



# **2009-2010 Update**

S. Cooley, J. Kleypas, R. Feely

OCB Activities

National Activities

International Activities



# OCB Ocean Acidification Activities

## *Reports and Papers*

### CONSEQUENCES OF HIGH CO<sub>2</sub> AND OCEAN ACIDIFICATION FOR MICROBES IN THE GLOBAL OCEAN

Ian Joint<sup>a)\*</sup>, David M. Karl<sup>b)\*</sup>, Scott C. Doney<sup>c)\*</sup>, E Virginia Armbrust<sup>d)</sup>, William Balch<sup>e)</sup>, Michael Beman<sup>b)</sup>, Christopher Bowler<sup>f)</sup>, Matthew Church<sup>b)</sup>, Andrew Dickson<sup>g)</sup>, John Heidelberg<sup>h)</sup>, Debora Iglesias-Rodriguez<sup>i)</sup>, David Kirchman<sup>j)</sup>, Zbigniew Kolber<sup>k)</sup>, Ricardo Letelier<sup>l)</sup>, Claudia Lupp<sup>m)</sup>, Stephen Maberly<sup>n)</sup>, Susan Park<sup>o)</sup>, John Raven<sup>p)</sup>, Daniel J. Repeta<sup>c)</sup>, Ulf Riebesell<sup>q)</sup>, Grieg Steward<sup>b)</sup>, Philippe Tortell<sup>r)</sup>, Richard E Zeebe<sup>b)</sup>, Jonathan P. Zehr<sup>s)</sup>.



# OCB Ocean Acidification Activities

## *Reports and Papers*

**CONSEQUENCES OF HIGH CO<sub>2</sub> AND OCEAN ACIDIFICATION FOR  
MICROBES IN THE GLOBAL OCEAN**

**AN INTERNATIONAL OBSERVATIONAL NETWORK FOR OCEAN ACIDIFICATION**

R. A. Feely<sup>(1)</sup>, V. J. Fabry<sup>(2)</sup>, A. G. Dickson<sup>(3)</sup>, J.-P. Gattuso<sup>(4)</sup>, J. Bijma<sup>(5)</sup>, U. Riebesell<sup>(6)</sup>, S. Doney<sup>(7)</sup>, C. Turley<sup>(8)</sup>,  
T. Saino<sup>(9)</sup>, K. Lee<sup>(10)</sup>, K. Anthony<sup>(11)</sup>, J. Kleypas<sup>(12)</sup>

P. Zehr<sup>s)</sup>.



# OCB Ocean Acidification Activities

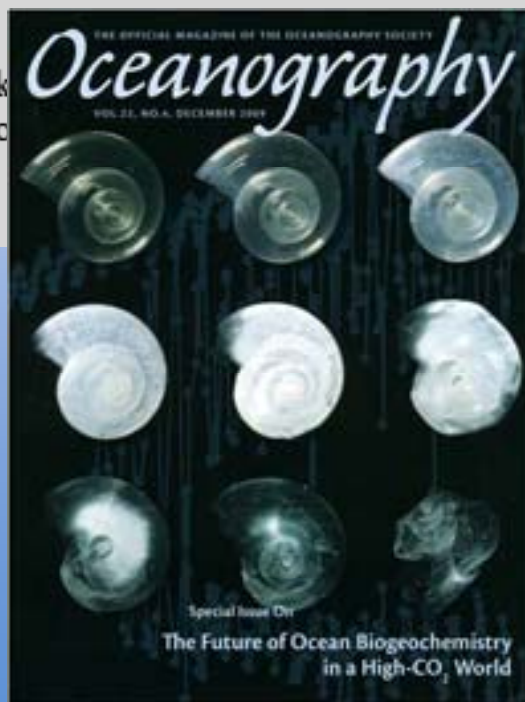
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# OCB Ocean Acidification Activities

## *Reports and Papers*

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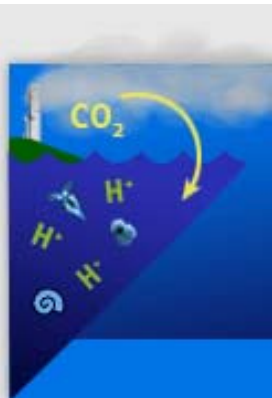
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### Response to EPA Notice of Call for Public Comment on 303(d) Program and Ocean Acidification from the Ocean Carbon and Biogeochemistry (OCB) Program

May 21, 2010





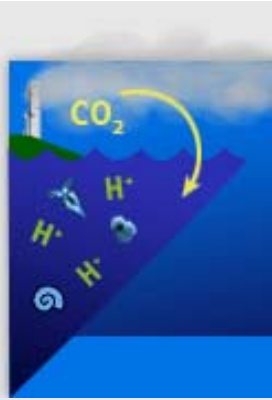


# OCB Ocean Acidification Activities

## *Educating Specialists*

OCB-OA Short Course • Woods Hole, MA • November 2-13, 2009  
[www.whoi.edu/courses/OCB-OA](http://www.whoi.edu/courses/OCB-OA)





# OCB Ocean Acidification Activities

## *Educating Specialists*

EPOCA, BIOACID, CalMarO and OCB training workshop on best practices in OA research • Kiel, Germany • March 8-12, 2010





# OCB Ocean Acidification Activities

## *Educating the Public*

## Completed Activities

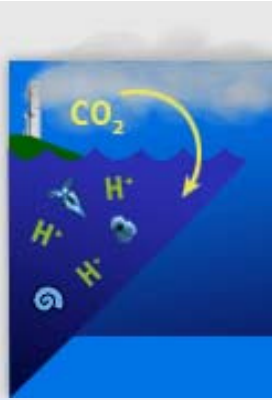
### Ocean Acidification Lab

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OA Lab Kit

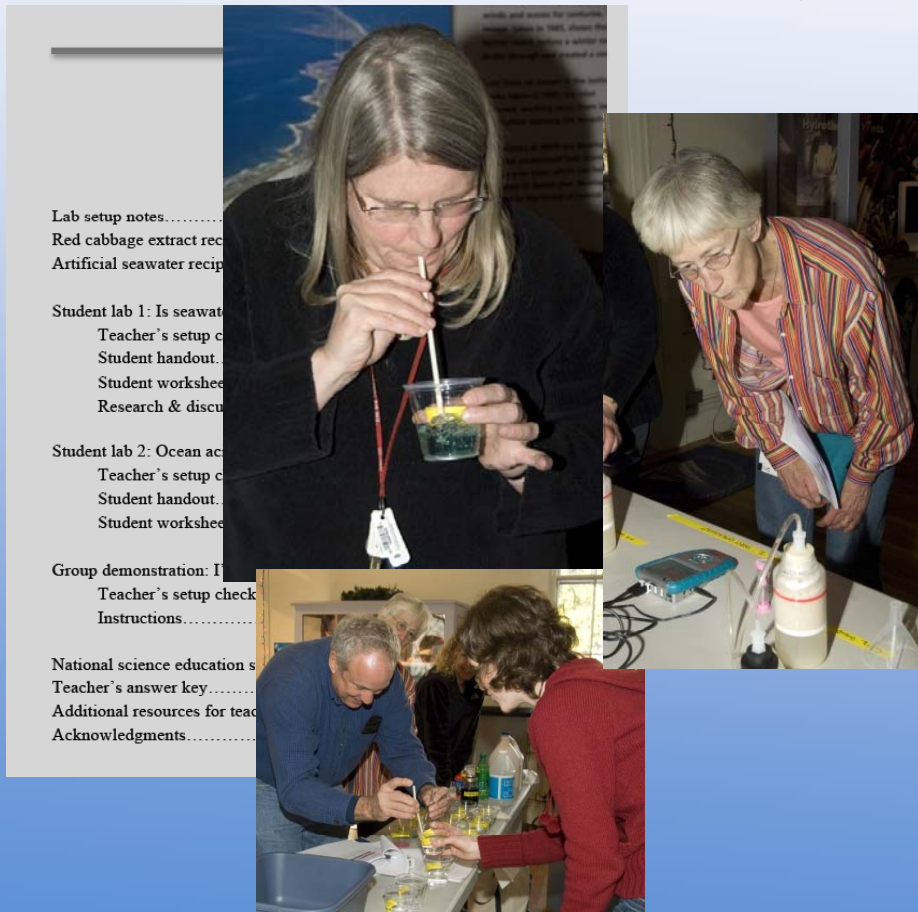




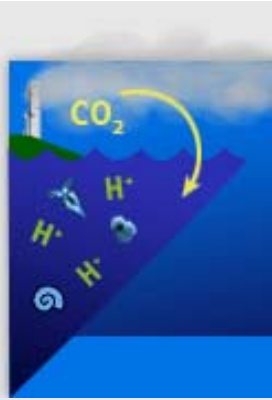
# OCB Ocean Acidification Activities

## *Educating the Public*

### Completed Activities



Teacher & Journalist Workshops



# OCB Ocean Acidification Activities

## *Educating the Public*

## Completed Activities

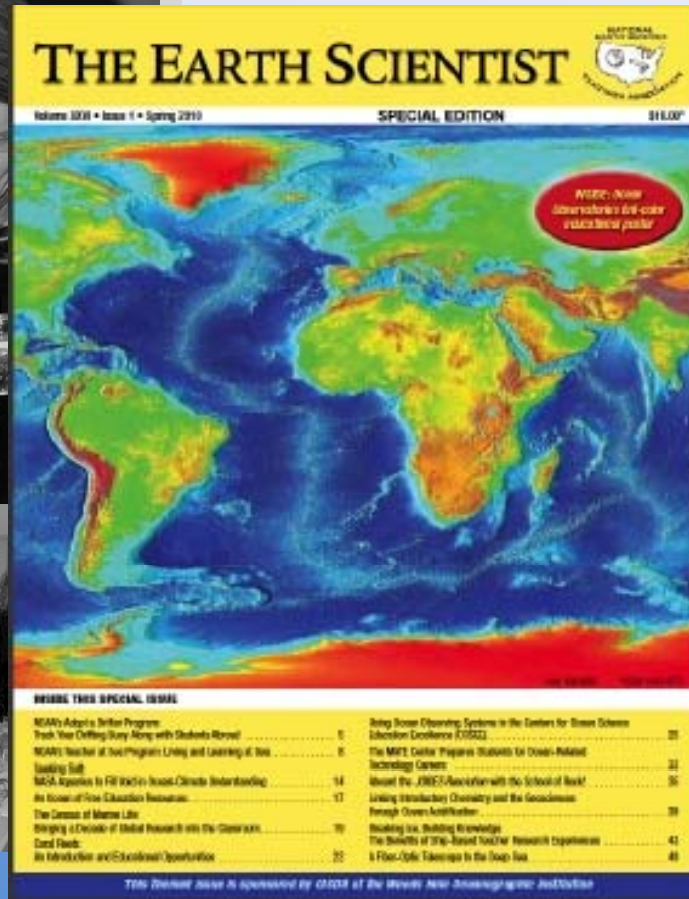
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Research & discussion

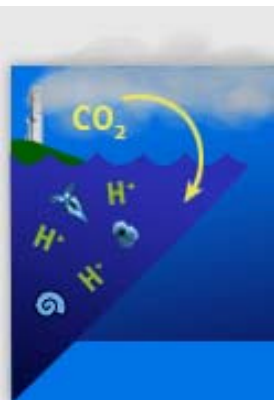
Student lab 2: Ocean acidification  
Teacher's setup checklist  
Student handout  
Student worksheet

Group demonstration: Is seawater acidic?  
Teacher's setup checklist  
Instructions.....

National science education standards  
Teacher's answer key.....  
Additional resources for teachers  
Acknowledgments.....



Article for NESTA magazine



# OCB Ocean Acidification Activities

## *Educating the Public*

### Completed Activities

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[www.us-ocb.org](http://www.us-ocb.org)  
[www.epoca-project.eu](http://www.epoca-project.eu)  
[www.oceanacidification.org.uk](http://www.oceanacidification.org.uk)

### Frequently asked questions about ocean acidification

#### Introduction

Ocean acidification is a new field of research in which most studies have been published in the past 10 years. Hence, there are some certainties, but many questions remain. Ocean acidification is also a multi-disciplinary research area that encompasses topics such as chemistry, paleontology, biology, ecology, biogeochemistry, modeling, and social sciences. Furthermore, some aspects of ocean acidification research, for example the carbonate chemistry, are intricate and counterintuitive. For these reasons, the media and the general public find some scientific issues or results confusing.

The U.S. Ocean Carbon and Biogeochemistry (OCB; [www.us-ocb.org](http://www.us-ocb.org)) program, supported by the European Project on Ocean Acidification (EPOCA; <http://www.epoca-project.eu/>), and the UK Ocean Acidification Research Programme (<http://www.oceanacidification.org.uk>), has compiled a list of frequently asked questions (FAQs). These questions were widely distributed to the research community with the request to draft concise replies summarizing current knowledge, yet avoiding jargon. The replies were then subject to an open peer-review and revision process to ensure readability without any loss of scientific accuracy. The response of the community was enthusiastic. In total, 27 scientists from 19 institutions and 5 countries contributed to the whole process.

We do hope that this FAQ list will prove useful and would like to point out that it is an on-going process. Anyone is invited to seek clarification or send comments to Sarah Cooley ([scooley@whoi.edu](mailto:scooley@whoi.edu)). The list will be revised periodically using this input and maintained at [www.whoi.edu/OCB-OA/FAQs](http://www.whoi.edu/OCB-OA/FAQs), [www.epocaproject.eu/index.php/FAQ.html](http://www.epocaproject.eu/index.php/FAQ.html), and [www.oceanacidification.org.uk](http://www.oceanacidification.org.uk).

Joan Kleypas and Richard Feely (OCB), Jean-Pierre Gattuso (EPOCA), and Carol Turley (UK Ocean Acidification Research Programme)

#### The name "ocean acidification"

*The ocean is not acidic, and model projections say the oceans won't ever become acidic. So why call it ocean acidification?*

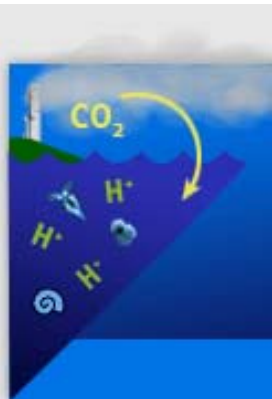
Ocean acidification refers to the process of lowering the oceans' pH (that is, increasing the concentration of hydrogen ions) by dissolving additional carbon dioxide in seawater from the atmosphere. The word "acidification" refers to lowering pH from any starting point to any end point on the pH scale. This term is used in many other scientific areas (including medicine and food science) to refer to the addition of an acid to a solution, regardless of the solution's pH value. For example, even though seawater's pH is greater than 7.0 (and therefore considered "basic" in terms of the pH scale), increasing atmospheric CO<sub>2</sub> levels are still raising the ocean's acidity and lowering its pH. In comparison, this language is similar to the words we use when we talk about temperature. If the air temperature moves from -40°C to -29°C (-40°F to -20°F), it is still cold, but we call it "warming." — J. Orr, C.L. Sabine, R. Key

MARCH 19, 2010

This document is sponsored by ODSR of the Woods Hole Oceanographic Institution

FAQs about OA





# OCB Ocean Acidification Activities

## *Educating the Public*

## Completed Activities

Lab setup notes.....  
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www.us-ocb.org  
 www.epoca-project.eu  
 www.oceanacidification.org.uk

UK Ocean Acidification Research Programme

### Frequently asked questions about ocean acidification

#### Introduction

Ocean acidification is a new phenomenon published in the past 10 years. Ocean acidification topics such as chemistry, pH and social sciences. Further example the carbonate chemistry and the general public.

The U.S. Ocean Carbon and Biogeochemistry (OCB) project is supported by the European Union (EU) and the U.S. National Science Foundation (NSF). The project is a clearinghouse of ocean acidification news and information to support the scientific research community, and it is maintained by the OCB Project Office, with oversight from the [Ocean Acidification Subcommittee](#) of the [Ocean Carbon and Biogeochemistry \(OCB\) program](#).

We do hope that this FAQ on-going process. Anyone: Cooley (cooley@whoi.edu) maintained at [www.whoi.edu](#) [www.epoca-project.eu/index](#)

Joan Kleypas and Richard J. Twilley (UK Ocean Acidification)

### The name "ocean acidification"

The ocean is not acidic, and so why call it ocean acidification?

Ocean acidification refers to the concentration of hydrogen ions in the atmosphere. The word "acid" is any end point on the pH scale, medicine and food science) to the solutions pH value. For example, therefore considered "basic" are still raising the ocean's acidity similar to the words we use from -40°C to -29°C (-40°F to -15°F).

C.L. Sabine, R. Key

## Ocean Acidification

Studying ocean acidification's effects on marine ecosystems and biogeochemistry

Home | Calendar | Who's Who | Research Aids | Info & Media

### Resources for Scientists and Educators

#### Supporting integrative ocean acidification research

Oceanic uptake of atmospheric CO<sub>2</sub> released by humans is altering global seawater chemistry in ways that will affect marine biota, ecosystems, and biogeochemistry. Forecasting these impacts requires an integrated understanding of the linkages among ecosystem components and feedbacks to climate. This website provides a clearinghouse of ocean acidification news and information to support the scientific research community, and it is maintained by the OCB Project Office, with oversight from the [Ocean Acidification Subcommittee](#) of the [Ocean Carbon and Biogeochemistry \(OCB\) program](#).

#### Ocean Acidification Daily News

Keep up to date on ocean acidification news and science with the [European Project on Ocean Acidification \(EPOCA\)](#) [Blog on Ocean Acidification](#).

#### OCEAN ACIDIFICATION NEWS

JUNE 21, 2010: The National Research Council has released the publication copy of its report ["Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean."](#)

MAY 21, 2010: The OCB response to the EPA call for public comment on addressing ocean acidification in the 303(d) program is available for download.

MAY 19, 2010: [Guide to Best Practices in Ocean Acidification Research and Data Reporting](#) now available for download.

MAY 3, 2010: Thomson Reuters Essential Science Indicators identified ["Ocean Acidification: The Other CO<sub>2</sub> Problem"](#) (2009, Annual Review of Marine Science) as a [New Hot Paper in Geosciences](#), meaning it is one of the most-cited papers in its discipline in the past two years. Affiliated

#### Related Links

National Research Council report on Ocean Acidification

[THE NATIONAL ACADEMIES PRESS](#)

Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean

Search this book

Heating on the Environmental & Economic Impacts of OA Testimonies: [Mr. Christopher M. Williams \(Author\)](#)

[www.whoi.edu/OCB-OA](http://www.whoi.edu/OCB-OA)





# OCB Ocean Acidification Activities

## *Educating the Public*

Activities in progress



NOAA Ocean Today Kiosk  
Short Film



**Web lectures**

Based on OCB-OA  
Short Course

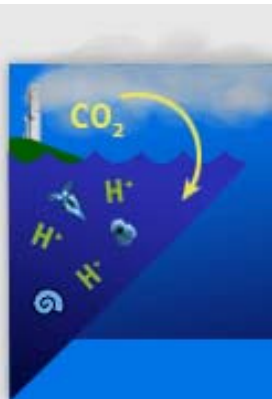


Washington, DC  
October 23-24, 2010



CO<sub>2</sub>calc application  
for PC, Mac, & iPhone

L.L. Robbins, M. Hansen,  
J.A. Kleypas, and S.C. Meylan



# National Ocean Acidification Activities

## *Legislative*



March 15, 2010

EPA's Federal Register notice seeks comments on [addressing OA under the Clean Water Act](#)



April 22, 2010

Senate Commerce, Science & Transportation Subcommittee Hearing

[“The Environmental & Economic Impacts of OA”](#)

Jim Barry – expert testimony

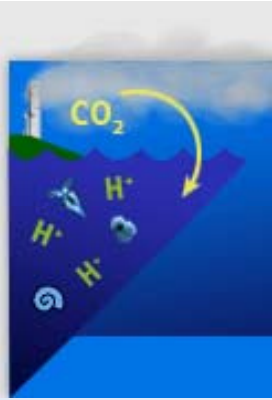


May 11, 2010

Senate Committee on Environment & Public Works Subcommittees on Oversight, Water & Wildlife Joint Hearing:

[“EPA's Role in Protecting Ocean Health”](#)

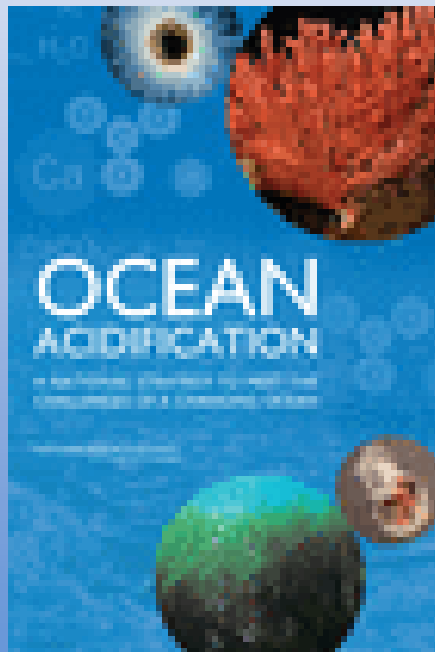
Sam Waterston – Ocean Acidification testimony



# National Ocean Acidification Activities

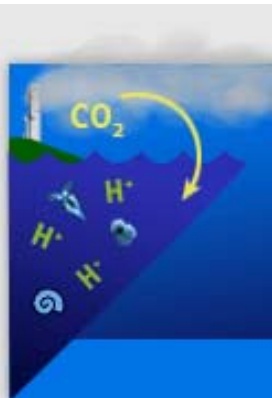
## National Research Council Report

*Ocean acidification: A national strategy to meet the challenges of a changing ocean*



Released June 2010

- A robust **observing** network
- **Research** to fulfill critical information needs
- Assessments and support to provide relevant information to **decision makers**
- **Data management**
- **Facilities** and **training** of ocean acidification researchers
- Effective program **planning** and **management**



# National Ocean Acidification Activities



## Ocean Research and Resources Advisory Panel (ORRAP) OA Task Force

- scientists from all organization types
- discuss national OA **priorities**, analyze federal plans
- formulate **recommendations** for ORRAP to give the federal agencies

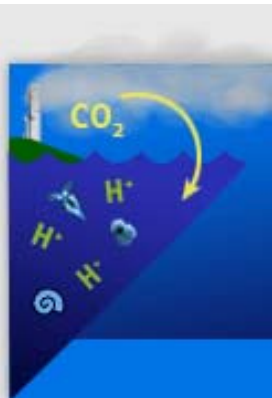


Office of Science and Technology Policy

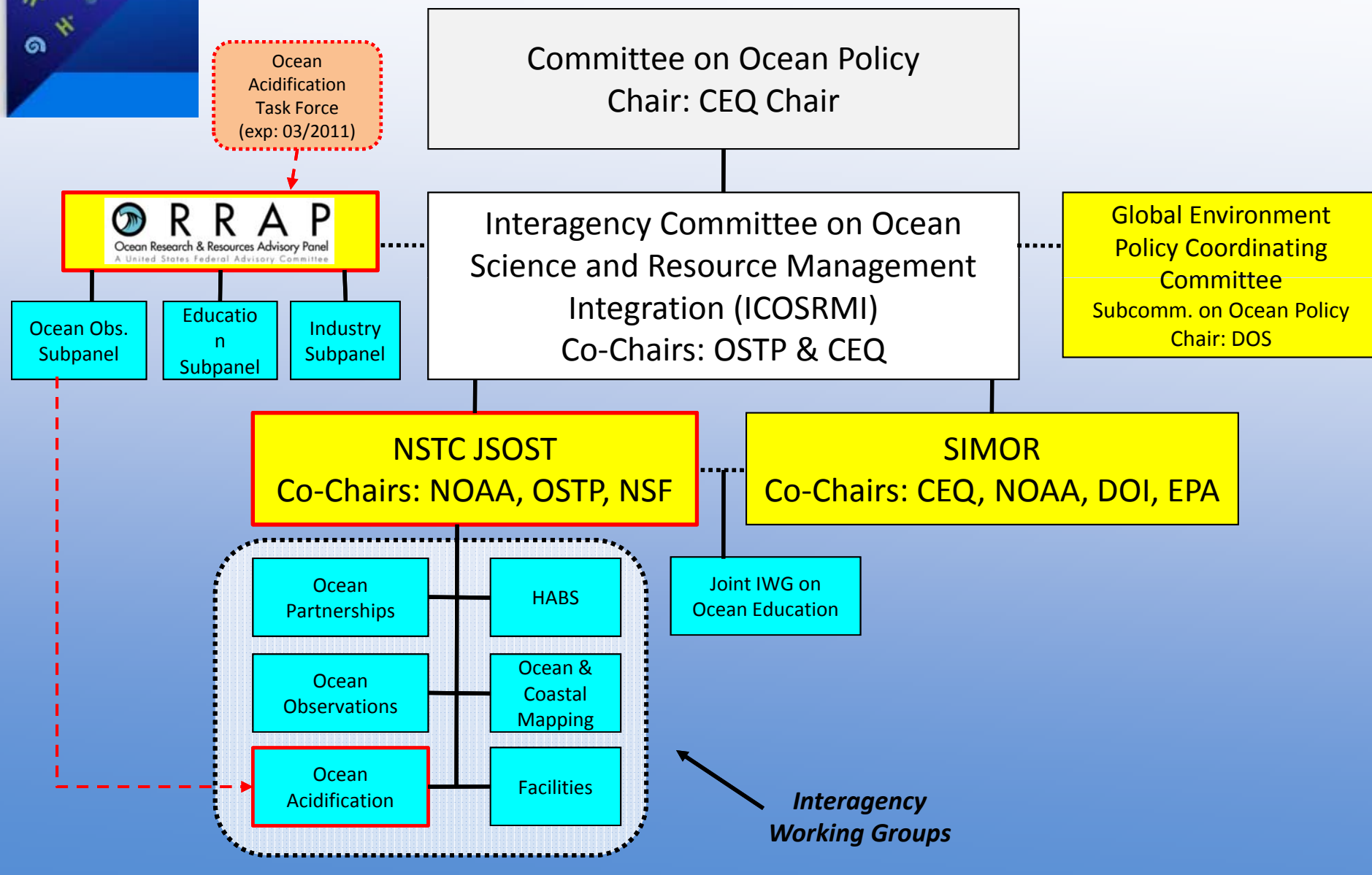
## Joint Subcommittee on Ocean Science & Technology Interagency Working Group on Ocean Acidification (IWG-OA)

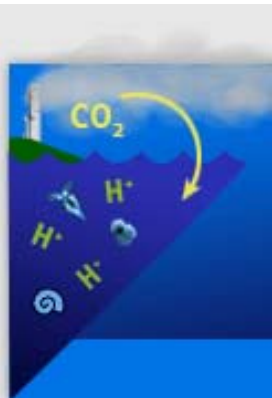
- communicate, **coordinate** OA activities among federal agencies
- **mandated** by FOARAM Act





# U.S. Ocean Governance and OA





# ORRAP Ocean Acidification Task Force



## Major Tasks

Peter Betzer\* (Chair)

Dan Costa\*

Bob Cowen\*

Celia Smith\*

Peter Brewer

Bob Byrne

Meg Caldwell

Francis Chan

Scott Doney

Vicki Fabry

Gretchen Hofmann

Sven Huseby

Dave Hutchins

Joanie Kleypas

Jeff Short

Jen Smith

Andy Stamper

- Provide **expert input** to the ORRAP on issues relating to federal OA activities
- Provide **preliminary advice and recommendations** to ORRAP on OA issues (which will be provided to the IWG-OA)
- **Enhance coordination** with academic, state, private, and federal stakeholders



# JSOST IWG-OA

Joint Subcommittee on Ocean Science and Technology

Interagency Working Group on Ocean Acidification



Office of Science and Technology Policy

## Major Tasks (from the FOARAM act)

Develop a [strategic plan](#) for Federal research and monitoring on ocean acidification

Prepare [reports](#) to Congress

Facilitate [input, communication and outreach](#) among the relevant research communities and agencies, including designation of an [OA information exchange](#)

Facilitate [international coordination](#) of OA activities

[Coordinate JSOST ocean acidification activities](#) with the Subcommittee on Integrated Management of Ocean Resources (SIMOR) & other Federal, non-Federal ocean-related entities (ORRAP)

Ned Cyr (Chair)

Phil Taylor (V Chair)

Fred Lipschultz (V Chair)

Richard Feely

Chris Sabine

Libby Jewett

Don Rice

Lisa Robbins

Bill Fisher

Courtney St. John

Mary Boatman

Bret Wolfe

Robert Domaingue

Sherry Sykes

NOAA

NSF

NASA

NOAA

NOAA

NOAA

NSF

USGS

EPA

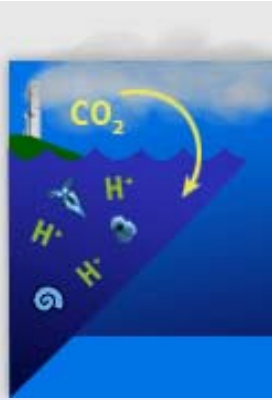
Navy

BOEMRE

USFWS

DOS

DOS



# National Ocean Acidification Activities

## *Agencies*

- Special NSF call for OA proposals
- Submitted: 95 Research, 8 exploratory, 2 community building
- \$12-15M over 5-10 years
- Support ongoing OA projects through core
- NOAA Research plan for OA
- Development of NOAA OA program office
- Support internal/external research
- NASA -- ongoing OA research with several products
- EPA -- how to incorporate OA/pH into Clean Water Act
- USGS – ongoing internal projects





# International Ocean Acidification Activities



5<sup>th</sup> Assessment Report



UK Ocean Acidification Research Programme

12M £, 5y effort

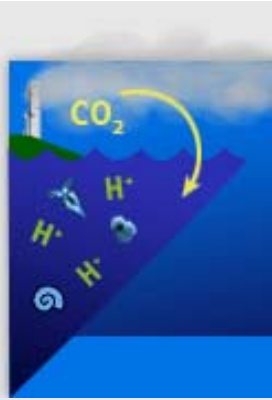
Coming soon:

- FAQ-based summary
- Map of OA research

**The Ocean in a High CO<sub>2</sub> World III**  
an international science symposium series  
**2012**

The Scientific Committee on Oceanic Research  
UNESCO - Intergovernmental Oceanographic Commission  
IAEA - Marine Environment Laboratory  
The International Geosphere - Biosphere Programme

Ocean Acidification THE FACTS



# International Ocean Acidification Activities

## *SOLAS-IMBER Working Group on OA*

### Planned activities

- Coordinated observation network
- Joint platforms and facilities
- Collaboration between natural and social sciences
- Exchange of students and postdocs
- Intercomparison exercises
- Best practices in research and data reporting
- Towards development of guiding principles for international management of OA data
- Training on OA

[www.whoi.edu/OCB-OA](http://www.whoi.edu/OCB-OA)  
[www.us-ocb.org](http://www.us-ocb.org)







# CO2calc

**CO2calc application for PC and Mac  
desktop and iPhone\***

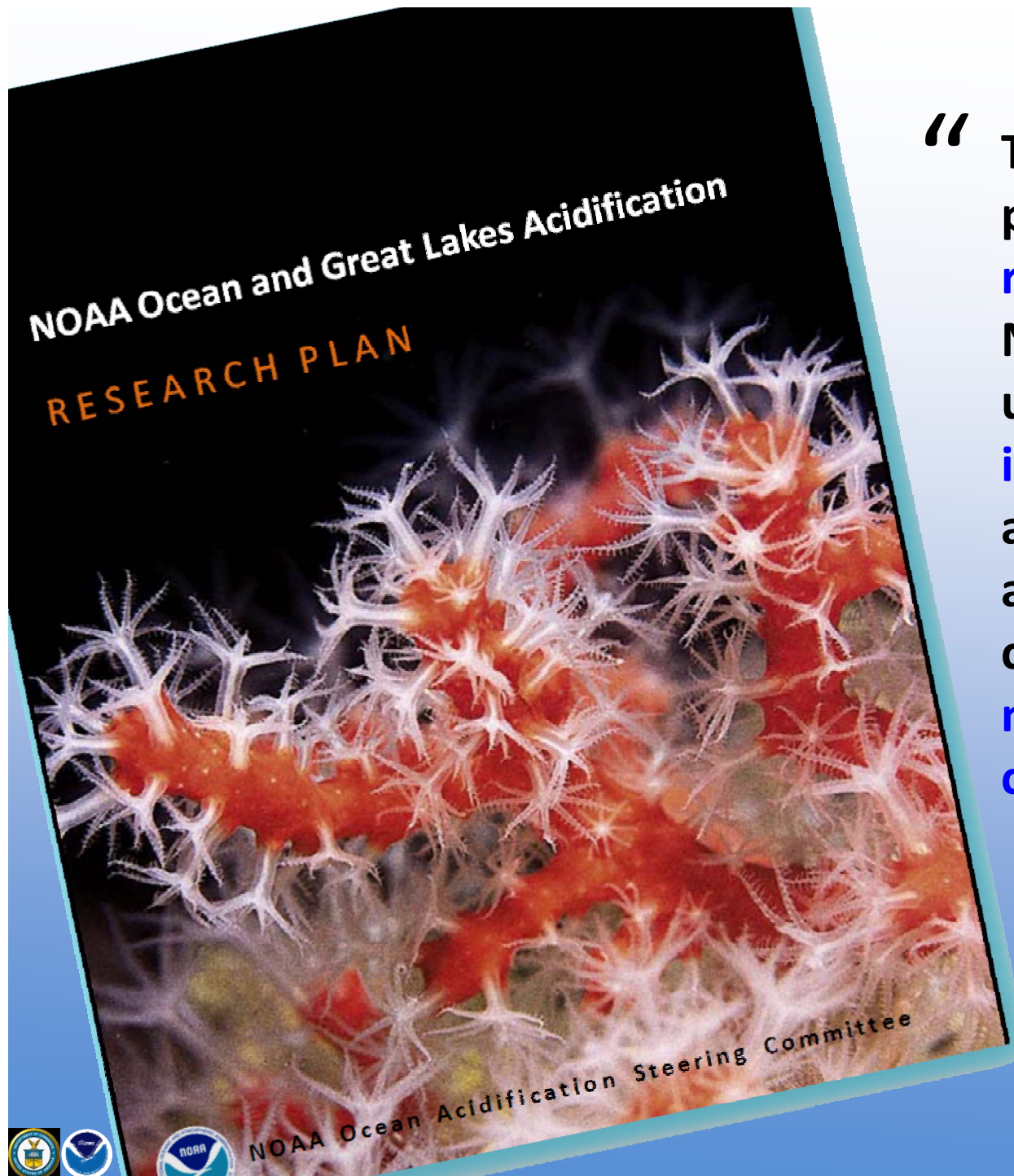
L.L. Robbins, M. Hansen,  
J.A. Kleypas, and S.C. Meylan

**In beta testing mode  
See Joanie Kleypas for  
information**

*\*Florida Shelf Ecosystems Response to  
Climate Change Project*

The screenshot shows the CO2calc application window with the following sections:

- Sample Information:** Fields for Name (optional), Date (1/ 1/2000), Latitude (optional), Comment (optional), Time (11:00:00 AM), and Longitude (optional).
- Input/Results Tabs:** The 'Input' tab is selected.
- Physical Data:** Salinity (ppt) = 35, t(°C) = 22, P (dbars) = 10.1325.
- Nutrient Data:** Total P (μmol/kgSW) = optional, Total Si (μmol/kgSW) = optional.
- Carbonate Data:** TA (μmol/kgSW) = choose 2 of 5\*, TCO<sub>2</sub> (μmol/kgSW) = choose 2 of 5\*, pH (chosen scale) = 8.1, fCO<sub>2</sub> water (μatm) = choose 2 of 5\*, pCO<sub>2</sub> water (μatm) = 300.
- Output Conditions:** t(°C) = 34, P (dbars) = optional, Air-sea CO<sub>2</sub> Flux: pCO<sub>2</sub> Air (μatm) = 380, Windspeed (knots) = optional.
- Footnote:** \*Enter any two except both fCO<sub>2</sub> and pCO<sub>2</sub>.
- Constants:** CO<sub>2</sub> constants: K1, K2 from Mehrbach et al, 1973; KHSO<sub>4</sub>: Dickson; pH scale: Seawater scale. A 'Change Constants...' button is present.
- Buttons:** Batch Processing..., Record to .csv (checkbox), Process, and Clear.



“ The *purpose* ... is to present a **consensus research strategy** for NOAA to advance the understanding of the **impacts** of ocean acidification and to address related challenges to **local and national ecosystems and communities**. ”

# THEMES

## 1 Monitor

Develop the monitoring capacity to quantify and track ocean acidification and its impacts in open-ocean, coastal, and Great Lakes systems

## 2 Assess

Assess the response of organisms to ocean and lake acidification

## 3 Forecast

Forecast biogeochemical and ecological responses to acidification

## 4 Manage

Develop management strategies for responding and adapting to consequences of ocean acidification

## 5 Synthesize

Provide a synthesis of ocean and Great Lakes acidification data and information

## 6 Engage

Provide an engagement strategy for education and public outreach

## Themes

# Research Plan

### 1 Monitor

OA moorings  
Coral reef monitoring sites  
OA sensors on NOAA research vessels & VOS ships

### 2 Assess

Single species experiments  
Multi-species mesocosm experiments

### 3 Forecast

Test/evaluate existing global & regional models  
Develop high resolution physical-biogeochemical-ecosystem models  
Coastal early warning system

### 4 Manage

Socioeconomic models and decision support tools  
Test mitigation approaches in lab

### 5 Synthesize

Data management coordination, synthesis,  
integrated synthesis activities

### 6 Engage

Education/outreach planning, curricula/product  
delivery

