Response of Florida Shelf Ecosystems to Climate Change: from Macro to Micro Scales

Introduction

U.S. Geological Survey (USGS) research in St. Petersburg, Fla., is focusing attention on marine environments of the Florida shelf at three levels, from regional to estuarine to the individual organism. The USGS is partnering on this project with the Florida Department of Agriculture and Consumer Services (DACS), National Oceanic and Atmospheric Administration (NOAA), and the University of South Florida (USF) in marine studies. The specific goals of these combined efforts are an improved understanding of the effects of ocean acidification on regional carbonate processes, changes in individual estuaries, and organism-level response (fig. 1). This understanding will assist in developing appropriate Federal, State, and local management responses to climate change in coastal areas.

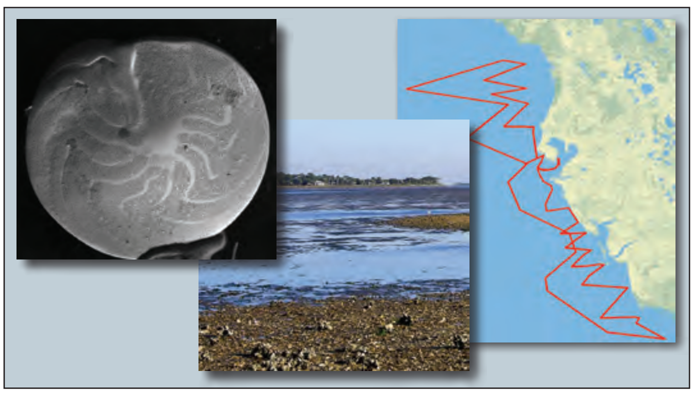


Figure 1. Water chemistry changes associated with ocean acidification can affect carbonate processes and the survival and competitive advantages of calcifying organisms from macro to micro scales.

Ocean Acidification

Our research focuses on climate change impacts to the shallow waters of the Florida shelf. With 1,350 miles of coastline, productive estuaries, and sandy beaches, Florida's economy relies substantially on marine and coastal resources. A major issue is the buffering capacity of oceans in the absorption of anthropogenic carbon dioxide (CO_2). Excess atmospheric CO_2 is absorbed at the ocean surface, lowering seawater pH, and reducing carbonate ions available to organisms. These changes in seawater chemistry are known as "ocean acidification." The pH of the world's oceans has declined by approximately 0.1 pH units since 1750.

Scientists are monitoring seawater chemical changes, such as pH and the aragonite saturation state (Ω_{arag}). These changes are important because they affect a range of biological processes in marine organisms: precipitation of calcium carbonate, fixation of CO_2, regulation of internal pH, and uptake of nutrients.

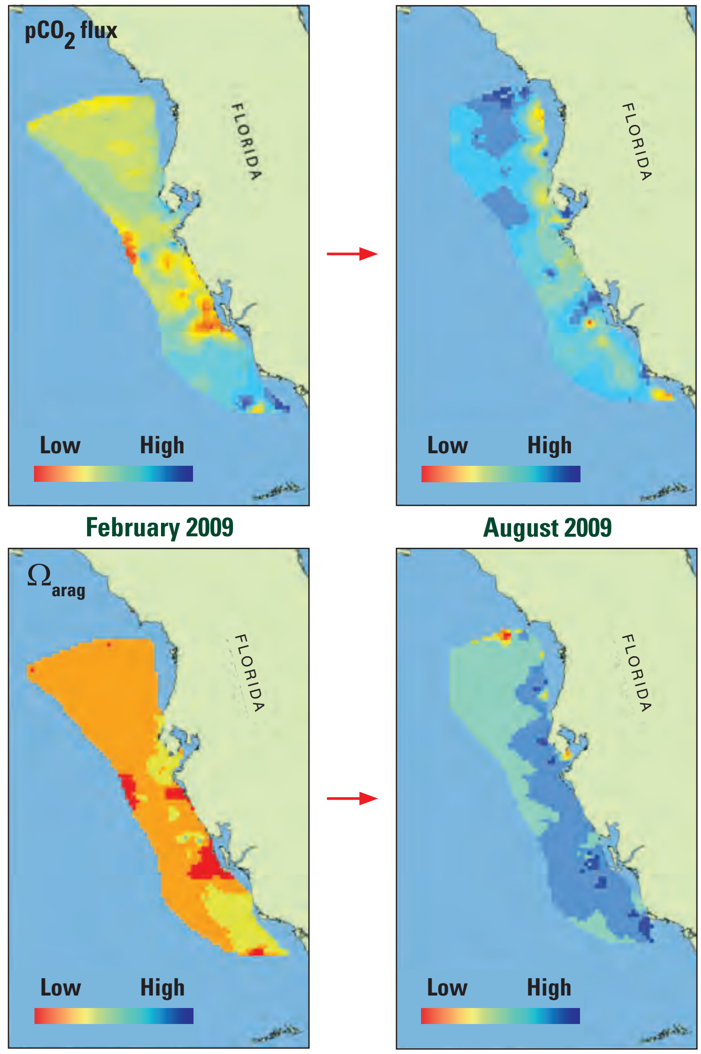


Figure 2. Preliminary contours of seasonal pCO_2 flux and aragonite saturation (Ω_{arag}) from USGS cruises, February and August 2009.

Regional Carbonate Chemistry

The goals of the combined regional-scale efforts are to determine baseline CO_2 fluctuation and Ω_{arag} and to synthesize existing carbon budget data for the Gulf of Mexico. USGS scientists are measuring pH, salinity, temperature, dissolved inorganic carbon and pCO_2 (partial pressure of CO_2) on the Florida shelf using discrete water samples and a Multi-parameter Inorganic Carbon Analyzer (MICA). CO_2 fluxes and Ω_{arag} on the shelf are calculated from these data (fig. 2). Understanding the seasonal and annual variability of carbonate-saturation states will enable researchers to more accurately predict long-term trends.

U.S. Department of the Interior
U.S. Geological Survey

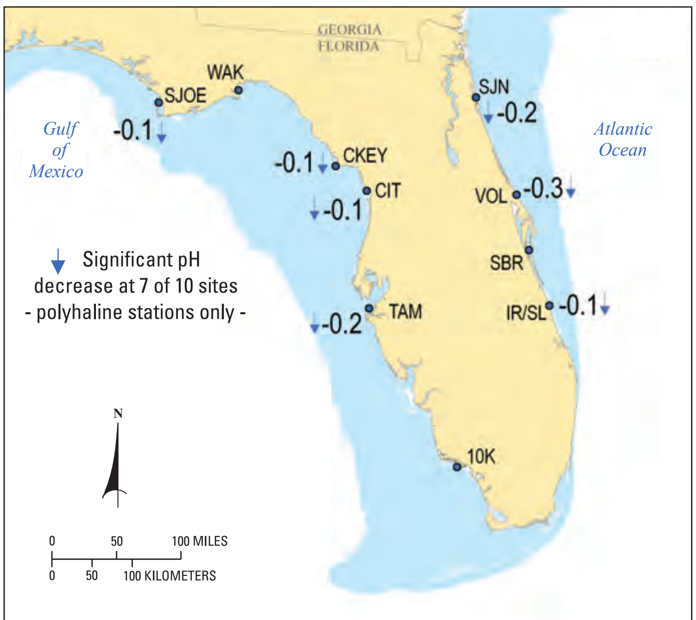
Printed on recycled paper

Fact Sheet 2010–3065
August 2010

Modern Estuarine Water Quality

USGS researchers are evaluating pH and other water-quality parameters from Florida DACS shellfish harvest sites. Ten estuaries with data records of 20 years or more are being evaluated and compared. Each estuary had multiple monitoring stations that were divided into saline to fresh categories for analysis. Preliminary analysis at polyhaline stations (average salinity 18-30 ppt) from the period of record shows significant time-related changes in water quality on Gulf and Atlantic coasts. Observed increases in temperature and salinity, and decreases in pH (fig. 3) may be associated with effects of climate change including sea-level rise, warming temperatures, and ocean acidification, and with alterations to freshwater supply and water quality.

Simultaneous changes in pH, salinity, and temperature can have deleterious effects on estuarine flora and fauna, exposing organisms to increased environmental stress and putting many species at a disadvantage when faced with competition, recovery, and adaptation pressures. Shellfish production in many coastal Florida counties may be affected by changes in water chemistry.



	Gulf						Atlantic			
	SJOE	WAK	CKEY	CIT	TAM	10K	SJN	VOL	SBR	IR/SL
pH	<	ns	<	<	<	ns	<	<	ns	<
Sal.	>	>	>	>	>	>	>	>	>	ns
Temp.	ns	>	>	>	>	>	>	>	>	>

< significant decrease, > significant increase, ns = not significant

Figure 3. Preliminary shellfish-harvest monitoring data around Florida, showing significant pH decline at 7 of 10 estuaries. pH decline was accompanied by increases in salinity and temperature.

Laboratory Studies

USGS laboratory studies focus on the organism-level response to determine the effects of low pH or reduced carbonate-saturation state on single-celled protozoa (*Foraminifera*), calcifying algae (*Halimeda;* fig. 4), and microbes. Organisms respond to environmental changes, such as ocean acidification, light levels, nutrients, and temperature, with individual physical and chemical alterations and large-scale changes in productivity and distribution.

Figure 4. Lab experiments are being conducted on *Halimeda incrassata,* a calcifying benthic green alga, to determine organism-level response to changes in pCO_2.

Laboratory experiments are being conducted at realistic forecast levels of pCO_2 in enclosed microcosms to assess the effects that changes in pH, pCO_2, and seawater carbonate chemistry will have on aragonitic green algae and benthic foraminiferal survival, calcification rates, and shell morphology. The selected species are abundant on carbonate shelves around Florida, where their tests and segments contribute significantly to shelf sedimentation and beach sand. Experiments to assess growth, calcification, and survival rates in temperature- and light-controlled environmental chambers are being performed. Historical archived samples of *Halimeda* have been analyzed for ultra-structural changes via Scanning Electron Microscopy (SEM) image analysis. These archived samples are being compared with results revealed in laboratory experiments.

Summary

It is expected that absorption of anthropogenic CO_2 will continue to decrease ocean carbonate-saturation state and have significant consequences for organisms that produce calcium carbonate. As climate, sea level, and ocean chemistry change, so too will Florida's coastal and marine resources.

Authors: Lisa Robbins, Principal Investigator, and Ellen Raabe, U.S. Geological Survey, St. Petersburg Coastal and Marine Science Center, 600 4th Street South, St. Petersburg, FL 33701

Web sites: FLaSH Web site go to: *http://coastal.er.usgs.gov/flash/* and
USGS Ocean Acidification go to: *http://coastal.er.usgs.gov/ocean-acidification/*