NOAA Coral Reef Conservation Program

Education and Public Outreach

Ocean Acidification Florida Educator Workshops

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Final Evaluation Report

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By

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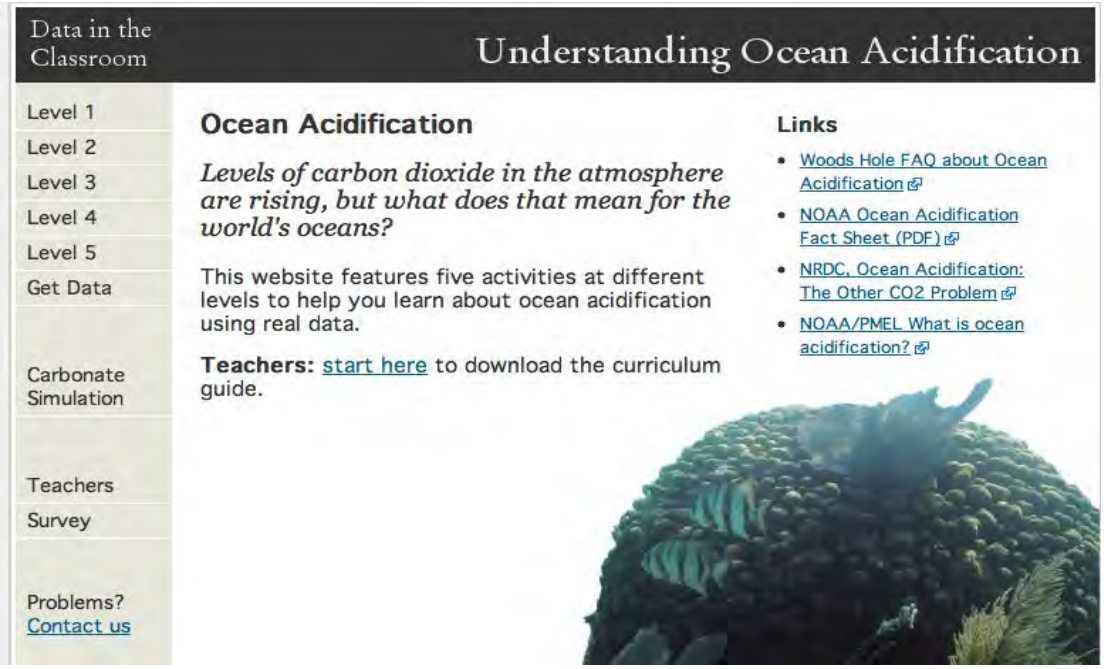
EXECUTIVE SUMMARY



The ocean acidification module homepage: http://www.dataintheclassroom.org/content/oa/

Ocean acidification (OA) represents a direct chemical change to global ocean chemistry in response to rising levels of atmospheric carbon dioxide, and it is a topic of growing concern for its potential wide-ranging effects on the marine foodweb. During June 13-17, 2011, NOAA's Coral Reef Conservation Program (CRCP) conducted a series of three workshops in south Florida on ocean acidification, its effects on corals, and how to use the new NOAA OA Data-in-the-Classroom NODE module developed by the CRCP. The OA module, designed for the high school science classes, uses real data accessed via a dedicated teacher/student web interface, within the context of five scalable lesson plans. This workshop report, produced by an external evaluator, represents part of the efforts at NOAA CRCP to gauge the effectiveness of its STEM investments, and track outputs and outcomes of these efforts.

A total of 83 participants attended the day-long workshops. Participants were mostly middle and high school science educators; though there was also participation from formal teacher instructors, and informal educators, including diving instructors, park rangers, and state and local NOAA staff. Teachers received the printed OA Module Teachers Guide, educational and other materials. All participants will also receive an OA educational DVD (in production stages) with the science presentation and other classroom materials.

The workshop was evaluated in terms of knowledge gains, effectiveness and materials. Evaluation used a mixed methods approach with a pre/post test. Teachers completed a

pretest at the beginning of the workshop and a posttest at the end of the day on 20 concepts about ocean acidification that are taught in the module. They also completed a satisfaction and intent-to-use survey. In each of these measurements, participants showed statistically significant increases in content knowledge, as measured by the pre/post test, and large increases in their self-reported confidence and ability to use data and to teach the workshop materials.

OA pre-test average score was 7.88 and post-test 13.8; **a difference of 5.92**, significant at the <0.01 level. Overall workshop ratings of **4.7 out of 5** revealed satisfaction with workshop elements of content, curriculum, materials, data, and approach used. When asked to rate their confidence in teaching ocean acidification before and after the workshop, teachers rated their confidence 1.63 before the workshop and 4.26 after, **an increase of 2.63** in a five-point scale. Before the workshop, teachers' self-ratings on their understanding ocean acidification well enough to teach it were 1.87 and post ratings were 4.66, **for a gain of 2.77**. For ability to use real data to teach ocean acidification, pre workshop self-ratings were 1.89, post 4.61, representing an **improvement of 2.98** on a scale of 1-5. Seventy percent of all educators rated the NODE modules as "Excellent." Among comments received:

- *"The NODE materials were easy to manipulate and easy to understand. I think they will engage my students and lead to increased learning."*
- *"Advanced enough for my AP classes"*
- "*They will assist in my class because chemistry students can use this as a real world scenario and see how we can use chemistry to answer fundamental questions for today. "*
- *"These modules are succinct and easy to use with students of various grade levels."*
- *"The interactive NOAA website and the data that it provides is quite impressive."*
- *"These materials put an incredible amount of data in the kids' hands. It allows the students to choose what data they wish to see, and then manipulate the data."*
- *"The program is well thought-out, with the levels designed to allow students to build upon information previously learned."*

Educators received a stipend for their workshop participation. They will receive an additional stipend once they complete a follow up survey on classroom material implementation during the next 12 months following the workshop. In addition, six teachers were recruited as part of a controlled quasi-experiment, where they will teach on OA in two classrooms during the school year, using workshop and NODE materials in one classroom, and using non-workshop/NODE materials in the second classroom, with the evaluator tracking anonymous student subject understanding and test performance in each classroom. A report outlining results from this year-long follow up on the OA NODE classroom implementation will be published by the end of the summer of 2012.

TABLE OF CONTENTS

Executive Summary 2

Background and Purpose 5

Workshop Description 6

Methods 8

Main NOAA OA Data in the Classroom MODULE Concepts 8

Main Workshop Concepts 9

Findings 10

Pre/Post Knowledge Test Results 12

Workshop Evaluation Results 25

Workshop structure and format 25

OA NODE levels that Particpants plan to use 26

Participants: Planned Use of OA Module 27

Educator objectives for using the Ocean Acidification module 32

Educator rating of the NODE materials 33

Participants: Materials Feedback 33

Before/After Participants self ratings 36

Participants: Workshop feedback 37

Conclusions 40

Next Steps 43

Appendices 44

BACKGROUND AND PURPOSE

Three workshops were offered in June 2011 in Florida:

Key West: Florida Keys National Marine Sanctuary Eco-Discovery Center Workshop

June 14	NOVA Southeastern Oceanographic Institute/ National Coral Reef Institute
June 15	University of Miami Rosenstiel School of Marine and Atmospheric Science
June 17	Florida Keys National Marine Sanctuary

Partners

Various partners contributed to fund and support the workshop series, adding to the funding provided by NOAA's Coral Reef Conservation Program. NOAA's National Ocean Service assisted in the early organization of the workshops. The **Florida Department of Environmental Protection's Coral Reef Conservation**

Ft. Lauderdale: NOVA National Coral Reef Institute Workshop

Program provided funds to support the first two workshops, and **Sanctuary Friends Foundation of the Florida Keys** provided funds for the third workshop. In addition, the **National Coral Reef Institute**, the **Rosenstiel School of Marine and Atmospheric Science** and **the Florida Keys National Marine Sanctuary** provided facilities and staff time.

In addition, Christopher Boykin with the Florida Coral Reef Conservation Program and Mary Tagliareni with the Florida Keys National Marine Sanctuary provided essential local support for planning, logistics and successful completion of the workshop series.

The workshops were advertised through:

- Monroe County teachers, principals and community colleges were emailed about the Key West workshop
- Miami-Dade County Schools professional development system
- Scuttlebutt listserv
- NOAA Coral Reef Conservation Program's website, and other NOAA educational outlets, including National Marine Sanctuaries Program, National Estuarine Research Reserve System, Climate Stewards, and others

WORKSHOP DESCRIPTION

Miami: University of Miami, Rosenstiel School of Marine & Atmospheric Science Workshop

In this workshop, educators learned to use real data from NOAA to teach ocean acidification and how it affects coral reefs and other marine calcifiers through the five integrated, scalable lesson plans associated with the ocean acidification module. The workshop included hands-on demos and experiments, a background science presentation on ocean acidification, and a walk-through of the five lesson plans and data exercises that are part of this Data-in-the-Classroom project, as outlined below.

Lesson 1: Ocean pH – Understanding spatial and temporal variations of ocean pH

Lesson 2: Ocean-Carbon connection – Understanding how CO_2 goes from land activity to atmosphere to ocean

Lesson 3: Carbonate Chemistry – Understand chemical pathway of how CO_2 lowers ocean pH and its affect on carbonate chemistry

Lesson 4: Aragonite Saturation and Marine Calcifiers – Understanding the concept of aragonite saturation state and marine animals affected by it

Lesson 5: Student-driven Investigation – Ability to design an investigation and obtain data to check it

The workshop also briefly presented the Water Quality module and a Corals & Watersheds presentation, aimed at building students' data literacy and inquiry skills, particularly at the middle school level.

Teachers applied online. Applications were reviewed by the program director. Acceptance was contingent on participants returning a letter of commitment signed by their supervisor. They received a $75 stipend for attending the workshop and will receive an additional $25 for completing a follow up survey after using the materials.

To be eligible to attend teachers were asked to:

1. Teach middle school or high school science, particularly biology and chemistry, or to be engaged in informal ocean education.
2. Currently teach ocean acidification and/or water quality or be willing and able to teach it next year
3. Able to bring a laptop to the workshop
4. Be willing and able to attend the entire workshop 9 am-5 pm
5. Be willing to complete pre/post tests and workshop evaluations
6. Be willing to complete a follow up survey after using the material

METHODS

This evaluation used a mixed methods approach with a pre/post design to examine the questions:

> *How effective is a one-day professional development workshop in preparing teachers to use the Ocean Acidification module? (feel confident, intent to use what they learned, able to use real data, understand enough to teach it)*
>
> *What impact does the workshop have on the teachers' knowledge of ocean acidification? (pre/post test change)*
>
> *To what extent are Ocean Acidification materials appropriate and helpful to teachers for use in their classrooms?*

Ft. Lauderdale: Workshop participants tour NOVA National Coral Reef Institute facilities

Teachers completed a pretest at the beginning of the workshop and a posttest at the end of the day on 20 concepts about ocean acidification that were covered in the presentation and many of which are taught in the module. They also completed a satisfaction and intent-to-use survey.

The posttest was developed by the coordinator to test the concepts in the modules. Four science educators reviewed the test for concept and content validity.

MAIN NOAA OA DATA IN THE CLASSROOM MODULE CONCEPTS

1. pH
2. CO_2 – Ocean connection

3. CO_2 and carbonate chemistry
4. Aragonite saturation level
5. Student-led investigation

MAIN WORKSHOP CONCEPTS

1. Definition of pH and how small changes represent large changes in chemistry
2. Definition of ocean acidification
3. Main contributors to OA
4. How pH has already changed in the oceans, and how it is expected to change
5. Carbon Cycle
6. Differences between shallow tropical waters and deep polar waters
7. Marine calcifiers
8. How calcification changes under OA in different marine species and life cycle stages
9. Relationship between pH and Aragonite saturation level
10. How corals can react to changes in Aragonite Saturation Level and threshold values
11. Calcification and its energy cost to corals
12. How OA can interact synergistically with other threats to corals
13. Winners and losers of OA
14. Common OA misconceptions

The courses and grades participants teach were obtained from the applications for the workshop. Pre/post results were analyzed by question for changes in the number and percentage of participants who chose each response. Participant tests were scored for correctness, then those pre/post scores analyzed for significance using a matched pair t-test. When questions allowed more than one answer, participants were given partial credit for each right answer they chose. In the tables presenting data by question, the number of respondents choosing each response is presented.

The end of the workshop evaluation survey data was analyzed by question with frequency of each rating presented and averages calculated. Open-ended responses were analyzed for themes, with quotations as examples.

FINDINGS

Workshop Enrollment and Attendance

	Registered	Attended	Pre	Post	End of workshop
June 14	35	32	28	25	27
June 15	40	32	30	26	30
June 17	18	19	18	18	17

Participants in the workshop were mostly formal educators at the middle and high school levels, but also included informal educators. The teachers in the workshop taught grades 6 through 12 with 38 teaching 6th grade, 41- 7th grade, 33 - 8th grade, 18 – 9th grade, 20 – 10th grade, 21 – 11th grade, 22 – 12th grade. The courses taught ranged across the sciences and included honors, advanced placement (AP), and international baccalaureate (IB) levels. The top six subjects taught were biology (24), comprehensive science (23), general science (13), marine biology (11), physical science (11), and marine science honors (10). Informal educators at the workshop included park rangers, dive instructors, local NOAA staff, Florida state staff, and an elected local government official.

Subject	**#**
Biology	24
Comprehensive Science	23
General Science	13
Marine Biology	11
Physical Science	11
Marine Science Honors	10

Courses taught by grade level

Grade	#	Courses taught
6	38	Advanced Science I (2), Agricultural science (1), Amazing Oceans (1), AP Environmental Science (2), Biology (4), Biology gifted (1), Biology Honors (1), Chemistry I (2), Chemistry I Honors (1), Climate change (1), Coastal Explorations (1), Comprehensive science (10), Computers/Technology (1), Coral reef ecosystems (1), Earth science (2), Earth/Space Science (5), Environmental Science (1), General Science (4), Gifted Science (2), Integrating Math (1), Invertebrate zoology (1), Language Arts (2), Marine Biology (3), Marine Honors (1), Marine Science I Honors (5), Marine Science II Honors (1), Mathematics (2), Non point-source pollution (1), Oceanography (1), Physical Science (2), Pre IB Biology (1), Reading (1), Social Studies (2), Space Science (1)
7	41	Advanced Science I(3), Agricultural science (1), Amazing Oceans (1), Anatomy and Physiology (1), Biology (2), Biology Honors (1), Coastal Explorations (1), Comprehensive Science (8), Earth/Space gifted (1), Environmental Science (1), General Science (2), Gifted Science (2), Interdisciplinary (1), Language Arts (1), Life Science (3), Marine Science II Honors (3), Mathematics (2), Physical Science (1), Science General (2), Sea water chemistry (1), Social Science (1)
8	33	Advance Science I (1), Agricultural science (2), Algebra I (1), Amazing Oceans (1), Biology AP (1), Biology Honors (1), Chemistry (1), Coastal Explorations (1), Comprehensive science (5), Comprehensive Science Advanced (4), Earth /Space (4), Earth/Space Honors (5), Environmental Science (1), Math (1), General Science (1), Gifted Science (1), Language Arts (1), Marine Science (2), Physical Science (6), Physical/Chemical Science (2), Science (1), Science Comprehensive Advanced (2), Seagrass and coral reef communities (1), Social Science (1)
9	18	Amazing Oceans (1), Biology (4), Biology Honors (1), Civic engagement (1), Coastal Explorations (1), Earth Science (1), Earth/Space Honors (2), Earth/Space Science (3), Environmental Science (1), General Science (1), Integrated Science/Honors (1), Intensive Math (Sped) (1), Leadership (1), Service learning (1)
10	20	Biology 1 (11), Biology Honors (3), Coastal Explorations (1), Environmental Science (2), General Science (1), Honors Chemistry I (1), Integrated Science II (2), Marine Biology (2), Physical Science (1)
11	21	AP Biology (1), AP Environmental Science (2), Biology (1), Chemistry (1), Coastal Explorations (1), DE Marine Biology (1), Earth Science (1), Environmental Management (AICE) (1), Environmental Science (3), General Science (1), H. Marine Science 1 (1), Hon. Marine Science I (1), Honors Chemistry (3), IB Chemistry (1), Interg. Math (sped) (1), Marine Biology (4), Marine biology Honors (1), Physical Science (1), Physics (1), Regular Chemistry I (1), Science Research (1)
12	22	AP Biology (1), AP Chemistry (2), AP Environmental Science (1), Biology (2), Coastal Explorations (1), DE Marine Biology (2), Ecology -Upper Division College (1), Environmental Management (AICE) (1), Environmental Science (1), Hon. Marine Science II (2), Honors Chemistry I (1), IB Chemistry (1), Kayaking/sailing (1), Marine Biology (2), Marine biology honors (1), Marine Policy and Affairs (1), Marine Science (3), Marine Science (AICE) (1), Oceanography-Upper Division College (1), Regular Chemistry I (1)

PRE/POST KNOWLEDGE TEST RESULTS

Pre/post results were analyzed by question for changes in the number and percentage of participants who chose each response. Participant tests were scored for correctness, then those pre/post scores analyzed for significance using a matched pair t-test. Right answers are marked with an asterisk.

A close up of a coral polyp from the NCRI's coral nursery

Overall pre/post knowledge test differences were significant at all three locations (.01). Given the similarity among locations, individual results by question are not presented. Although there were 84 participants, only 64 submitted usable pre/post surveys.

Location	N	pre	post	diff	t-test
1	25	8.19	14.23	6.04	<.01
2	23	7.06	13.77	6.71	<.01
3	16	8.57	13.15	4.58	<.01
All	**64**	**7.88**	**13.8**	**5.92**	**<.01**

Below are each of the questions part of the pre/post survey. Correct answer is shown in bold and with an asterisk.

HOW MUCH, IF ANYTHING, HAVE YOU READ OR HEARD ABOUT OCEAN ACIDIFICATION?[1]

Pretest scores indicate that 43.4% of the participants had read or heard "some" of ocean acidification, compared to 29% had heard or read "a little", 19.7% had heard "nothing," and 7.9 % "a lot." In the posttest the "some" category increased 7.3%, while "a lot" increased 34.8%, "a little" dropped to 10.1%, and "nothing" to 4.4%

Answer choices	Nat'l	Pre		Post		Diff	
	%	**#**	**%**	**#**	**%**	**#**	**%**
A lot	1	6	7.9	24	34.8	18	26.9
Some	6	33	43.4	35	50.7	2	7.3
A little	17	22	29	7	10.1	-15	-18.9
Nothing	77	15	19.7	3	4.4	-12	-15.3

WHICH OF THE FOLLOWING CAUSES OCEAN ACIDIFICATION?

In the pretest 73.6% of the participants knew the correct answer for the cause of ocean acidification, and warmer ocean temperatures was the second highest cause given at 10.5%. In the posttest the correct answer response increased 23.5% to 97.1%.

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[1] First two questions were part of a nation-wide survey, *Americans' Knowledge of Climate Change,* by Yale University, conducted in the general U.S. population. Those results are provided here for reference. Report available at: http://environment.yale.edu/climate/files/ClimateChangeKnowledge2010.pdf

Answer choices	Nat'l	Pre		Post		Diff	
	%	#	%	#	%	#	%
Absorption of carbon dioxide by the ocean*	**32**	**56**	**73.6**	**67**	**97.1**	**11**	**23.5**
Chemical spills in the ocean	16	5	6.5	0	0	-5	-6.5
Acid rain	19	4	5.2	0	0	-4	-5.2
Warmer ocean temperatures	13	8	10.5	2	2.9	-6	-7.6
Don't know	21	3	3.9	0	0	-3	-3.9

PH IS A MEASURE OF

In the pretest 81.5% of the participants knew the correct answer for what pH measures, and 11.8% indicated it was to measure dissolved CO_2. In the posttest the correct answer response increased 14.1% to 95.6%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Carbonate	1	1.3	0	0	-1	-1.3
Concentration of H ions*	**62**	**81.5**	**66**	**95.6**	**4**	**14.1**
Concentration of OH ions	4	5.2	1	1.45	-3	-3.7
Dissolved CO_2	9	11.8	1	1.45	-8	-10.3
Bicarbonate	0	0	1	1.45	1	1.45

A PH DROP OF 0.3 UNITS (E.G., 8.2 TO 7.9) REPRESENTS WHAT H^+ % CHANGE IN THE SOLUTION?

In the pretest 6.5% of the participants knew the correct answer to "A pH drop of 0.3 units (e.g., 8.2 to 7.9) represents what H^+ % change in the solution?" The second highest incorrect response was 33% more H^+ at 48.6%. In the posttest the correct answer response increase 38.4% to 44.9%, and the same incorrect response decreased by 5.2%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
33% more H^+	37	48.6	30	43.4	-7	-5.2
33% less H^+	15	19.74	5	7.2	-10	-12.5
100% more H^+ *	**5**	**6.5**	**31**	**44.9**	**26**	**38.4**
66% less H^+	2	2.6	3	4.3	1	1.7
Don't know	17	22.3	0	0	-17	-22.3

OCEAN ACIDIFICATION …

In the pretest 40.7% of the participants responded correctly to the question that ocean acidification "shares cause with climate change", and 34.2% responded incorrectly that ocean acidification "is an effect of climate change." In the posttest the correct answer response increased 11.4% to 52.1%, and the same incorrect response decrease 9.6%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Is an effect of climate change	26	34.2	17	24.6	-9	-9.6
Is caused by climate change	7	9.2	8	11.5	1	2.3
Shares cause with climate change *	**31**	**40.7**	**36**	**52.1**	**5**	**11.4**
Is independent of climate change	2	2.6	8	11.5	6	8.9
Not quite sure	10	13.1	0	0	-10	-13.1

CURRENT OCEAN PH IN 2011 IS

In the pretest 34.2% of the participants chose the correct answer for the current pH of the ocean, and 27.6% chose the incorrect answer of a 7.8 pH. In the posttest the correct response increase 55.5% to 89.8%, and the same incorrect response decreased 23.2%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
8.7	1	1.32	0	0	-1	-1.3
8.3	8	10.5	4	5.8	-4	-4.7
8.1*	**26**	**34.2**	**62**	**89.8**	**36**	**55.5**
7.8	21	27.6	3	4.35	-18	-23.2
7	0	0	0	0	0	0
Don't know	20	26.3	0	0	-20	-26.3

EXPECTED OCEAN PH BY 2100 IS

In the pretest 23.6% of the participants chose the correct answer for the "expected ocean pH by 2100, 32.8% indicated they "Don't know," and 13.6% chose an incorrect answer of "8.1" pH. In the posttest the correct answer response increased 61.9% to 85.5%, and 8.7% chose an incorrect response of "8.3" pH.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
8.7	2	2.6	2	2.9	0	0.3
8.3	5	6.5	6	8.7	1	2.2
8.1	10	13.16	0	0	-10	-13.16
7.8*	**18**	**23.6**	**59**	**85.5**	**41**	**61.9**
7	16	21	2	2.9	-14	-18.1
Don't know	25	32.8	0	0	-25	-32.8

MY FACEBOOK POST SAYS "OCEANS ARE PREDICTED TO STAY BASIC, NOT ACIDIC." YOUR INFORMED REPLY IS

In the pretest 11.8% of the participants chose the correct informed reply of "Of course! They are expected to stay basic". "For now, but eventually they will turn acidic," (52.6%), and "It depends - tropical oceans will become acidic, polar oceans will stay basic" (31.5%) were the second and third Incorrect responses respectively. In the posttest the correct response rate increases 33.1%. "For now, but eventually they will turn acidic," decreased 6.3%, and "It depends - tropical oceans will become acidic, polar oceans will stay basic" decreased 25.7%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
"For now, but eventually they will turn acidic"	40	52.6	32	46.3	-8	-6.33
You Like it and reply: "Of course! They are expected to stay basic" *	**9**	**11.8**	**31**	**44.9**	**22**	**33.1**
"It depends - tropical oceans will become acidic, polar oceans will stay basic"	24	31.5	4	5.8	-20	-25.7
You dislike it and Unfriend me	3	3.9	2	2.9	-1	-1

THE DIFFERENCE BETWEEN SHALLOW TROPICAL CORAL REEFS AND DEEP POLAR CORALS IS

In the pretest all five answers were correct and the percentage of responses was similarly distributed. From highest to lowest were "Biomass and biodiversity" (27.5%), "Depth" (25.5%), "Symbiotic relationship with zooxanthellae" (21.4%), "Calcification" (13.4%), and

“Number of snorkelers that visit” was the exception (12%). In the posttest “Calcification” increase 19.9% to 33.3%, “Depth” decreased 1.6% to 23.9%, “Biomass and biodiversity” decreased 1.5% to 18.1%, “Symbiotic relationship with zooxanthellae” decreased 7.4% to 14%, and the “Number of snorkelers that visit” decreased 1.5% to 10.5%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Depth *	**38**	**25.5**	**41**	**23.9**	**3**	**-1.6**
Calcification *	**20**	**13.4**	**57**	**33.3**	**37**	**19.9**
Symbiotic relationship with zooxanthellae *	**32**	**21.4**	**24**	**14**	**-8**	**-7.4**
Number of snorkelers that visit *	**18**	**12**	**18**	**10.5**	**0**	**-1.5**
Biomass and biodiversity *	**41**	**27.5**	**31**	**18.1**	**-10**	**-9.4**

ACID RAIN IS RELATED TO OCEAN ACIDIFICATION BY SHARING

In the pretest 5.2% of the participants chose the correct answer that acid rain is related to ocean acidification by sharing the “Same state of matter.” Second was “Same cause“(48.6%), third “Same pH change” (22.3%), and “Same effect” (18.4%). In the posttest the correct answer response increased 4.8% to 10.1%. “Same cause“decreased 15.3% to 33.3%, “Same pH change” decreased 13.6% to 8.7%, “Same effect” increased 4.7% to 23.1%, and “Same agency regulating it (EPA)” increased from 1.3% to 17.5%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Same cause	37	48.6	23	33.3	-14	-15.3
Same effect	14	18.4	16	23.1	2	4.7
Same state of matter *	**4**	**5.2**	**7**	**10.1**	**3**	**4.8**
Same pH	3	3.9	4	5.8	1	1.9
Same pH change	17	22.3	6	8.7	-11	-13.6
Same agency regulating it (EPA)	1	1.3	13	18.8	12	17.5

WHICH ONE DOES NOT BELONG?

In the pretest 72.3% of the participants chose the correct answer “Seaweed.” “Crustaceans” was the second highest at 9.2%. In the posttest the correct answer response increased 21.9% to 94.2%, and “Crustaceans” decrease 7/8% to 1.4%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Coralline algae	8	1.5	1	1.4	-7	-0.1
Crustaceans	7	9.2	1	1.4	-6	-7.8
Mollusks	3	3.9	1	1.4	-2	-2.5
Hard corals	3	3.9	1	1.4	-2	-2.5
Seaweed *	**55**	**72.3**	**65**	**94.2**	**10**	**21.9**

WHICH CORAL LIFE CYCLES/PROCESSES MIGHT BE MOST AFFECTED BY OA?

In the pretest 7.8% of the participants chose the correct answer "Settling." Other significant responses in descending order were "Adult growth" 27.3%, "Reproduction" 25.7%, "Planula (free swimming fertilized egg)" 17.1%, and "Don't know" 12.5%. In the posttest the correct answer response increased from 12.3% to 20.1%. "Adult growth" increased 4.2% to 31.5%, "Reproduction" decreased 4.3% to 21.4%, "Planula (free swimming fertilized egg)" increased 1% to 18.1%, and "Don't know" decreased 12.5%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Settling *	**10**	**7.8**	**30**	**20.1**	**20**	**12.3**
Adult growth	35	27.3	47	31.5	12	4.2
Reproduction	33	25.7	32	21.4	-1	-4.3
Fragmentation	12	9.3	13	8.7	1	-0.6
Planula (free swimming fertilized egg) *	**22**	**17.1**	**27**	**18.1**	**5**	**1**
Don't know	16	12.5	0	0	-16	-12.5

IN OA, WHAT IS THE ORDER OF CHANGES (FIRST X, THEN Y, FINALLY Z)?

In the pretest 39.4% of the participants chose the correct answer CO_2 – pH – ASL. The second highest incorrect response was "Don't know" 32.8% and the third CO_2 – ASL – pH at 15.7%. In the posttest the correct answer response increased 43.2% to 82.6%, "Don't know" decreased 29.9% to 2.9%, and CO_2 – ASL – pH decreased 7% to 8.7%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
CO_2 – pH – ASL *	**30**	**39.4**	**57**	**82.6**	**27**	**43.2**
pH – CO_2 – ASL	5	6.5	3	4.3	-2	-2.2
CO_2 – ASL – pH	12	15.7	6	8.7	-6	-7
ASL – CO_2 – pH	4	5.2	0	0	-4	-5.2
pH – ASL – CO_2	0	0	1	1.4	1	1.4
Don't know	25	32.8	2	2.9	-23	-29.9

WHAT IS THE RELATIONSHIP BETWEEN PH AND ARAGONITE SATURATION LEVEL (ASL)?

In the pretest 18.4% of participants chose the correct answer "pH is one of parameters affecting ASL." The highest incorrect responses were "Don't know" (44.7%), and "Both are directly affected by dissolved CO_2" (30.2%). In the posttest the correct answer response increased from 16.3% to 34.7%. "Don't know decreased 44.7%, and "Both are directly affected by dissolved CO_2" increased 32.1%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
pH is only parameter affecting ASL	2	2.6	0	0	-2	-2.6
pH is one of parameters affecting ASL *	**14**	**18.4**	**24**	**34.7**	**10**	**16.3**
ASL drives pH	3	3.9	2	2.9	-1	-1
Both are directly affected by dissolved CO_2	23	30.2	43	62.3	20	32.1
Don't know	34	44.7	0	0	-34	-44.7

YOU'RE BUILDING A WOODEN HOUSE. IN THIS SCENARIO, THE CLOSEST ANALOGY TO ASL IS:

In the pretest 38.1% of the participants chose the correct answer "Density of wood in surrounding area." The highest incorrect responses were "Ratio of the number of people that build it over numbers that inhabit it" (30.2%), and "Food readily available in the surrounding area that will sustain the work" (15.7%). In the posttest the correct number of responses increased from 50.3% to 88.4%. "Ratio of the number of people that build it over numbers that inhabit it" decreased 30.2%, and "Food readily available in the surrounding area that will sustain the work" decreased 8.5% to 7.2%. There were also decreases in all other responses.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Number of people available to build the house	6	7.8	3	4.3	-3	-3.5
Density of wood in surrounding area *	**29**	**38.1**	**61**	**88.4**	**32**	**50.3**
Amount of time it would take you to build the house	6	7.89	0	0	-6	-7.89
Food readily available in the surrounding area that will sustain the work	12	15.7	5	7.2	-7	-8.5
Ratio of the number of people that build it over numbers that inhabit it	23	30.2	0	0	-23	-30.2

LOW LEVELS OF ARAGONITE SATURATION MIGHT AFFECT A CORAL'S

In the pretest four of the five responses were correct. Of the available correct responses 28.5% chose "Overall growth rate," 27.2% "Density of skeleton," 14.9% "Energy needed to build skeletal structure," and 14.2% "Extension of skeleton." In the posttest "Overall growth rate" decreased 2.2% to 26.3%, "Density of skeleton" decreased 1.4% to 25.8%, "Energy needed to build skeletal structure" increased 7.9%, and "Extension of skeleton" increased 6.7%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Density of skeleton *	**42**	**27.2**	**52**	**25.8**	**10**	**-1.4**
Extension of skeleton *	**22**	**14.2**	**42**	**20.9**	**20**	**6.7**
Overall growth rate *	**44**	**28.5**	**53**	**26.3**	**9**	**-2.2**
Energy needed to build skeletal structure *	**23**	**14.9**	**46**	**22.8**	**23**	**7.9**
Symbiotic relationship with zooxanthellae (disruption)	23	14.9	8	3.9	-15	-11

WHAT IS CONSIDERED AN ASL VALUE **JUST** ADEQUATE FOR CORAL REEFS?

In the pretest 6.6% of the participant chose the correct answer 3.2. The highest incorrect responses were "Don't know" (41.3%), and "7.8" and "8.1" were equal at 17.3%. In the posttest correct answer responses increased 22.3% to 28.99%. "Don't know" decreased 41.3%, "8.1" decreased 15.9%, "7.8" decreased 14.4%, and "4" increased to 57.3% from 9.3%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
4	7	9.3	46	66.6	39	57.3
2.5	6	8	0	0	-6	-8
7.8	13	17.3	2	2.9	-11	-14.4
3.2 *	**5**	**6.6**	**20**	**28.9**	**15**	**22.3**
8.1	13	17.3	1	1.4	-12	-15.9
Don't know	31	41.3	0	0	-31	-41.3

OUT OF THE LIST BELOW, WHICH ANIMAL GROUP IS EXPECTED TO BE AFFECTED LEAST BY OA?

In the pretest 23.6% of the participants chose the correct answer "Crustaceans." The highest incorrect responses were "Plankton" (40.7%), "Scleractinian corals" (19.7%), "Bivalves" (9.2%), and "Mollusks" (6.5%). In the posttest the correct answer response increased from 18.4% to 42%. "Plankton" decreased by 1.6%, Scleractinian corals" decreased by 11%, "Bivalves" by .5%, and "Mollusks" 5.1%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Bivalves	7	9.2	6	8.7	-1	-0.5
Crustaceans *	**18**	**23.6**	**29**	**42**	**11**	**18.4**
Mollusks	5	6.5	1	1.4	-4	-5.1
Scleractinian corals	15	19.7	6	8.7	-9	-11
Plankton	31	40.7	27	39.1	-4	-1.6

OA MIGHT AFFECT CORALS BY

In the pretest three of the five responses were correct. Of the available correct responses 23.3% chose "Reducing availability of building blocks," 20.4% "Increasing dissolution rates," and 16.9% "Exerting higher energy costs to calcify." Incorrect response rates were "Actively dissolving them" (22.8%), and "Bleaching them" (16.3%). In the posttest "Reducing availability of building blocks" increased 3% to 26.3%, "Increasing dissolution rates" increased .1%, and "Exerting higher energy costs to calcify," increased 15.2%. "Actively dissolving them" decreased 8.1% to 14.7%, and "Bleaching them" decreased 10% to 6.3%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Actively dissolving them	39	22.8	28	14.7	-11	-8.1
Increasing dissolution rates *	**35**	**20.4**	**39**	**20.5**	**4**	**0.1**
Exerting higher energy costs to calcify *	**29**	**16.9**	**61**	**32.1**	**32**	**15.2**
Reducing availability of building blocks *	**40**	**23.3**	**50**	**26.3**	**10**	**3**
Bleaching them	28	16.3	12	6.3	-16	-10

HOW OA CAN INTERACT WITH OTHER THREATS TO CORALS?

In the pretest 33.3% of the participants chose the correct answer "Makes corals more susceptible to other effects." Incorrect response rates were "Diminishes their symbiotic relationship with zooxanthellae" (24.5%), "Don't know" (20.1%), "Makes corals bleach directly" 12.2%, and "OA effects are confined to coral skeletal growth." In the posttest the correct response increased 18.7% to 52%. "Diminishes their symbiotic relationship with zooxanthellae" decreased 9.5% to 15%, "Don't know" decreased 20.1%, "Makes corals bleach directly" decreased 4.2% to 8%, and ""OA effects are confined to coral skeletal growth" increased 15.4% to 25%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
OA effects are confined to coral skeletal growth	11	9.6	25	25	14	15.4
Makes corals bleach directly	14	12.2	8	8	-6	-4.2
Diminishes their symbiotic relationship with zooxanthellae	28	24.5	15	15	-13	-9.5
Makes corals more susceptible to other effects (synergistic effects) *	**38**	**33.3**	**52**	**52**	**14**	**18.7**
Don't know	23	20.1	0	0	-23	-20.1

YOU ARE A CORAL POLYP GROWING A SKELETAL STRUCTURE. WHICH PARAMETER WOULD YOU BE MOST INTERESTED IN READING THE FORECAST FOR IN THE MORNING NEWSPAPER, PROVIDED YOUR BASIC NEEDS ARE MET?

In the pretest 19.7% chose the correct answer "Aragonite saturation level." Incorrect response rates were "pH" (28.9%), "Water temperature" (19.7%), "Dissolved CO_2" (17.1%), "Calcium level" (14.4%). In the posttest the correct answer response increased 58.5% to

78.2%. “pH” decreased 23.1% to 5.8%, “Water temperature” 19.7%, “Dissolved CO_2” 2.7% to 14.4%, “Calcium level” 14.4%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Seasonal zooplankton menu	0	0	1	1.4	1	1.4
pH	22	28.9	4	5.8	-18	-23.1
Aragonite saturation level *	**15**	**19.7**	**54**	**78.2**	**39**	**58.5**
Dissolved CO_2	13	17.1	10	14.4	-3	-2.7
Calcium level	11	14.4	0	0	-11	-14.4
Water temperature	15	19.7	0	0	-15	-19.7
Expected kayakers morning route	0	0	0	0	0	0

IF MARINE CREATURES WERE STOCK, WHICH TWO WOULD HAVE A BUY RATING BASED ON THEIR 20-YR “YIELD”?

In the pretest two of the five answers were correct. “Seagrass” scored 25.3% and Jellyfish 22.3%. Incorrect response rates were “Crabs” (21.6%), “Fish” (18.6%), and “Clams” (11.9%). In the posttest the correct answer “Seagrass” increase 9.7% to 35%, and “Jellyfish increase 13.4% to 35.7%. “Crabs” decreased 12.2% to 9.4%, “Fish” decreased 4.8% to 13.8%, and “Clams” decreased 6.1% to 5.8%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Clams	16	11.9	8	5.8	-8	-6.1
Seagrass *	**34**	**25.3**	**48**	**35**	**14**	**9.7**
Crabs	29	21.6	13	9.4	-16	-12.2
Fish	25	18.6	19	13.8	-6	-4.8
Jellyfish *	**30**	**22.3**	**49**	**35.7**	**19**	**13.4**

AND WHICH THREE WOULD HAVE A “SELL” RATING BASED ON THEIR 20-YR “YIELD”?

In the pretest three of the five answers were correct. “Corals” scored 26.8%, “Bivalves” 24.3%, and “Phytoplankton” 15%. Incorrect response rates were “Crabs” (20%) and “Fish” (13.7%). In the posttest the increased correct answer response rates were “Corals” 4% to 30.8%, and “Bivalves” 5.9% to 30.2%, “Phytoplankton” decreased 1.3% to 13.7%. The

incorrect responses rates were “Crabs” a decrease of 1.2% to 18.8%, and “Fish” a decrease of 7.5% to 6.2%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Corals *	**43**	**26.8**	**54**	**30.8**	**11**	**4**
Crabs	32	20	33	18.8	1	-1.2
Bivalves *	**39**	**24.3**	**53**	**30.2**	**14**	**5.9**
Phytoplankton *	**24**	**15**	**24**	**13.7**	**0**	**-1.3**
Fish	22	13.7	11	6.2	-11	-7.5

WHAT ARE SOME COMMON OA MISCONCEPTIONS?

Because this question allowed participants to choose one or more, the numbers and percentages in the table below represent the respondents who chose that answer. Some people only chose one, others chose more than one. Four of the five responses are misconceptions. “Ocean pH changes are very small, therefore negligible” was selected by 31.8% of respondents, “Marine organisms and ecosystems will adapt to these changes” 26.7%, “Acid rain exacerbates OA” 14.6% and “Unabated, oceans will eventually become acidic” (12.7%) . The incorrect response was “Warming ocean waters are causing OA” (14.6%), and. In the posttest “Ocean pH changes are very small, therefore negligible” decreased 4.2% to 27.6%, “Marine organisms and ecosystems will adapt to these changes” decreased 5.8% to 20.9%, and Acid rain exacerbates OA” increased 4.7% to 18.7%. “Warming ocean waters are causing OA” increased 1.9% to 16.5, and “Unabated, oceans will eventually become acidic” increased 3.3% to 16%.

Answer choices	Pre		Post		Diff	
	#	%	#	%	#	%
Ocean pH changes are very small, therefore negligible *	**50**	**31.8**	**62**	**27.6**	**12**	**-4.2**
Marine organisms and ecosystems will adapt to these changes *	**42**	**26.7**	**47**	**20.9**	**5**	**-5.8**
Acid rain exacerbates OA *	**22**	**14**	**42**	**18.7**	**20**	**4.7**
Warming ocean waters are causing OA	23	14.6	37	16.5	14	1.9
Unabated, oceans will eventually become acidic *	**20**	**12.7**	**36**	**16**	**16**	**3.3**

WORKSHOP EVALUATION RESULTS

Participants took the end of workshop survey online at the end of the day. The results are presented in this section by question.

Educators during a hands-on portion of workshop

WORKSHOP STRUCTURE AND FORMAT

The overall rating was 4.7 (out of 5) indicating the participants were very positive about the content of the workshop. Individual components were rated as: The science presentation at the workshop was useful and informative (4.7); The curriculum presentation at the workshop was useful and targeted (4.7); I would recommend this workshop to colleagues (4.6); I plan to use what I learned today in the near future (4.6); The OA module provides a useful context for teaching core science (4.6); The OA Teacher Guide provides me with a useful structure that gives me tips on how to integrate scientific content and real-time satellite data together (4.6); The graphs, maps, and charts of data were clear and easy to use (4.6); and, Understanding OA and its increasing levels of inquiry are helpful to me for integrating real-time data into my instructional practice (4.7).

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Average
The science presentation at the workshop was useful and informative.				17	57	4.7
The curriculum presentation at the workshop was useful and targeted.				19	55	4.7
I would recommend this workshop to colleagues.				24	50	4.6
I plan to use what I learned today in the near future				23	51	4.6
The OA module provides a useful context for teaching core science.				27	46	4.6
The OA Teacher Guide provides me with a useful structure that gives me tips on how to integrate scientific content and real-time satellite data together.			2	21	51	4.6
The graphs, maps, and charts of data were clear and easy to use.		2		18	54	4.6
Understanding OA and its increasing levels of inquiry are helpful to me for integrating real-time data into my instructional practice.			1	20	53	4.7
					Overall Average	**4.7**

OA NODE LEVELS THAT PARTICPANTS PLAN TO USE

The two levels that participants indicated they would most likely use with their students were Level 1: Entry – Measuring Ocean pH (22.7%), and Level 2: Adoption – The Ocean-Carbon Connection (22.7%). Level 3: Adaptation – Carbonate Buffering System was rated at 20.5%, Level 4: Interactivity – Aragonite Saturation & Marine Calcifiers 19%, and Level 5: Invention -- Design Your Own Investigation 15%.

Level	%
Level 1: Entry – Measuring Ocean pH	22.7%
Level 2: Adoption – The Ocean-Carbon Connection	22.7%
Level 3: Adaptation – Carbonate Buffering System	20.5%
Level 4: Interactivity – Aragonite Saturation & Marine Calcifiers	19%
Level 5: Invention -- Design Your Own Investigation	15%

Please explain how you plan to use each of the levels after learning about them today (or NA=not applicable if you are not planning to use that level).

The two most common themes on how the participants plan to use each level were in the development of "real world scenarios" and "integrating the subject matter into their current lesson plans." Other occurring themes were the "material provided a better understanding of particular concepts," it would be used in "inquiry-based labs," and "enhance teaching of the scientific method and research approaches." The common subject areas of intended use were chemistry and marine science.

PARTICIPANTS: PLANNED USE OF OA MODULE

Above- Portion from an enthusiastic evaluation form received at workshop

- *They will assist in my class because chemistry students can use this as a real world scenario and see how we can use chemistry to answer fundamental questions for today.*
- *I may only apply level 5 to my advanced students*
- *I can better explain OA to others as well as incorporate it into other programs here and there.*
- *Using this to build the ideas of the scientific method. Use the data to build science fair like reports.*
- *Will use them in informal discussions.*
- *Computer based research/response*

- *Instruction, active activities with student and continuous research*
- *I will use this as an inquiry based lab when we come to the acid and base chapters in the textbook. This will be a great real world application of the tools we received today.*
- *Incorporate the OA in my lesson plans and ESL centers for science Labs.*
- *I will use the first three lessons in order with guidance. I will divide students into cooperative learning groups for Level 4. Students will complete Level 5 for their science project for Spring 2012.*
- *Integrate into acid/base and environmental chemistry topic*
- *Effects of continued use of fossil fuels*
- *Levels 1-3 fit into my existing solutions unit with real data practice for my students.*
- *I do a unit on weather and how it affects the ocean. I think this will fit into that unit.*
- *I would introduce the unit to the students and plan to spend about 3 weeks total on the levels. It would start out as a background information session to review pH and chemistry terms and then lead up to the individual levels (not sure about implementing level 5).*
- *Through my marine science class when I cover physical oceanography and marine issues.*
- *When teaching biogeochemical cycles and ph levels and*
- *Differently for various students (differentiation)*
- *I will implement this curriculum with both marine and regular science students.*
- *Plan to use modules. May adapt some (add additional content) for some courses.*
- *I teach a Marine Science Honors Class. I will use it in the unit on coral reef ecology,*
- *I plan to use these levels during my Ocean Chemistry lectures and Lesson Plans. Depending of the level of students in my classes, I plan to at least get to Level 4.*
- *I plan to use each of these levels to introduce the concept of ocean acidification, and reinforce the bigger thought of interconnectedness of organisms. While I teach a full-time gifted classroom, I'm not certain that I will have all of my students able to grasp the concepts and skills covered in Levels 4 and 5 as they were presented. I will, however, modify the content of Levels 4 and 5 and allow for further investigation using these techniques.*
- *The next time I teach marine biology, I will integrate the concept of ocean acidification throughout the curriculum. My students do an independent research project for my class. I will use the level 4/5 activities to help them prepare for this activity. They may also be able to use the data in their independent project.*
- *I would modify the lessons to fit the needs of my students.*
- *I plan to integrate the entire program into the curriculum for my Environmental Science class.*
- *I would plan to have students create resear4ch projects based on the information presented to them on the lower levels.*

- *I plan to use level 1 and 2 as an application to the pH scale acids and bases and why hydrogen ion concentration is important and relative to real life. Level 3 will be a continuation of the acid-base chemistry and how buffers work. We will look at what is the buffering system in the oceans and how the effect and changes of these can affect whole ecosystems. Lastly level 4 will be applicable when I am teaching about ionic compounds and I can introduce an application to carbonate, bicarbonate ions and the formation of compounds like calcium carbonate including their usage.*
- *As we used them in the workshop today. An increasing level of understanding*
- *Use of the websites and technology offered. Also the dvd/cd provided will make the topic much more usable by my class.*
- *By making it grade level. For example, using a PH kit from the pet store.*
- *Since I teach sixth grade I will be using the chapter in our science book along with materials, DVD, and the Internet information I've acquired by attending this workshop.*
- *I intend to use this program when teaching the nature of science and scientific method. This will provide the students an opportunity to collect and interpret relevant data to prepare them for their own research projects later in the year.*
- *Level 1 - Upon completion of general pH information will Ocean pH combined with aquaculture production and effects of OA on aquaculture products. Level 2 - Will tie into recycling, pollution reduction to help understand effects of all these on the aquatic animal life. Level 3 - Will reinforce concept of pH and what is required to raise or lower and how chemistry relates to real life situation. Level 4 - Reinforce impact that OA through pollution and deforestation has on aquatic marine life and to compliment teaching students how to develop a research project. Level 5 - As a reinforcement of how to do scientific investigation and research projects from now through college graduation.*
- *I'll use the different levels according to the pacing guide.*
- *In the order presented/organized with marine science; specifically marine science 2. I'll incorporate by dividing it into the four areas of oceanography as much as possible.*
- *I will use the modules when I teach the Conservation Biology/Ecology Unit. The lessons offer an ideal opportunity to explore natural history using live data.*
- *Introduction to graphs charts, THE NOOA, ocean acidification, interactive PH game where students align ph levels with product. Learning how to identify trends in graphs and EL NINO website.*
- *Using in the oceanography unit in enhancing real world stuff*
- *Begin as introductory lessons and progress to level 5 with competent students*
- *As a technology teacher I plan to work with the science instructors to integrate as well as facilitate implementation of each of the levels. Working together we will be able to effectively meet the objectives of each level.*
- *Using a project based in oceanography, the students will develop all levels of study.*

- *I plan to use the module as presented*
- *When I am going to teach Solution and pH, Earth chemistry.*
- *Levels 1-3 were great introduction and low-level inquiry skills for students. Depending if I have advanced students (or regular with high abilities) will dictate if I can reach level five.*
- *I would adapt them to the specific needs of my students.*
- *To teach introduction to acid base reactions in a real life context*
- *I will use each of these modules with the LVA Tutors.*
- *The objectives for the procedures could be a little clearer.*
- *Not sure yet. Depended how it applies to SSS. I may do the afterschool program and base a unit on acidification.*
- *This will be an excellent companion to the coral Reef Classroom experience where we introduce the science of the coral reefs and take the students on a snorkel trip to one of our local reefs.*
- *I am teaching AP Chemistry next year and feel like incorporating these lessons throughout the year will be beneficial. I then plan to use the 'Design Your Own Investigation' lesson for an end of the year wrap up, after the AP exam of course. :)*
- *I will use this to better understand ocean acidification when I talk to students and groups.*
- *I teach Earth and Space to high schoolers. I can use all the levels to help differentiate my instruction. The lower level students can use level 1 and my honors students can use number 5*
- *Use a UBD approach and allow students to learn by investigation*
- *Not a school teacher, share with community*
- *At the end if the biodiversity unit; use in state of the art computer lab for hands-on interaction activities*
- *I will be teaching 2 Marine Science classes and plan to imbed all 5 levels in those classes. Additionally, I will be using the interactive pH game with my general Biology students.*
- *Middle school students explore site after intro and create presentation*
- *I will use levels 1,2,3 with my on level marine science I and use all 5 levels with Honors marine science I and II classes.*
- *I teach grades 2- 12 and will use either part of or all depending on the grade level using a tiered approach*
- *1- explain ph scale and making measurements. 2- carbon cycle. 3- what buffering system means and how it works. 4- the relationship between aragonite & saturation. 5- yes, students will develop their own*
- *Level 1: During pH unit, students will interpret provided data from graphs. Level 2: Nutrient cycles - students will analyze effects of human activity on the carbon-ocean connection. Level 4: When studying enidarians and their development. Level 5: This would be for specific students as a project that they might present to class.*

- *Level 1: How to measure, define, importance in ocean chemistry and OA. Level 2: Incorporate into global learning and fossil fuel consumption. Levels 3 and 4: Coral ecology and calcium building organisms. Level 5: Research project using cooperative learning*
- *Levels 1-3: With the scientific method, graphs and analysis, and extensions. Level 4: In lab technology in content area.*
- *Level 1: Basic introduction, teacher directed. Level 2: Teacher directed. Level 3: Introduce possible scenarios with the simulation, student -directed. Level 4 and 5: For my honors students only at first to see how it goes.*
- *Level 1: Use with AICE Env. Mng and AICE Marine science. Follow guidelines, add in pH lab in class. Level 2: Follow module. Level 3: Follow curriculum guide. Level 4: Include with an id section, search for date regrading conc. of marine calcifiers. Level 5: Science fair project.*
- *Level 1: After renewing pH (the typical labs), I will intro the unit and begin L1. Level 2: Start long labs of crush coral with different pH. Level 3: Will continue with the lessons as planned (at least for the first time). Level 4: none. Level 5: 8th grade, they will sue the lab 7 data, previously collected data to present science board in table groups.*
- *Level 1: Examine maps and graphs. Level 2: Understand how data form graphs affect acidification. Level 3: Students create models on line. Level 4: Prove a given or set hypothesis. Level 5: Students design an investigation.*
- *Level 1: Application of pH knowledge to do science research. Level 2: Examples of chemical reactions and how human activities affect ocean balance. Level 3: Learning about using models in science research. Level 4: Data manipulation. Level 5: Use the data to test a hypothesis related OA.*
- *Level 1: Reviewing pH (chemistry), water cycle. Level 2: Atmosphere* CO_2 *cycle impacts the environment. Level 3: ASL students develop acid testing techniques of scientific method, collecting data with in the community. Level 4: Using the shells; demonstrate pH effects on items (real world). Level 5: Hopefully students can design their own question and experimentation.*
- *Level 1: Application of pH knowledge to do science research. Level 2: Examples of chemical reactions. Level 3: Using models in science research. Level 4: Data manipulations. Level 5: Not applicable*
- *Level 1-5: Incorporate lessons on pH into our kayaking field trips with the marine science teacher at my school who attended today*

EDUCATOR OBJECTIVES FOR USING THE OCEAN ACIDIFICATION MODULE

The highest rated objective to be accomplished by using the OA module was that "Students will be able to use data represented in map and graph displays" (17.1%). Second was "Students will be able to access and interpret maps and graphs of ocean pH, sea surface temperature and CO_2 concentration (15.5%)," third "Students recognize that ocean acidification is a critical emerging problem in ocean sciences (15.4%)," fourth "Students will be able to describe the relationship between sea surface temperature (14.4%), fifth "Students will able to explain the impact of changing aragonite saturation state on marine calcifiers (13.2%)," sixth "Students will be able to describe the relationship between sea surface temperature, CO_2 concentration and aragonite saturation state (13%)," seventh "Students will be able to design their own research project using online data gathering as a central component of the research design" (11.1%).

%	Standard
17.1%	Students will be able to use data represented in map and graph displays.
11.1%	Students will be able to design their own research project using online data gathering as a central component of the research design.
15.5%	Students will be able to access and interpret maps and graphs of ocean pH, sea surface temperature and CO_2 concentration.
14.4%	Students will be able to describe the relationship between sea surface temperature, CO_2 concentration and ocean pH.
13%	Students will be able to describe the relationship between sea surface temperature, CO_2 concentration and aragonite saturation state.
13.2%	Students will able to explain the impact of changing aragonite saturation state on marine calcifiers.
15.4%	Students recognize that ocean acidification is a critical emerging problem in ocean sciences.

EDUCATOR RATING OF THE NODE MATERIALS

- *Excellent: 70.2%*
- *Good: 25.6%*
- *Average: 2.7%*
- *Poor: 0%*
- *Below average: 0%*

Overall the participants indicated that the materials were easy to use and understand. They also found them to be comprehensive, accessible, an excellent resource, and adaptable to all grade levels.

PARTICIPANTS: MATERIALS FEEDBACK

- *The materials are easy to use and easy to understand. Also, they are simple to work with.*
- *There were a few mistakes, however overall the text was very useful.*
- *I think what is here is excellent, however I would like more biological information and parameters to look at, compare and extract.*
- *Easy to follow. Good material. Helps students learn. Need to have NGSSS link to each module.*
- *For my purposes, the materials are not useful, but they would be helpful to a classroom teacher.*
- *User friendly - students will find the materials a bit on the boring side.*
- *Very instructional and friendly user.*
- *Needed to be able to have multiple graphs on one graph.*
- *I felt comfortable with the format & ease of use. Facilitators were friendly and very helpful. I can't wait for the DVD to arrive and use it in my LP's.*
- *This workshop was wonderful! I enjoyed the hands-on activities and practice. This information will be utilized in the classroom.*
- *The OA unit has great interactive maps and graphing capabilities. It would take longer than I have to do all five levels.*
- *They are easy to use and read.*
- *Some materials need a bit of review and actual classroom testing, but the overall concepts are good and I look forward to using them in the classroom.*
- *Very user friendly and will translate well to the classroom.*

- *Materials were great, but I felt that the presentation after lunch good have been given to groups and then have the groups present their findings.*
- *Great stuff!*
- *This is a very comprehensive curriculum which lend itself to integrate technology, field and lab instructions*
- *Some units need to be defined. Chemical compounds should be proofed for correct charges.*
- *The materials were very well planned out. I liked the progression.*
- *great materials, would be even better if we could expand the area to compare different geographic locations*
- *The information presented in this module could seem overwhelming to an elementary teacher, but the excellent staff organized and structured the training in such a way that we felt compelled to learn the material, and differentiate the instruction so that it became a useful tool in our classrooms. This group of presenters was professional, personable, and amazing group.*
- *These materials put an incredible amount of data in the kids' hands. It allows the students to choose what data they wish to see, and then manipulate the data.*
- *Very easy to access and full of excellent resources such as the video, teachers guides, etc.*
- *The program is well thought-out, with the levels designed to allow students to build upon information previously learned.*
- *All the presenters were knowledgeable and the material was insightful and thought provoking.*
- *Program and online simulations are self explanatory and easy to use. They also provide colorful maps of data, which allows for visualization of the information that will capture the students' interest.*
- *While not an expert on the ocean, I was able to understand and use the module with ease*
- *The handouts were clear and easy to interpret. The use of color in the presentation materials was of great help in maintaining focus and attention. Most importantly, the materials and presentation were easily adaptable to the student population that I teach!*
- *Everything was very well planned*
- *Although I'm not as skilled in the chemistry area, there was plenty of excellent information that can be modified to the curriculum I'll be using. Thank you for a great and informative day!*
- *The materials are very user friendly.*
- *The information is great. Most of it needs to be modified in some way or the other to apply easily to middle school students that are the level of the students I teach.*
- *Excellent preparation.*

- *It added to my knowledge of oceanography, provided materials for the classroom, and allowed networking*
- *The materials and explanations are easily understood and transferable to other objectives within the Science curriculum.*
- *Cutting edge technology, great presenters with tons of enthusiasm-SO GLAD I 'm here!*
- *So many workshops are not at an advanced level for experienced teachers*
- *Well-designed and user-friendly curriculum. Some at higher level for middle school*
- *Material is perfectly created to meet the needs of my middle school students*
- *The presentation was outstanding and reached all levels planned.*
- *Advanced enough for my AP classes*
- *Very good!*
- *Well defined*
- *I do not have all materials yet.*
- *Very easy to use and informative. They give a variety of ways to use and view real time data.*
- *These modules are succinct and easy to use with students of various grade levels.*
- *The interactive NOAA website and the data that it provides is quite impressive.*
- *I enjoyed the real time data. Cannot wait until we have more current data to use so students see a value!*
- *This is material I can definitely use in the classroom and I'm looking forward to using it with my students.*
- *I felt like there could have been more use of the materials and guidance through that process instead of the instructor having to teach science teachers what they should already know, especially at a middle/ high school level.*
- *The materials were very complete and it is important to have a leader interpret materials.2*
- *It is very easy to use and navigate. It also allows the students to see real data and come up with their own conclusions*
- *I like the fact that it gives you step-by-step instruction and explanation. That way, I learn how to present the first time and then add more in as I see that my students might need*
- *Easy to share online*
- *Very informative and engaging*
- *The NODE materials were easy to manipulate and easy to understand. I think they will engage my students and lead to increased learning.*
- *Very accessible*
- *These are great for the level of students I teach*
- *The presentation was well thought out and presented in an understanding fashion3*
- *Very good instruction*

- *Abundant amount of data that is easy for students to explain. Levels provided are so important in that lessons can be taken to any level.*
- *Professionally put together with the educator in mind and professionally presented and organized! Good job!*
- *Video is horrible for high school students - maybe college/teachers. Demos should be at eye level.*
- *I really enjoyed the workshop. I look forward to the one on coral bleaching.*

BEFORE/AFTER PARTICIPANTS SELF RATINGS

	Strongly Disagree		Disagree		Neither agree nor disagree		Agree		Strongly Agree	
	B	A	B	A	B	A	B	A	B	A
I understand ocean acidification well enough to teach it in my class	41.9%	0	18.9%	0	20.3%	4.1%	16.2%	54.1%	0	39.2%
I can use real data to use to teach ocean acidification	44.6%	0	21.6%	1.4%	16.2%	2.7%	12.2%	25.7%	1.4%	67.6%
I have good interactive resources for teaching ocean acidification	47.3%	0	23%	1.4%	17.6%	0	6.8%	29.7%	1.4%	66.2%
I feel confident teaching ocean acidification	44.6%	0	24.3%	1.4%	16.2%	8.1%	10.8	45.9%	0	41.9 %

The average rating of understanding and confidence in using the material before “After” the workshop increased measurably. “I understand ocean acidification well enough to teach it in my class” increased by 2.42; “I can use real data to use to teach ocean acidification increased

2.77. “I have good interactive resources for teaching ocean acidification” increased by 2.98, and “I feel confident teaching ocean acidification” increased by 2.63.

Average rating	Before	After	**Diff**
I understand ocean acidification well enough to teach it in my class	1.87	4.29	**2.42**
I can use real data to use to teach ocean acidification	1.89	4.66	**2.77**
I have good interactive resources for teaching ocean acidification	1.63	4.61	**2.98**
I feel confident teaching ocean acidification	1.63	4.26	**2.63**

PARTICIPANTS: WORKSHOP FEEDBACK

- *None. I think that everything was well thought out and planned....I would not know how to make this workshop better (9)*
- *Finally a teacher workshop worth attending!! Excellent workshop! Please continue doing workshop like this. (7)*
- *Maybe more demos and hands-on activities (let us do the lab) :) (4)*
- *Thank you very much for this opportunity. (4)*
- *I learned a lot today. Excellent instruction and resources. (3)*
- *The presentation needed to be a bit more clear about what the lessons we emphasizing. However once they are read again it makes sense.*
- *I really enjoyed today's workshop. I hope that there are other pertinent workshops available to attend in the realm of Marine Science.*
- *Multiple parameters overlayed; information exported into a datasheet, preferably Excel or something that gives the column headers; biological information on calcification - input and take up and then what the rate is of each so those variables can be thrown into calculations as well as understanding that it does have an impact on OA --this way when I am speaking with someone and they are saying it is a natural thing I can give them/show them data that we humans are impacting at a much hire (alarming) rate than the natural occurrences... this will have a much bigger impact on students being able to see this; My Biggest comment/suggestion is to make sure that when information of this high*

importance is being taught to us or for us to teach to others is to bring it home - to show how what we do impacts us - not something that we normally don't see or have anything to do with us... people are selfish and only generally care what is going to impact their daily lives, not the future, not others, but themselves!

- *Seemed to be beyond the control of group leaders, but room temperature was an issue in both rooms. [One instructor] came across as a bit too matronly and pushy to other instructors. I know this was primarily directed to classroom teachers, and appreciated the opportunity to learn more about the subject.*
- *Tough for average level or below students to grasp.*
- *Motivation to get local gov'ts to act on OA. Political and economic.*
- *I loved the sharing of knowledge and interaction between the workshop presenters.*
- *More content...less pedagogy*
- *A flow chart indicating* CO_2 *increase in the atmosphere to aragonite saturation would be useful*
- *Have a better coordination with group activities as it seemed a bit disorganize and confusing. We really didn't work much in a group nor really shared much as far as how it would be implemented/changed for classroom use. Other than that, I really enjoyed my time at this workshop and feel confident in teaching ocean acidification to my students.*
- *Do not have the presenters present level 3,4,5 and 5*
- *It was great to experience such flexibility, all around, on the part of presenters.*
- *Very informative and I look forward to using the materials with my students.*
- *Thank you for an amazing day of training. Even after waking at 4:30 to drive 4 hours to this training my first day of summer vacation, the training was so well presented that I was energized, rather than drained.*
- *Please emphasize the carbonate chemistry at the beginning. Up until today, it was something that I always 'took on faith' because I didn't understand it. I knew that acidic water dissolved CaCO3, but I didn't know why or how. I think it is critical that we, as teachers, are able to understand this. Otherwise, we can't explain it to our kids.*
- *I thoroughly enjoyed the workshop. I wish we could have spent more time on the content and research data and the water quality and not all the time doing the lessons in the packet.*
- *As stated before, the materials presented were easily adapted to my student composition. The presenters were very knowledgeable and easy to understand. they were enthusiastic and able to retain my attention and keep me motivated to learn more.*
- *I am looking forward to getting the DVDs.*
- *I would like to have more of this workshops*

- *Thank you for this unique opportunity. I look forward to sharing these lessons with my students.*
- *KEEP UP THE GOOD WORK!*
- *Thanks for supporting teachers and their need for real world materials*
- *Great instruction and resources!*
- *The program is a comprehensive, well thought out curriculum. I look forward to implementing each level with my students.*
- *I feel very comfortable now, with the material obtained in the workshop and I understand better reasons of acidification of the ocean*
- *Present the topic for different levels of instruction*
- *Well-timed and guest speakers were great.*
- *This workshop was very insightful, I feel I have developed a better understanding of ocean acidification.*
- *Very informative*
- *I wish this presentation could be given to all of NOAA's Climate Stewards.*
- *The sequence in which the material was comprehensive. Additionally, the hosting center of the workshop was quite pleasant as well*
- *Good job presenting and bring it to a level teachers can grasp.*
- *Excellent presentation.*
- *Sometimes at conferences I feel like we should have to pass a 'basic requirement' test to be allowed to attend. Just a thought. It would allow a baseline of knowledge so our time could be maximized.*
- *It gave me a better understanding of ocean acidification since I have very little chemistry knowledge.*
- *Have a teacher manual and suggestions for elementary grades. This is where they are exposed and learn life lessons for helping our oceans!!!*
- *Understanding ocean acidification, exercise page 43, IPCC scenario A2*
  the results of Water Temp and CO_2 *are unreadable because they overlap*
- *I am glad to know about the NODE site and wish I had known about it when I was teaching Environmental Science*
- *I would like to see more on the sources of* CO_2 *in the atmosphere*
- *I will use this program in my 2nd hour marine science class and I will compare to not using this program in the 4th hour marine science class.*
- *I will get more confident as I teach this material; the more I use it the better I get and I will figure out how to adapt it to the needs of my students.*

CONCLUSIONS

This evaluation focused on the three questions:

Workshop participants tour of NCRI's coral nursery facilities

How effective is a one-day professional development workshop in preparing teachers to use the Ocean Acidification module? (feel confident, intent to use what they learned, able to use real data, understand enough to teach it)

What impact does the workshop have on the teachers' knowledge of ocean acidification? (pre/post test change)

To what extent are Ocean Acidification materials appropriate and helpful to teachers for use in their classrooms?

The findings from this evaluation provide clear evidence that the materials are appropriate and helpful to teachers, and that the workshop prepares them to use the materials in their classrooms, and increases their knowledge of ocean acidification. The findings are summarized by evaluation question below.

HOW EFFECTIVE IS A ONE-DAY PROFESSIONAL DEVELOPMENT WORKSHOP IN PREPARING TEACHERS TO USE THE OCEAN ACIDIFICATION MODULE?

- When asked to rate their confidence in teaching ocean acidification before and after the workshop, teachers rated their confidence 1.63 before the workshop and 4.26 after, an increase of 2.63.
- Before the workshop, teachers' self-ratings on their understanding ocean acidification well enough to teach it were 1.87 and post ratings were 4.66, for a gain of 2.77.
- For ability to use real data to teach ocean acidification, pre workshop self-ratings were 1.89, post 4.61, for a gain of 2.98 of a scale of 1-5.

- On a scale of 1-5, teachers rated, “The science presentation at the workshop was useful and informative” 4.7.
- Teachers rated, “The curriculum presentation at the workshop was useful and targeted 4.7.
- “I would recommend this workshop to colleagues” was rated 4.6.
- “I plan to use what I learned today in the near future” was rated 4.6.

WHAT IMPACT DOES THE WORKSHOP HAVE ON THE TEACHERS’ KNOWLEDGE OF OCEAN ACIDIFICATION? (PRE/POST TEST CHANGE)

Pre/post knowledge test differences were significant at all three locations at a 99% confidence level (<.01). Each participant’s pre and posttests were scored. The total scores were compared using matched pair t-tests.

For individual questions, correct responses increased for 24 of the 24 questions. In seven of the items that had more than one response, incorrect choices also increased. These are summarized by question below:

Which coral life cycles/processes might be most affected by OA?

Correct answers increased: “Settling” (12.3%) and “Planula” (1%), but so did misconception “Adult growth” (4.2%).

Acid rain is related to ocean acidification by sharing

The correct answer, “Same state of matter” increased (4.8%), but the misconception that they are related because the “EPA regulates them both” (17.5%) increased more.

What is the relationship between pH and Aragonite saturation level (ASL)?

The correct answer responses, “pH is one of the parameters affecting ASL” (16.3%), so did the misconception “Both are directly affected by dissolved CO_2” (32.1%).

For the question, “***Low levels of Aragonite Saturation might affect a coral’s***:” two of the correct choices increased, “Extension of skeleton” (6.7%), and Energy needed to build skeletal structure” (7.9%), while the other two correct answers decreased, “Density of skeleton” (-1.4%) and “Overall growth rate” (-2.2%).

What is considered an ASL value just adequate for coral reefs?

The correct answer, 3.2, increased by 22.3%, but the optimal level, 4.0, increased by 57.3%). This was the next best choice if the person wasn't reading the question carefully.

How OA can interact with other threats to corals?

The correct response, "Makes corals more susceptible to other effects" increased on the posttest (18.7%), but so did the response, "OA effects are confined to coral skeletal growth" (15.4%)

And which three would have a "sell" rating based on their 20-yr "yield"?

The correct responses increased; "Corals" (4%) and Bivalves (5.9%), but the third correct choice, "Phytoplankton" decreased slightly -1.3%).

Recommendation: Improving the knowledge test – some questions, sp the ones that had multiple answers, caused confusion. Some statements in the questions above and in the answers provided in the survey instrument were ambiguous or not specific enough.

TO WHAT EXTENT ARE OCEAN ACIDIFICATION MATERIALS APPROPRIATE AND HELPFUL TO TEACHERS FOR USE IN THEIR CLASSROOMS?

- 95.8% of the teachers rated the modules good or excellent.
- For "I have good interactive resources for teaching ocean acidification" teachers' pre workshop ratings were 1.63, compared with post ratings of 4.61, a gain of 2.98.
- Teachers rated, "The OA module provides a useful context for teaching core science" 4.6/5
- On a scale of 1-5, teachers rated 4.6 "The OA Teacher Guide provides me with a useful structure that gives me tips on how to integrate scientific content and real-time satellite data together"
- Teachers rated the clarity of the graphs, maps, and charts of data 4.6/5.
- Teachers rated the helpfulness of the OA increasing levels of inquiry for integrating real-time data into my instructional practice 4.7.

NEXT STEPS

The next steps are divided within next three months (by September, 2011), and within next twelve months (by July, 2012).

NEXT 3 MONTHS

OA NODE Module Teachers' Guide – Guide needs to be updated to fix errors, typos and clarify some instructions that teachers found confusing during workshop.

OA Ed DVD – Disk containing supporting educational resources to assist effective classroom teaching of OA needs to be finalized and distributed to workshop participants by the start of the school year.

OA NODE page – the NODE page on OA needs to be updated to include additional resources that were used in workshops, including Florida science standards, interactive & multimedia tools, among others.

NEXT 12 MONTHS

Workshop participant follow up – Educators will be asked to provide feedback based on their classroom implementation of the OA NODE module in order to receive the final portion of their stipends.

Classroom study – six teachers will be followed closely as they set up parallel classroom teachings on OA, one using their existing materials and another one using NODE module. Student understanding and knowledge gained, among other parameters, will be tracked.

Final OA NODE Report – by summer of 2012, project will produce a final report summarizing how the materials were implemented in the classroom. This report will assist in making final changes to the OA module, and will inform the implementation of the upcoming Coral Bleaching NODE module and teacher training.

APPENDICES

APPENDIX A: APPLICATION FORM

1) Location

2) Please provide your contact Information. Confirmation of your acceptance to the workshop will be sent via email with further workshop details. Any stipends you may receive will be mailed to the street address you provide. Please know that this information is confidential and will only be used to provide you with information about the workshop, follow up opportunities, and directly related educational activities.

First Name; Last Name

Address

Phone

Email Address

3) Please give the names of the courses you currently teach or plan to teach next year by

6, 7, 8, 9, 10, 11, 12

4) How do you currently teach coral reefs, ocean acidification, and water quality? (Not currently teaching is okay as long as you are willing and able to integrate it next year - see next question)

5) How do you plan to integrate the NOAA module and data on ocean acidification and/or water quality into your curriculum?

6) This program focuses heavily on using real data in the classroom available online. Please describe how you currently have students using data to learn. (If you are not currently having students use real data, describe your vision for doing it in your classroom)

7) Students will need access to the module on line. Please describe how your students will access the modules and data on the Internet.

APPENDIX B: PRE-WORKSHOP REGISTRATION QUESTIONS

These four questions were asked on the registration form to decide on acceptance and to provide further insight into how coral reefs is currently addressed in the curriculum, and how teachers planned to implement the NOAA data in the classroom modules.

Participants teaching of Coral reefs, OA and water quality

Specific units on Coral Reefs was the most common subject area that ocean acidification was currently taught, with Costal Exploration second, and Marine Science third. Other subject areas included chemistry, biology, physical science, atmosphere, and oceanography. Chemical analysis, data collection, research, field trip labs, and inquiry-based lessons were the most common teaching methodologies.

Plans to integrate the NOAA module and data on OA and/or water quality into your curriculum?

The most common methods of integration of the NOAA module and data on ocean acidification were adapting current lessons to use real data, development of hands on labs, and sharing the materials with other science teachers. The two most common subjects for integration were chemistry and marine science. Development of an after school club was also noted to utilize the materials.

How you currently have students using data to learn

Use of real data is currently being used most commonly in classroom and field based labs, utilizing the Internet to access a variety of data sources to assist students in the development of critical thinking skills in the areas of water quality analysis, global warming, meteorology, and marine ecosystems. Real data is also used to have students develop self-directed projects and understand how to present data in formats that can be easily interpreted e.g. charts and graphs.

How your students will access the modules and data on the Internet?

The majority of participants reported that their schools were Wi-Fi enabled and/or they had computers in their classrooms, library, or media centers. Laptop computers were cited for use in fieldwork and the use of Smart Boards in classrooms for group instruction.

APPENDIX C: PRE/POST TEST

Name _____ Date _____ Location _____

Choose closest value/answer from the choices given. Question indicates if there is only one best answer, or more than one (could be 2, 3 or 4 answers to some questions).

How much, if anything, have you read or heard about ocean acidification? *Choose one*.

__ A lot __ Some __ A little __ Nothing

Which of the following causes ocean acidification? *Choose one*.

- Chemical spills in the ocean
- Absorption of carbon dioxide by the ocean
- Warmer ocean temperatures
- Don't know
- Acid rain

pH is a measure of: *Choose one*.

- Carbonate
- Concentration of H ions
- Concentration of OH ions
- Dissolved CO_2
- Bicarbonate

A pH drop of 0.3 units (e.g., 8.2 to 7.9) represents what H^+ % change in the solution? *Choose one*.

- 33% more H^+
- 33% less H^+
- 100% more H^+
- 66% less H^+
- Don't know

Ocean acidification … *Choose one*.

- Is an effect of climate change
- Is caused by climate change
- Shares cause with climate change
- Is independent of climate change
- Not quite sure

Current ocean pH in 2011 is: *Choose one*.

__ 8.7 __ 8.3 __ 8.1 __ 7.8 __ 7.0 __ Don't know

Expected ocean pH by 2100 is: *Choose one*.

__ 8.7 __ 8.3 __ 8.1 __ 7.8 __ 7.0 __ Don't know

My Facebook post says "*Oceans are predicted to stay basic, not acidic."* Your informed reply is *(Choose one)*:

- "For now, but eventually they will turn acidic"
- You Like it and reply: "Of course! they are expected to stay basic"
- "It depends - tropical oceans will become acidic, polar oceans will stay basic"
- You dislike it and Unfriend me

The difference between shallow tropical coral reefs and deep polar corals is: *Choose one or more*.

- Depth
- Calcification
- Symbiotic relationship with zooxanthellae
- Number of snorkelers that visit
- Biomass and biodiversity

Acid rain is related to ocean acidification by sharing: *Choose one.*

- Same cause
- Same effect
- Same state of matter
- Same pH
- Same pH change
- Same agency regulating it (EPA)

Which one does not belong? *Choose one.*

- Coralline algae
- Crustaceans
- Mollusks
- Hard corals
- Seaweed

Which coral life cycles/processes might be most affected by OA? *Choose one or more.*

- Settling
- Adult growth
- Fragmentation
- Planula (free swimming

- Reproduction
- fertilized egg)
- Don't know

In OA, what is the order of changes (first X, then Y, finally Z)? *Choose one.*

- CO_2 – pH – ASL
- pH – CO_2 – ASL
- CO_2 – ASL – pH
- ASL – CO_2 – pH
- pH – ASL –CO_2
- Don't know

What is the relationship between pH and Aragonite saturation level (ASL)? *Choose one.*

- pH is only parameter affecting ASL
- pH is one of parameters affecting ASL
- ASL drives pH
- Both are directly affected by dissolved CO_2
- Don't know

You're building a wooden house. In this scenario, the closest analogy to ASL is: *Choose one.*

- Number of people available to build the house
- Density of wood in surrounding area
- Amount of time it would take you to build the house
- Food readily available in the surrounding area that will sustain the work
- Ratio of the number of people that build it over numbers that inhabit it

Low levels of Aragonite Saturation might affect a coral's: *Choose one or more.*

- Density of skeleton
- Extension of skeleton
- Overall growth rate
- Energy needed to build skeletal structure
- Symbiotic relationship with zooxanthellae (disruption)

What is considered an ASL value **just adequate** for coral reefs? *Choose one.*

__ 4.0 __ 2.5 __ 7.8 __ 3.2 __ 8.1 __ Don't know

Out of the list below, which animal group is expected to be affected **least** by OA? *Choose one.*

- Bivalves
- Scleractinian corals

- Crustaceans
- Mollusks
- Plankton

OA might affect corals by: *Choose one or more.*

- Actively dissolving them
- Increasing dissolution rates
- Exerting higher energy costs to calcify
- Reducing availability of building blocks
- Bleaching them

How OA can interact with other threats to corals? *Choose one or more.*

- OA effects are confined to coral skeletal growth
- Makes corals bleach directly
- Diminishes their symbiotic relationship with zooxanthellae
- Makes corals more susceptible to other effects (synergistic effects)
- Don't know

You are a coral polyp growing a skeletal structure. Which parameter would you be most interested in reading the forecast for in the morning newspaper, provided your basic needs are met? *Choose one.*

- Seasonal zooplankton menu
- pH
- Aragonite saturation level
- Dissolved CO_2
- Calcium level
- Water temperature
- Expected kayakers morning route

If marine creatures were stock, which two would have a buy rating based on their 20-yr "yield"? *Choose one or more.*

- Clams
- Seagrass
- Crabs
- Fish
- Jellyfish

And which three would have a "sell" rating based on their 20-yr "yield"? *Choose one or more.*

- Corals
- Crabs
- Bivalves
- Phytoplankton
- Fish

What are some common OA misconceptions? *Choose one or more.*

- Ocean pH changes are very small, therefore negligible
- Marine organisms and ecosystems will adapt to these changes
- Acid rain exacerbates OA
- Warming ocean waters are causing OA
- Unabated, oceans will eventually become acidic

APPENDIX D: END OF WORKSHOP SURVEY FORM

Name _____ Date _____ Location _____

Thank you for attending the workshop. We appreciate your feedback and reflections on today. Your responses are completely confidential. All results will be reported as a group.

Please indicate the degree to which you agree or disagree with the following statements about the lesson structure and format.

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
The science presentation at the workshop was useful and informative.					
The curriculum presentation at the workshop was useful and targeted.					
I would recommend this workshop to colleagues.					
I plan to use what I learned today in the near future					
The OA module provides a useful context for teaching core science.					
The OA Teacher Guide provides me with a useful structure that gives me tips on how to integrate scientific content and real-time satellite data together.					
The graphs, maps, and charts of data were clear and easy to use.					
Understanding OA and its increasing levels of inquiry are helpful to me for integrating real-time data into my instructional practice.					

The *Understanding Ocean Acidification* module includes five lessons at different levels. Check all levels that you plan to use with your students.

_ Level 1: Entry – Measuring Ocean pH

_ Level 2: Adoption – The Ocean-Carbon Connection

_ Level 3: Adaptation – Carbonate Buffering System

_ Level 4: Interactivity – Aragonite Saturation & Marine Calcifiers

_ Level 5: Invention -- Design Your Own Investigation

Please explain how you plan to use each of the levels after learning about them today (or NA=not applicable if you are not planning to use that level).

Level 1: Entry – Measuring Ocean pH

Level 2: Adoption – The Ocean-Carbon Connection

Level 3: Adaptation – Carbonate Buffering System

Level 4: Interactivity – Aragonite Saturation & Marine Calcifiers

Level 5: Invention -- Design Your Own Investigation

Which of the following objectives would you hope to accomplish by using the Ocean Acidification module with your students? Check one or more.

_ Students will be able to use data represented in map and graph displays.

_ Students will be able to design their own research project using online data gathering as a central component of the research design.

_ Students will be able to access and interpret maps and graphs of ocean pH, sea surface temperature and CO_2 concentration.

_ Students will be able to describe the relationship between sea surface temperature, CO_2 concentration and ocean pH.

_ Students will be able to describe the relationship between sea surface temperature, CO_2 concentration and aragonite saturation state.

_ Students will able to explain the impact of changing aragonite saturation state on marine calcifiers.

_ Students recognize that ocean acidification is a critical emerging problem in ocean

sciences.

Overall, I would rate the NODE materials:

___ Poor ___ Below average ___ Average ___ Good ___ Excellent

Please explain

Please rate each of the following for you before and after this workshop. 1=Strongly disagree 2=Disagree 3=Neither agree nor disagree 4=Agree 5=Strongly Agree

BEFORE		AFTER
	I understand ocean acidification well enough to teach it in my class	
	I can use real data to use to teach ocean acidification	
	I have good interactive resources for teaching ocean acidification	
	I feel confident teaching ocean acidification	

Additional thoughts or comments you would like to share with the project developers? Your comments, suggestions and feedback would be **MOST** welcome.

APPENDIX E: COMMITMENT LETTER

NOAA Coral Reefs - Educator Participation Commitment Letter

Fax or email pdf of completed form to hilarie@techforlearning.org

Name: School/Organization Name:
Preferred Contact Phone Numbers: Daytime Evening

____**YES,** I understand that by agreeing to participate in this program, I am required to do the following:

- Attend the June workshop from 9-5 pm
- Complete an evaluation of the workshop including a description of how I intend to use what I learned
- Complete an evaluation 6-9 months after the workshop to describe how I actually used the material along with evidence of its effects on students
- Optional - apply to participate in a study of the effects of using the ocean acidification module on student knowledge, attitudes and aspirations

____**YES,** my principal/director/supervisor supports my participation in this program

_____ _____

Supervisor - print name Signature

____**YES,** I understand I will receive $75 for attending the entire workshop and $25 for the follow up activity

_____ _____ _____

Print your name Signature Date