NOAA Coral Reef Watch

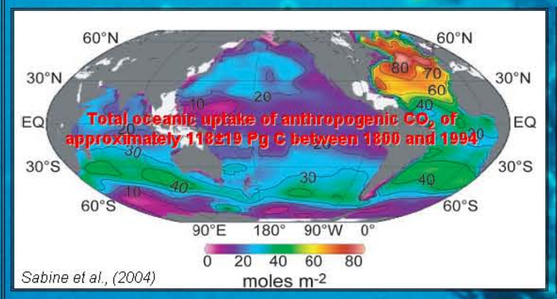
# COUPLING REMOTE SENSING AND *IN SITU* DATA TO DERIVE A CALCIFICATION INDEX FOR CORAL REEF ECOSYSTEMS

Dwight Gledhill, C. Mark Eakin, Gang Liu, Tyler Christensen , Scott Heron, Jessica Morgan, William Skirving, Alan Strong
NOAA Coral Reef Watch, SSMC1, E/RA 31, 1335 East-West Highway, Silver Spring, MD 20910-3226

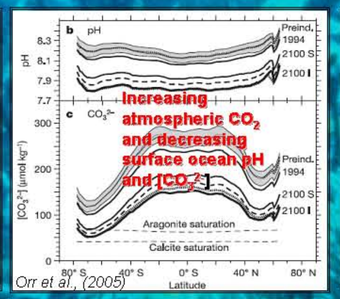
**Introduction –** Coral reefs are biologically diverse ecosystems built upon the accumulation of calcium carbonate produced by frame-building scleractinian corals and calcareous algae. There is growing concern that as a consequence of ocean acidification from increasing atmospheric $CO_2$, marine calcifiers including prominent coral reef building organisms may suffer reducing rates of calcification. NOAA Coral Reef Watch (CRW) seeks to establish a sustained monitoring network that will provide a qualitative index of system level coral reef calcification at selected sites throughout the Wider Caribbean. Once established, the network will provide continuous monthly reporting of a calcification index that can be provided to reef managers, conservationists and interested academic and government agencies overseeing the welfare of these unique and valuable resources.

## That other $CO_2$ problem!

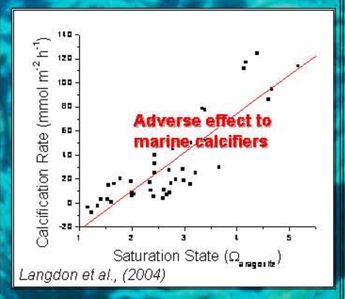
**Ocean Acidification –** Approximately half of all the anthropogenic carbon dioxide released since the onset of the industrial revolution has been taken up by the surface waters of the world's oceans. While this has served to moderate atmospheric $CO_2$ levels, it has resulted in pronounced changes in ocean chemistry with potentially dire consequences for certain marine organisms. A measurable decrease in the saturation state with respect to the minerals from which coral reefs build their calcareous skeleton mass ("calcification") has been observed. Community scale calcification rates of coral reef organism have been demonstrated to be highly sensitive to such changes and could decline from between 15 – 40% relative to preindustrial levels by 2100.



Sabine et al., (2004)



Orr et al., (2005)



Langdon et al., (2004)

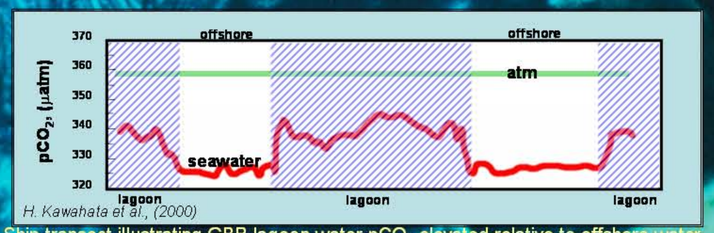
## Deriving a Proxy for Reef Calcification

Photosynthesis Respiration

$$CO_2 + H_2O \leftrightarrow CH_2O + O_2$$

Calcification

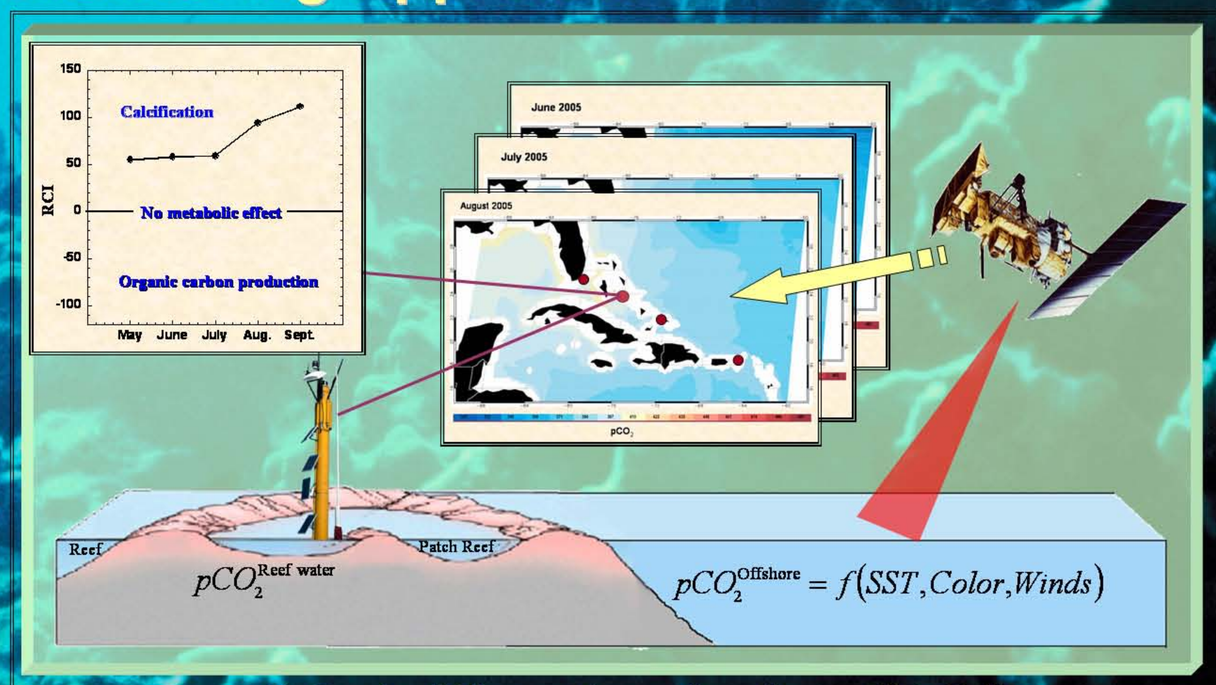
$$Ca^{2+} + 2HCO_3 \rightarrow CaCO_3 + H_2O + CO_2$$



H. Kawahata et al., (2000)
Ship transect illustrating GBR lagoon water $pCO_2$ elevated relative to offshore water

**Coral Reefs and $CO_2$ –** A coral reef influences the surrounding water carbon chemistry both by taking up $CO_2$ through photosynthesis and by releasing $CO_2$ as a byproduct of calcification. In reef systems where active calcification is occurring, there is a net increase in the overlying water $pCO_2$. When hydrographic considerations are accounted for, the magnitude of this effect can be used to model the metabolic performance of the reef. The dynamics of $CO_2$ and carbon mass balance considerations provide an overall, integrated view of reef metabolism. Such measurements can be useful for understanding changes in reef carbon cycling should these ecosystems transition from coral-dominated communities to macroalgae-dominated communities in response to the multiple anthropogenic and environmental stresses now subjecting many reef systems.

## Monitoring Approach




## Reef Calcification Index (RCI)

$$RCI = pCO_2^{\text{Reef water}} - pCO_2^{\text{Offshore}}$$

- CRW is developing the RCI, a monthly index of ecosystem-level coral reef calcification.
- The RCI couples remote sensing and *in situ* observations of carbon dioxide partial pressure ($pCO_2$) to monitor changes in reef community structure.
- Monitoring the balance between organic carbon and calcium carbonate production, the RCI reflects ecosystem-level changes and reef responses to a series of environmental stresses including ocean acidification.
- The RCI adds to the suite of CRW products, providing an important tool in monitoring coral reef response to mounting environmental stresses related to climate change.

## CCSP Relevance

- The RCI will provide important overall coral reef health information to decisionmakers and other stakeholders for informed decisionmaking.
- The RCI will serve as a key observational and modeling tool for regional decision support.
- Web accessibility to monthly reporting will provide timely and efficient communication of key research quality scientific information.
- The RCI will offer an important metric for reef conservation and restoration effectiveness.

**Conclusion –** An underappreciated and potentially grave threat to coral reef ecosystems in coming decades will be the acidification of the world's oceans as a consequence of a continued rise in atmospheric carbon dioxide. Calcification rates are expected to decline in response to a decreasing ocean pH making corals more susceptible to bioerosion and rising sea levels. Reduced calcification rates will also hamper reef recovery following acute environmental stresses such as large-scale bleaching (which is likely to become more prevalent with rising seawater temperatures). As these stony coral systems give way to macroalgal dominance, changes in the local carbon budget will be reflected in the surrounding aqueous $CO_2$ system. NOAA Coral Reef Watch seeks to establish a sustained monitoring of these changes at selected reef communities throughout the Wider Caribbean Sea by coupling remote sensing and *in situ* data to derive a monthly Reef Calcification Index (RCI). The RCI will be made readily accessible to decisionmakers and other stakeholders providing a timely metric for overall coral reef health.