PAPER

Preparing Educators with Practical Science: Ocean Observing in the Classroom

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ABSTRACT

Over the past two years, the UNH Coastal Observing Center and the Gulf of Maine Ocean Observing System (GoMOOS) have co-sponsored two week-long teacher workshops that offer curriculum content and hands-on experience in using ocean observation data as a successful teaching tool in the classroom. Teachers ranging from grammar school to high school levels worked to create practical lessons that incorporate ocean observing data into their current classroom settings and are using it today. This paper will explain how the UNH/GOMOOS summer Educator Institutes have been run, what teachers have been learning in these workshops, and how they planned and started using ocean observing data in their classrooms.

I. Introduction

Scientists have been observing the ocean for centuries using a wide variety of tools. Today we have the ability to monitor the ocean on a continuous basis and in some places collect data as frequent as every 15 minutes or less, 7 days a week. In coastal zones around the United States and in the Great Lakes, scientists are working with federal and state agencies to set up oceanographic monitoring stations on, near, and offshore that will collect thousands of gigabytes of data to answer critical questions about how the marine environment works. What is fascinating is that teachers, fishermen, and the interested public have access to these large oceanographic data sets, but without necessary training, these data will go untouched by this audience.

The Gulf of Maine Ocean Observing System and the University of New Hampshire (UNH) Center for Coastal Observing are two of many ocean observing organizations that are dedicated to education and outreach in the ocean observing field. Through teacher trainings, useful classroom resources, online tutorials, continual teacher collaboration, and much more, we are preparing educators with methods to use and integrate practical ocean science into their curricula. Here we address how our teacher workshops are set up, why the process is successful, and why the call to engage the public and educators on issues concerning the protection and study of the ocean is so important.

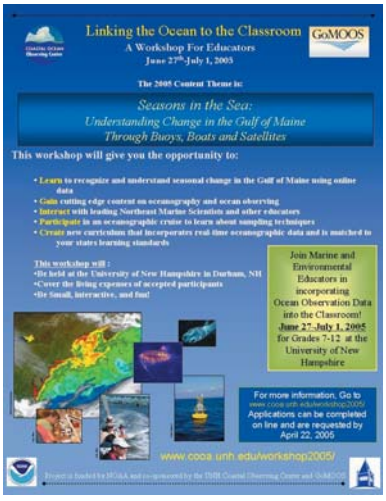
II. Teacher Workshops

A. Why Offer Teacher Workshops?

For years, educators have sought to prepare their students with skills and knowledge needed to contribute positively to a world with many unsolved questions. Many educational reform efforts phrase this type of preparation as the need to become science or ocean literate (AAAS, 1993). The U.S. Commission on Ocean Policy as well as the Pew Oceans Report support the approach that students learn science and technology fastest by being exposed and connected to scientists and their research (USCO, 2004; Pew, 2003). With real/near-real-time data, current environmental case studies, and access to new Web-based tools,

2005 Ocean Observing Educator Institute participants aboard the R/V Gulf Challenger

2005 workshop advertisement sent through the Web, to schools and to marine science associations.



students and teachers can participate in science in a brand new way. By leading extended professional development workshops using ocean observing data we help teachers "deepen their content knowledge and learn new methods of teaching" while gaining an authentic learning experience (McDiarmid, 1995). This next section will explain how we have run the first two, week-long educator institutes at the University of New Hampshire.

B. How Have We Run Them?

The past two 5-day educator institutes were structured around a science theme with clear learning objectives—"Predicting and Detecting Phytoplankton Blooms in the Gulf of Maine" in 2004 and "Seasons in the Sea: Understanding Change in the Gulf of Maine Through Buoys, Boats, and Satellites" in 2005 (UNH Coastal Observing System Workshop Web page, 2006). Both institutes used ocean observing data from the Gulf of Maine collected from buoys, boats, and satellites. The goal of these workshops was to prepare teachers with marine science content and educational tools to use ocean observation data in their curricula. The week-long program, designed to achieve this goal, provided background knowledge in ocean science, examples of how to use and create ocean observing classroom materials, structured time to collaborate and brainstorm with other teachers, and authentic access to scientists. Using this approach, participants gained greater confidence and a deeper commitment to integrating ocean science into their existing curricula while developing an understanding of the major role the ocean plays in the Earth system.

FIGURE 1

Agenda for the 2005 educator institute showing thematic focus, daily themes and objectives, and balance of activities. A detailed agenda is available at www.cooa.unh.edu/workshop2005/

2005 Ocean Observing Educator Institute
Understanding Change in the Gulf of Maine through Buoys, Boats, and Satellites

Day 1
Theme: Understanding the Gulf of Maine Ecosystem
Objective: Teachers will:
- Learn background information on the region
- Practice using Web-based tools to monitor change in the ocean with access to data.

Day 2
Theme: Phytopia and At-Sea Research
Objective: Teachers will:
- Brainstorm what they know and don't know about phytoplankton
- Learn how to use Phytopia CD Rom in order to use it in their classrooms
- Demo lesson plans imbedded within CD
- Participate in a research cruise in the Gulf of Maine on the R/V Gulf Challenger

Day 3
Theme: Research on Three Trophic Levels: Phytoplankton, Zooplankton, and Fish.
Objective: Teachers will:
- Learn about cutting edge research in 3 UNH labs
- Interact with scientists and ask specific questions of scientists in three fields

Day 4
Theme: Detecting Change from Space using Satellites and Curriculum Planning
Objective: Teachers will:
- Learn how satellite images are used both as pictures and as data
- Practice downloading and interacting with different types of satellite images
- Collaborate and brainstorm with other teachers to create practical lesson plans to be used in their classrooms

Day 5
Theme: Final Teacher Presentations: Curriculum Collaborative
Objective: Teachers will:
- Present curriculum materials they have created to the group.
- Explain how they will use what they have generated in the classroom next year
- Gain new ideas from other teachers

Participants discuss how they have previously used marine science data in their classroom/work.

These two workshops were open to 20 participants including both formal and informal educators. Most educators taught grades 7-12 although some elementary level teachers and principals have attended. Workshops started on Monday and ran through Friday afternoon, ending with teacher presentations of how they plan to use the information in their classrooms. Figure 1 includes an abbreviated version of the 2005 workshop agenda. Each day's schedule is balanced with an equal amount of science content, teacher planning time, practice using tested curriculum materials, or training in how to use computer based satellite software useful

(Left) Informal educator Wendy Wicke collects water from a Nisken bottle aboard the research vessel R/V Gulf Challenger.

Classroom teacher Beth Marass inspects a sample of plankton in a UNH research lab.

for teaching. Evening programs are offered that include guest speakers or activities that encourage reflection to deepen understanding of ocean science concepts.

C. Key Components of a Workshop

There are several basic components to consider when leading a professional development workshop for teachers. To reach more teachers, we found that it is important to include the following components:

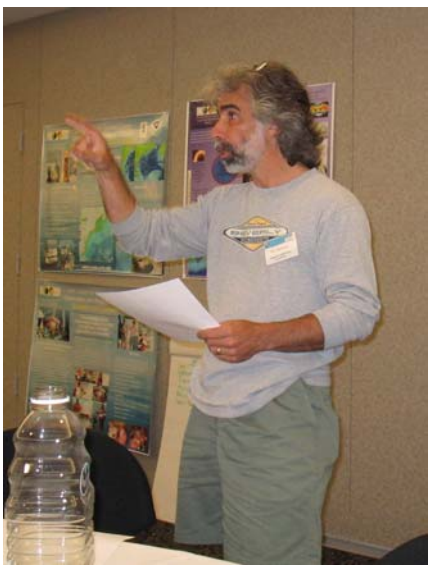
1. Clearly defined and articulated goals and objectives upon which to build a solid workshop framework;
2. Early involvement of and communication with scientists and workshop speakers so they understand the goals of the workshop and the topics to cover if they are not part of the preliminary planning committee;
3. Opportunities for teachers to work with scientists, to learn about their research and the oceanographic equipment they use to address key research questions;
4. Early advertisement of the workshop to a wide audience using effective means. The 2005 workshop announcement was distributed to individuals primarily in the Northeast found on at least 8 different e mail lists. Distribution resulted in participants from 7 states, mostly on the east coast: Pennsylvania, Virginia, Georgia, Massachusetts, New Hampshire and Maine, although Washington state was also included.
5. Provide key background materials to participants to be read and completed before the workshop begins. This pre-workshop "homework" helps to create a common foundation or knowledge base among participants;
6. Develop and implement a method to assess and evaluate the program, before, during, and after each workshop; and
7. Last and most important, the workshop agenda needs to be planned with the learner in mind. Understanding how people learn at different grade levels as well as adults is important in how the work shop details get planned.

Research technicians Rebecca Jones and Erin Gordon explain technology used to study zooplankton.

Lectures are a fast way of delivering content, but they are not ideal for the learner to absorb, digest and critically think about the information presented. As a rule, we planned for an equal amount of human processing time (e.g., reflection, discussion and writing) for all science and educational materials presented. In 2004, "more time for processing" was the most common request from the institute participants (UNH/GoMOOS, 2004/2005). Teachers wanted more time to collaborate and reflect on what they were learning to improve their ability to translate the materials for themselves and ultimately their students. We found this to be the most critical piece in planning a successful teacher workshop. To make effective use of the additional processing time, structured activities that engage the learner are required to help teachers unpack what they do and don't understand about a subject. By building in adequate blocks of brainstorming time and requiring teachers to present how they plan to integrate their new knowledge and skills into their classrooms, we increase the likelihood that teachers will be confident enough to use their new understandings in the classroom.

Throughout the workshop, teachers were encouraged and reminded to use the backwards planning framework known as "beginning with the end in mind" throughout the workshop. Teachers were asked to give thoughtful consideration to the "enduring

Middle School teacher Bill Andrake, explains how he plans to use GoMOOS buoy data in his class.



Classroom teachers, Kimberly Johnson and Arden Thompson work with research technician Mike Novak to separate and label plankton samples.

understandings" or concepts worth knowing beyond the school-age years as described in Wiggins and McTighe's book *Understanding by Design* (2000). By planning with state and national standards in mind, teachers found ways to teach essential skills using ocean observing case studies. Participants worked together to create detailed outlines for curriculum materials in biology, Earth science, physics, and chemistry at a variety of grade levels. Two elementary teachers and their principals attended the workshop and took away lists of ideas and plans for units they could distribute to colleagues in their schools and districts.

In addition, participants were encouraged to use Bloom's Taxonomy and Howard Gardner's theory of Multiple Intelligences when planning their lessons (Forte & Schurr, 1996). Bloom's taxonomy is a hierarchical structure used to address different levels of cognitive reflection in teaching. The theory of Multiple Intelligences provides specific examples and reasoning behind how students learn and that good teaching requires many more creative methods than lecturing if students in the classroom are to be reached. These two essential workshop pieces reminded teachers to engage their students who have different learning styles and understand the content at different levels using new methods and resources. Because we asked teachers to think in new ways, the workshop also modeled different learning styles including involvement, movement, presentation, songs, an evening of Art in Marine Science and much more. Using art as a hands-on processing activity encouraged participants to describe what they had learned about seasonal change in the Gulf of Maine, by constructing a 2-dimensional collage incorporating content learned throughout the week. Four examples are seen in Figure 2.

FIGURE 2

Examples of participant created thematic collages that illustrate their new knowledge using a visual learning medium.

Participants learn remote sensing software called *ImageJ* to study satellite images.

D. Creative Curricula

With a wide range of resources to use, clear background content about the subjects, and time to create learning materials, teachers generated useful and interesting classroom materials. Access to computer labs for many classroom teachers is a challenge. Because of this reality, some participants spent more time generating materials they could use before their students visited the computer laboratory. Once in the computer lab they agreed they could use the GoMOOS Web site to explore temperature, salinity, current and wind direction, wave height and many more parameters to explore seasonal changes in the Gulf of Maine (GoMOOS, 2006). In addition, they found the previously created Earth Exploration Toolbook chapter that explores the timing of the spring phytoplankton bloom in the Gulf of Maine to be useful (Blaha & Cline, 2004). Within the fast moving five-day workshop teachers spent time discussing, brainstorming, matching oceanographic concepts to their existing curricula, reviewing the Image J tutorial software (2006), the Phytopia CD-ROM (2006), the GoMOOS Website (2006), and practicing how to download satellite data from the Coastal Observing Center's data portal (2006).

During the workshop, participants engaged in high-level curriculum development that uses ocean observing data. Some of the learning materials teachers planned to use as preparatory activities prior to their students' visits to the computer lab included 'hands on' density labs using salt, freshwater, food coloring, and ice. This is an excellent activity to do

prior to using ocean-observing data to examine density. Using simple materials, this lab helps students understand the physical and chemical properties that effect density and the behavior of fluids with different densities. This activity provides context for the examination of density within the ocean and how ocean density information is collected by GoMOOS buoys. During the workshop other teachers made connections to the carbon cycle and the ongoing scientific debate associated with iron fertilization and phytoplankton blooms. These teachers planned to used the iron fertilization controversy as a pre-computer lab discussion to set the context for computer lab investigations on phytoplankton boom formation in the Gulf of Maine using chlorophyll, sea surface temperature, and stratification information collected by buoys and satellites.

Other participants realized that remote sensing data could be used to examine ocean fronts and their relation to blue fin tuna distribution in the Gulf of Maine. A high school chemistry teacher described how learning about tuna tags and the structure of the materials within them would be perfect for students to see how chemistry is an integral part of oceanography. Other teachers stretched further and wrote lessons that included creative assessment tools using "content song writing" that required students to show understanding of content, terms, and use of oceanographic buoy data through music. Another teacher planned a terrestrial field trip to their school pond to collect data on abiotic and biotic factors, followed by studying data collected in the marine environment through a webquest that used the GoMOOS Web site, Woods Hole Oceanographic Institution-Harmful Algae page (2006), and Bigelow Labs for Ocean Sciences Web sites (2006). These are just a few of the ways teachers used their structured and unstructured planning time to create useful lessons that added context to their specific curricular materials so that students would be prepared to absorb information on how and why ocean observing data is important. We felt it was important for teachers to create curricular materials they would use in their classroom—drawing from the materials and resources we provided.

Teacher Jasmine Charity inspects a lobster before throwing it back.

E. Lessons Learned

Running successful professional development workshops is difficult and effectively evaluating those workshops can seem even more challenging. A commonly cited professional development model established by Donald Kirkpatrick uses the following four criteria in evaluation (Diaz-Maggioli, 2004) and was used as a reference in planning these workshops.

1. Reaction of participants to the program model and procedures.
2. Learning that results from engagement in the program
3. Use of the knowledge gained in the program
4. Results of students' learning.

The workshops described in this paper focused on the first two criteria stated in the list above. We are continuing to collect information addressing the last two criteria which require longer and more in-depth methods of study. Pre- and post-surveys, as well as evaluation tools during the workshop allowed us to collect valuable information from the participants. The evaluation results directly influenced how we planned future workshops and the materials we created during the year for the next year's workshop.

The workshop participants called both workshops a "tremendous success." Although many improvements were made in year two in response to the evaluation results from year one, the primary change in year two was to increase the participants' structured discussion and reflection time so they would absorb more substance from the week. More human processing time was added to each day's activities, and the time spent and the variety of topics encountered in the research labs was increased significantly from 15 to 50 min creating a lab class atmosphere. Participants rotated through phytoplankton, zooplankton, and tuna research labs which allowed teachers to develop a more complete picture of why the research was necessary and a better understanding of the underlying hypotheses and research questions. Background information in each lab was handed out to each participant and included a list of key questions and current research projects. Teachers and students often lack an understanding of what is known *versus* what is unknown in a field of science. Teachers and students often do not understand that many of the basic questions about the oceans have not been answered. In comparison to terrestrial ecosystems, where many of these questions have been answered, it is very difficult to study the ocean on the appropriate time and space scales. Teachers told us that learning directly from research scientists gave them an authentic experience to share with their students. In turn, scientists benefit from this interaction, as this is a way for scientists to share their studies and broaden the impact of their outreach.

Running these workshops, we also learned to package and deliver content in more palatable ways. Setting the stage for the week with an introductory oceanography talk is important. This talk must not be rushed; ample time

Informal Educator Karen Romano Young presents her plan for her next children's book.

is needed for teachers to ask basic and burning questions they may have about the subject. This is the time to create an atmosphere of freedom for teachers to ask questions without feeling foolish. Concepts about how marine ecosystems work can be explored and misconceptions corrected once an atmosphere of trust is established among teachers and researchers.

During the workshops, participants examined satellite data of the ocean using *ImageJ*, a free data analysis package. This software package allows the user to view satellite data of the ocean from space as images and to analyze them. It was clear after the first year that more time was needed to address this component of the program and that knowledge acquired from other parts of the program was necessary to make effective use of this component. Consequently, in the second year, this remote sensing component was moved to the end of the agenda and given more and richer coverage. The background talk and the tutorial used to learn *ImageJ* were improved to greatly increase the teachers' ability to understand this topic and to develop more excitement around its successful use in their classrooms. We know that teachers are still trying to find ways to integrate this software into their classrooms, because its successful use is limited by access and availability of computers within the school in addition to the teachers' comfort level.

In 2005, three teachers returned from the first year and their enthusiasm unexpectedly sparked a greater commitment from the group. These teachers voluntarily shared what they learned from the previous year and how they had used that knowledge in their classrooms.

Tom Shyka of GoMOOS filters water at several depths while on the research cruise.

They have become self-declared ambassadors of the program and will be presenting their classroom materials during the 2006 workshop. We plan to invite selected alumni to the first day of the workshop to share how they have used their new knowledge and skills in their classrooms. These alumni will assist the incoming group of teachers by presenting a written and field-tested lesson plan that they created using their new knowledge of ocean science and ocean observing.

F. What Teachers Said

The final evaluation summary for both 2004 and 2005 were strongly positive (UNH/GoMOOS, 2004/2005). The qualitative responses to the open ended questions told us that the teachers walked away excited yet still only partially prepared. Fifty-six percent of the 18 participants that responded in 2004 said that they felt very prepared in response to, *"How well did this workshop prepare you to integrate ocean observing into your existing curriculum?"* Seventy-eight percent of the participants in 2004 also said "yes" to the question "*Do you think you are going to incorporate some of these ideas into your curriculum this year?"* These two questions are very useful and help meet the first criteria discussed above (see section E). These two questions also suggest many more questions that can be addressed through further evaluations. In 2005, we asked teachers how comfortable they were with the material after addressing several different topics. Their varied responses confirm that each participant comes in, and leaves, with extremely different academic backgrounds and comfort levels in teaching the subjects covered in our 5-day workshop. Although 79% of participants in 2005 said the conference was "well balanced" as far as number of talks, computer time, time at sea, collaborative time, etc., 75% of participants in 2005 told us they were well prepared to motivate others to participate in marine science instruction. Sixty-three percent of participants in 2005 said they were "well prepared" to give a 15-20 minute talk to other teachers about using ocean observing data in the classrooms (UNH/GoMOOS, 2004/2005). We now know that the final follow-up survey needs to address how participants comfort level changed once they have tried to use their new knowledge and skills in their classroom, and what additional information they now need.

Reaserch technician Chris Manning demonstrates how the zooplankton ring net works.

As described in Section D, teachers' final presentations described numerous ways ocean observing data and information could be integrated into their curricula and we are following up to learn how they used this material in their classrooms. Participants reported using these materials in their classrooms and planned to create more related materials. Teachers explained that the GoMOOS Graphing and Download tool allows them to explore buoy data in a user-friendly format. Participants also said that they are using the online Earth Exploration Toolbook chapter entitled "When is Dinner Served?" (Blaha & Cline, 2004). This chapter explains how to download satellite and buoy data to predict the next spring phytoplankton bloom in the Gulf of Maine and was one of the prepared curriculum resources we offered to teachers as building blocks. A published paper copy of a 3 week unit using ocean observing data, written by a high school science teacher in Maine was also given to participants (The Carbon Cycle, 2005). Through this ongoing feedback, we also know that teachers are ordering plankton samples for classroom use with "Phytopia," a comprehensive CD-ROM produced by Bigelow Laboratory for Ocean Sciences (2003). We also know that informal educators are creating informal museum exhibits using ocean observing data as well as boat-based science instructors are using hands-on activities provided and generated during this workshop as part of ocean-going field trips for classrooms of students in Puget Sound, Washington.

III. Conclusion

In conclusion, planning, facilitating, and evaluating a 5 day workshop requires months of preparation and a unique team of people with complementary skills. Following up with workshop participants is also essential and a key component to a successful summer workshop. These 5-day workshops present background content and examples of how to use ocean observing data in the classroom. Teachers are asked to absorb large amounts of new information, develop new inquiry and data handling skills, in order to translate this new information into learning materials that they can integrate into their existing curriculum. Through running these workshops, we found that teachers need concentrated time to plan, brainstorm, and connect this new knowledge to concepts required in the National Science Education Standards (NRC, 1996). Teachers quickly learn that teaching about the ocean is not an 'add-on' but an alternative to teaching science using land based examples. Teachers told us that authentic, first-hand science experiences in research labs and on research vessels combined with the opportunity to create and examine new classroom resources are what excite teachers. They told us that they are returning to their classrooms energized and ready to transfer their excitement about the ocean to their students. It is our hope that this excitement lasts for years and is directly passed on to their students. These Educator Institutes also help teachers to realize that we know much less about the ocean than we know about it which is important for students to understand and question.

Even though we have learned a great deal about running professional development workshops, we have much more to learn concerning the structure and organization of teacher workshops so they effectively meet educators' needs over the long term. Each year the University of New Hampshire's Coastal Observing Center and the Gulf of Maine Ocean Observing System offer an Ocean Observing Educator Institute. These workshops challenge us to provide materials that educators need that also match the depth of content they are looking presented in a way they can understand. This process is an art and requires more depth of understanding, experience, and background than most realize. Running workshops are just one of many useful avenues to broaden the reach of ocean observations and related scientific research. We believe ocean observing systems offer an unprecedented opportunity for teachers, students, fishermen, coastal managers and the public to examine, study, and analyze the ocean as never before possible. To realize this opportunity, we as a community must first inspire and educate the present generation of teachers in thoughtful and engaging ways.

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