from April 2007 to November 2010 at 30-minute intervals
- Random individuals were selected to be relocated to incubation tanks in situ and chemical injections of NaHCO3 and HCl were used to decrease pH value by 0.1 - 0.2 units
- Calcification rates were calculated for all samples
- Coral samples incubated in chambers with a decreased pH also had decreased calcification rates of 50% - 52% according to a drop of 0.1 to 0.2 units respectively

Impacts

Ecological impacts on reefs include decreased:

Linear expansion, density, rugosity, reproduction

Socio-economic impacts in South FL include negative effects on:

Coastal protection, tourism, local fisheries, medicinal opportunities

Recommendations and Conclusion

Ocean acidification is gradually causing a net carbonate dissolution in South Florida's coral reefs, impacting their ability to grow and reproduce properly and causing a decline in population. This negatively affects their intrinsic and socio-economic value. Recommendations for mitigation and adaptation include:

- Reduce other local stressors such as pollution, water quality degradation, and overfishing to give reefs a better chance to recover
- Advance research and restoration efforts such as marine protected areas, restoring key species, micro fragmentation techniques, assisted breeding, and gene modification

Micro fragmentation of orbicella faveolata at Sea Base. (Camden, 2020)

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