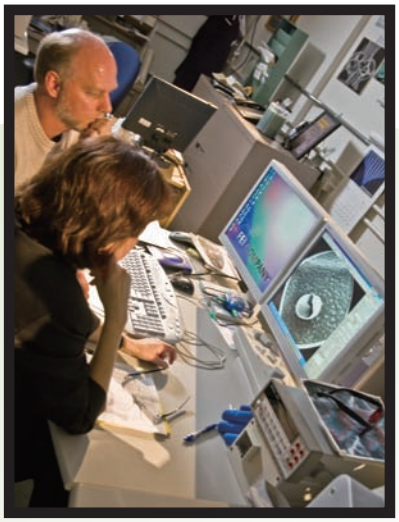
Invisible NO MORE:

Scripps Investigates Ocean Acidification

WITH SHOCKING SPEED, THE INCREASING ACIDIFICATION OF THE WORLD'S OCEANS HAS BEEN TRANSFORMED FROM AN ABSTRACT PROBLEM WITH AN INDEFINITE TIME SCALE TO A CONSEQUENCE OF CLIMATE CHANGE THAT HAS TANGIBLE EFFECTS OBSERVABLE NOW. SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO IS PART OF A GLOBAL EFFORT TO BRING PUBLIC ATTENTION TO A SUBTLE BUT PROFOUND CRISIS THAT NEEDS TO BE UNDERSTOOD AND ADDRESSED.

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego



SCRIPPS RESEARCHERS ARE DESIGNING STUDIES TO TRACK THE EFFECTS OF ACIDIFIED SEAS ON MARINE ORGANISMS RANGING FROM CORAL TO MICROSCOPIC INVERTEBRATES AT THE BASE OF MARINE FOOD WEBS.

THE PROBLEM OF INCREASING GREENHOUSE GAS concentrations in the atmosphere is well-known, but the effects of our fossil fuel use on ocean chemistry are only now beginning to be understood.

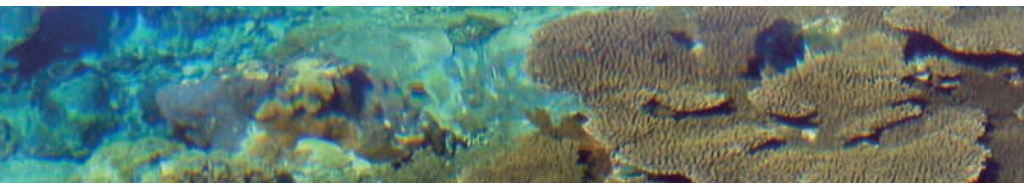
About one-third of the carbon dioxide produced every day by vehicle exhaust, coal-fired power stations, and wood-burning stoves around the world is absorbed into the oceans. The gas reacts with seawater, changing its pH and reducing the concentration of carbonate ion, an essential component in the calcium carbonate that makes up seashells and corals.

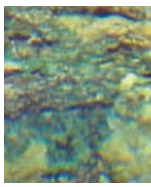
Since the late 1980s, researchers at Scripps Institution of Oceanography at UC San Diego and elsewhere have recorded a drop in pH at certain ocean locations. Recent research has since found falling pH levels in a variety of ocean regions, with particularly vulnerable systems being detected in polar waters and off the west coast of North America. The decrease is enough to put many key marine organisms at risk. The pace of acidification will likely not give many organisms sufficient time to adapt. Some estimates suggest, for example, that the growth rate of coral might be outpaced by its depletion rate by mid-century. One recent estimate indicates that some vulnerable polar ecosystems could experience initial stages of corrosive surface waters within 20 to 30 years.

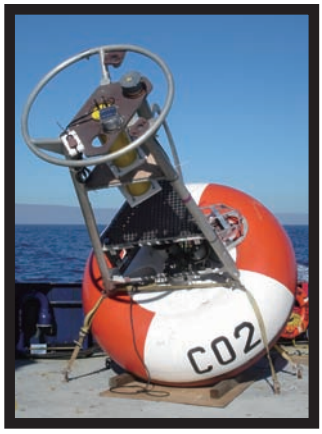
Some of the species most vulnerable to ocean acidification are vital to ocean food webs. Pteropods are small marine snails that are a large part of the diet of salmon and other commercially important fish species. Some pteropod species have shells so thin that they are transparent. Increasingly corrosive waters threaten the formation of these shells and could substantially reduce pteropod populations in polar and subpolar regions worldwide. Residual effects will resonate through ocean food webs.

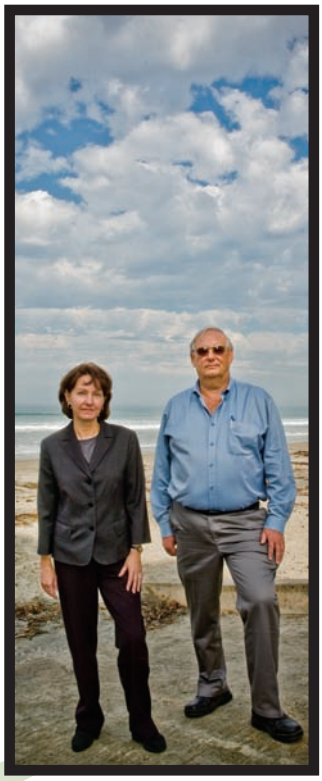
A number of questions need to be answered as soon as possible. Scientists are attempting to discover when tipping points for widespread damage will be reached and what the effect of reducing carbon dioxide emissions will be. Researchers are trying to understand the difference in reactions to acidification among marine species. For example, why are some species sensitive to high CO_2 concentrations while others are not?

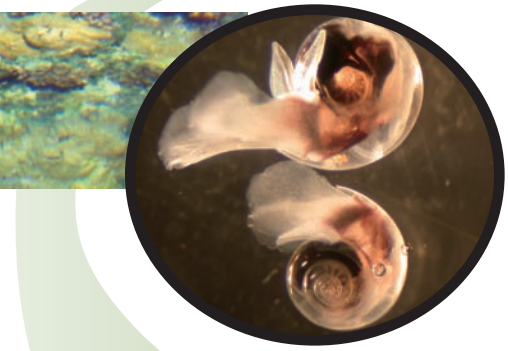
Scripps Oceanography is uniquely poised to address this growing global problem. Located adjacent to the most studied ocean region in the world, the institution's history of data collection makes it a repository of records that can help scientists retrace trends in ocean chemistry over more than 50 years. Scripps scientists have created key reference standards used in the measurement of seawater carbon dioxide levels. Most importantly, though, Scripps is home to some of today's leading ocean acidification researchers. They are bridging fields such as marine biology, physics, and chemistry to bring an interdisciplinary focus to a problem that needs answers now.











The Foundation: Data Collection at Scripps

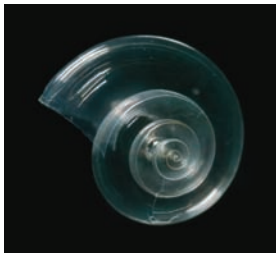
OCEAN CO_2 MEASUREMENTS

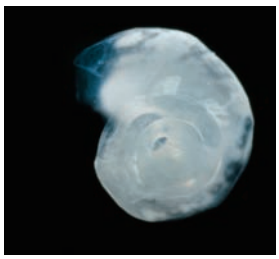
The record of rising atmospheric carbon dioxide levels is often referred to as the Keeling Curve after Charles David Keeling, the Scripps geochemist who began a steady measurement series atop Hawaii's Mauna Loa in 1958. Keeling also launched a complementary measurement series of carbon dioxide concentrations in the oceans, which today is led by Scripps marine chemist Andrew Dickson. Dickson has also created a reference standard for proper measurement of ocean CO_2 levels. It is the basis of a protocol followed by marine chemistry labs around the world. Today Dickson's lab prepares and bottles thousands of reference samples each year for distribution throughout the research community.

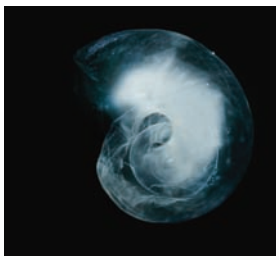
CALCOFI

For some 60 years, the California Cooperative Oceanic Fisheries Investigations (CalCOFI) has gathered fundamental biological, chemical, and physical data within a grid off the West Coast. Scripps biological oceanographer Mark Ohman is facilitating an effort to look back through decades of CalCOFI information to estimate changes in ocean CO_2 levels over time. Researchers anticipate that the endeavor will provide crucial historical context for current ocean acidification trends.

LEFT, TOP TO BOTTOM, *ONGOING RESEARCH INCLUDES DEPLOYMENTS OF FIELD SENSORS OFF THE CALIFORNIA COAST; RESEARCHERS VICTORIA FABRY AND ANDREW DICKSON; THE PTEROPOD, OCEAN ACIDIFICATION'S EMBLEMATIC ORGANISM.*







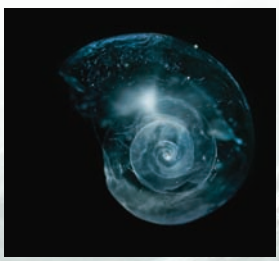
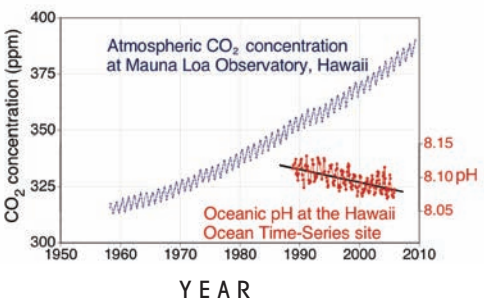


Photo credits: David Liittschwager, National Geographic Stock.

LEFT, *VICTORIA FABRY AND COLLEAGUES EXPOSED A PTEROPOD SHELL TO CARBONATE ION-DEPLETED SEAWATER WITH ACID LEVELS SET TO THE PH OF SOUTHERN OCEAN WATER EXPECTED IN 2100. THE SHELL DISSOLVED AFTER 45 DAYS.* **BELOW**, *RISING CO_2 LEVELS IN THE ATMOSPHERE, PLOTTED ON THE FAMOUS KEELING CURVE, DIRECTLY CORRESPOND TO INCREASING ACIDITY (DECREASING pH) OF SEAWATER.*



The Future: Collaborative Research at Scripps

BIOLOGICAL IMPACT ASSESSMENTS

Dickson and biological oceanographer Victoria Fabry, a visiting research scientist at Scripps, will lead a study funded by the California Ocean Protection Council that will include complementary field and lab components. The researchers, working with colleagues from several West Coast research centers, will deploy a mooring off the Northern California coast equipped with carbon dioxide sensors transmitting near-real-time data.

The National Science Foundation has awarded a grant to biological oceanographer Lisa Levin as part of a large-scale study of acidification's effects on ecosystems. Levin will study the larval shells of marine invertebrates raised in seawater with varying pH and oxygen levels to see if changes in their chemical structure are an indicator of changes in ocean chemistry driven by acidification or declines in oxygen levels. These data could become an interpretive tool to assess pH exposures in living organisms and fossils.

OCEAN CLIMATE MONITORING

Scripps physical oceanographer Uwe Send developed a mooring outfitted with a surface water carbon dioxide sensor provided by NOAA's Pacific Marine Environmental Laboratory, which Send first deployed with Ohman off the California coast in 2008. The mooring joins an open ocean monitoring effort known as OceanSITES. OceanSITES is building a network of stations around the world's oceans to collect long time-series measurements of trends in ocean climate and ecosystem dynamics.

The Mission: Bringing Ocean Acidification to a World Stage

THE MONACO DECLARATION

Fabry and Dickson joined 150 leading scientists in signing the Monaco Declaration in 2008. The document was presented in conjunction with the second international symposium "The Ocean in a High CO_2 World" and urged immediate action toward reduction of greenhouse gas emissions.

PRINCE ALBERT II OF MONACO AND THE ROGER REVELLE PRIZE

In October 2009, Scripps honored a champion of ocean acidification research and his efforts to bring the issue into households and legislative halls around the world. The institution presented His Serene Highness Prince Albert II of Monaco with the Roger Revelle Prize at Scripps. The prize recognizes leaders in public and private sectors whose outstanding contributions advance or promote research in ocean, climate, and earth sciences.

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