

TACKLING ACIDIFICATION

Photo Credit: James Wheeler

What we know about the impacts of ocean acidification
and what we can get from the next wave of research

Ocean acidification - a fundamental shift in ocean chemistry - has already driven some U.S. shellfish hatcheries to change their operations. Other industries and state governments have begun to look for ways to avoid or minimize future threats. In the face of this growing concern, research initiatives have helped define the problem and understand the impacts - and now seek solutions. From coordinated monitoring efforts to understanding the likelihood that marine species can adapt to acidifying waters, science is informing an array of options for tackling the challenge ocean acidification poses to our communities and livelihoods.

Ocean Acidification 1.0: Changing Chemistry

Since the industrial revolution, we have seen an approximately 30% increase in seawater acidity globally due to increases in atmospheric carbon dioxide dissolving in the oceans. This fundamental change in chemistry makes it difficult for some marine animals, like oysters and corals, to build shells and grow at normal rates.

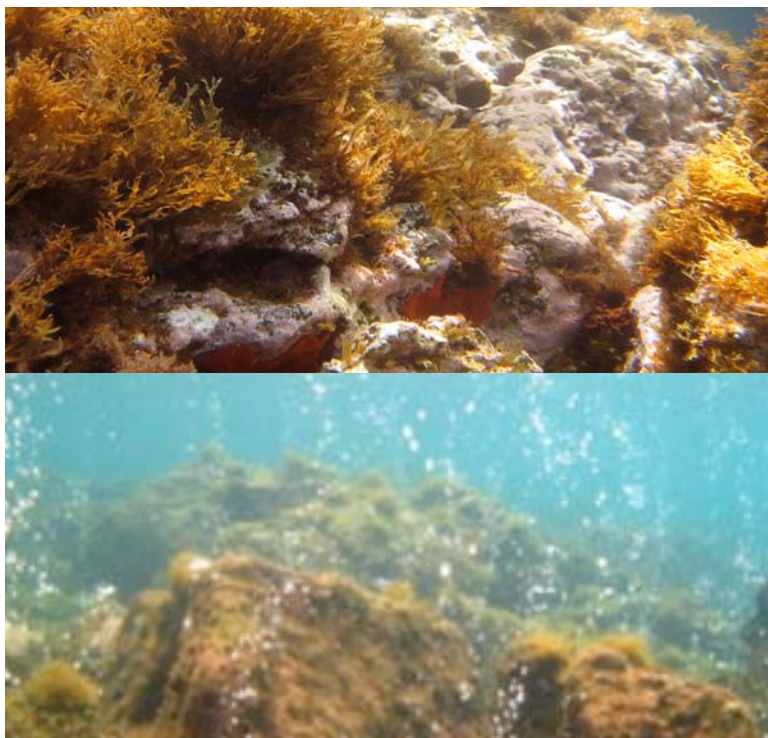


Ocean Acidification 2.0: Ecological & Industry Impacts

We now know that many species respond differently to changes in acidity. West Coast shellfish hatcheries have experienced severe failures, while other species exhibit the potential to adapt. Our increasingly sophisticated understanding of how ocean acidity varies from place to place and through time - including the role of local, land-based drivers - allows us to better understand how local management can play a role in addressing current and potential future impacts to coastal ecosystems.

Ocean Acidification 3.0: Towards Solutions

Looking ahead, ocean acidification research is critical to informing how local and global actions can reduce social and economic vulnerability to changes in seawater chemistry. We seek to better understand a) how acidification levels vary from place to place and over time, b) the crucial tipping points for marine ecosystems, and c) which species are most likely to be harmed by - or adapt to - these changes, particularly in coastal regions. Coordinated monitoring efforts in coastal systems can reveal the relative importance of the many factors that can contribute to acidification, therefore shaping management priorities.



These striking images show a rocky reef ecosystem under typical levels of acidity (top) compared to a reef near a natural carbon dioxide vent that increases seawater acidity (bottom). Photos courtesy of Kristy Kroeker

For More Information

Dr. Stephen Palumbi

Professor, Hopkins Marine Station, Stanford University, Pacific Grove, CA

Phone: 831-655-6214 | E-mail: splaumbi@stanford.edu

Dr. Scott Doney

Senior Scientist & Director, Ocean and Climate Change Institute, Woods Hole Oceanographic Institution
Woods Hole, MA

Phone: 508-289-3776 | E-mail: sdoney@whoi.edu

Dr. Kristy Kroeker

Postdoctoral Scholar, Bodega Marine Lab, University of California, Davis, Bodega Bay, CA

Phone: 707-875-2009 | E-mail: kjkroeker@ucdavis.edu

Dr. Jan Newton

Senior Principal Oceanographer, Applied Physics Laboratory & Executive Director, Northwest Association of Networked Ocean Observing Systems (NANOOS), University of Washington, Seattle, WA

Phone: 206-543-9152 | E-mail: newton@apl.washington.edu

SCIENTIST BIOGRAPHIES



Stephen Palumbi

Jane and Marshall Steel Professor of Marine Science, Harold A. Miller
Director of Hopkins Marine Station
Stanford University, Pacific Grove, CA

Phone 831-655-6214 | **E-mail** spalumbi@stanford.edu

Stephen Palumbi's research group is engaged in study of the genetics, evolution, population biology and systematics of marine species in the context of rapid environmental change. A major focus is on the conservation and management of marine populations based on insight from molecular genetics. This approach has been applied to the design and implementation of marine protected areas for conservation and fisheries enhancement, as well as to reconstruction of past population sizes of baleen whales, the identification of whale and dolphin products available in commercial markets, and strategies for finding and protecting the world's strongest corals. Steve is the Director of the Hopkins Marine Station, co-Director of the Aldo Leopold Leadership Program, and a board member for several conservation organizations. Steve holds a Ph.D. from the University of Washington, and a B.A. from The Johns Hopkins University. He has received numerous awards for research and conservation, including a Pew Fellowship in Marine Conservation. He is also the author of three books - *The Evolution Explosion*, *The Death and Life of Monterey Bay: A Story of Revival*, and the upcoming *Shark and Awe: The Extreme Life of the Sea* - and is the creator of a *Short Attention Span Science Theater*, a micro-documentary project.



Scott Doney

Senior Scientist & Director, Ocean and Climate Change Institute
Woods Hole Oceanographic Institution
Woods Hole, MA

Phone 508-289-3776 | **E-mail** sdoney@whoi.edu

Scott Doney is a Senior Scientist and the director of Ocean and Climate Change Institute at the Woods Hole Oceanographic Institution. Much of his research focuses on how the global carbon cycle and ocean ecology respond to natural and human-driven climate change, and he has over 200 peer-reviewed publications. A key focus is on ocean acidification due to the invasion into the ocean of carbon dioxide from fossil fuel burning. He graduated with a PhD in chemical oceanography from the Massachusetts Institute of Technology/ Woods Hole Oceanographic Institution Joint Program in Oceanography in 1991. He was a postdoctoral fellow and later a scientist at the National Center for Atmospheric Research, before returning to Woods Hole in 2002. He was the inaugural chair of the U.S. Ocean Carbon and Biogeochemistry Program. He has been recognized by numerous awards including the James B. Macelwane Medal from the American Geophysical Union, Aldo Leopold Leadership Fellow, and AGU and AAAS Fellow.



Kristy Kroeker

Postdoctoral Scholar, Bodega Marine Lab
University of California, Davis, Bodega Bay, CA

Phone 707-875-2009 | E-mail kjkroeker@ucdavis.edu

Kristy Kroeker is a marine ecologist conducting research at Bodega Marine Laboratory of University of California, Davis, where she is a postdoctoral scholar with the Bodega Ocean Acidification Research Group. Her research examines the emergent ecological effects of climate change and ocean acidification on marine communities and ecosystems. Current research addresses how multiple concurrent changes in the environment, ranging from warming to ocean acidification to nutrients, impact marine species and ecosystems, and whether actions at a local-scale can offset the effects of global change. Kroeker received her PhD in 2012 from Stanford University where she studied marine community ecology at Hopkins Marine Station. Her dissertation examined the potential for ecosystem shifts in response to ocean acidification at shallow water volcanic carbon dioxide vents, which was published in top-tier scientific journals including *Nature Climate Change* and *Proceedings of the National Academy of the Sciences*. In addition, Kroeker was the lead author on two major meta-analyses of ocean acidification's effects that have been cited over 230 times since 2010, and highlighted in the upcoming Intergovernmental Panel on Climate Change Report. She is also a Rising Environmental Leader Fellow at the Woods Institute for the Environment at Stanford, and worked as a fellow for the Center for Ocean Solutions.



Jan Newton

Senior Principal Oceanographer, Applied Physics Laboratory
Executive Director, Northwest Association of Networked Ocean
Observing Systems (NANOOS)
University of Washington, Seattle, WA

Phone 206-543-9152 | E-mail newton@apl.washington.edu

Jan Newton is a Principal Oceanographer with the Applied Physics Laboratory of the University of Washington and affiliate faculty with the UW School of Oceanography and the School of Marine and Environmental Affairs, both in the UW College of the Environment. She is the Executive Director of the Northwest Association of Networked Ocean Observing Systems (NANOOS), the US IOOS Regional Association for the PNW. Jan is a biological oceanographer who has studied the physical, chemical and biological dynamics of Puget Sound and coastal Washington, including understanding effects from climate and humans on water properties. Currently she is working with colleagues at UW and NOAA to assess the status of ocean acidification in Pacific Northwest waters. Jan was appointed to serve on Washington state Governor Gregoire's Blue Ribbon Panel on Ocean Acidification. She has recently been appointed co-Director of the Washington Ocean Acidification Center at the University of Washington, College of the Environment.