Using Ocean Observing Systems Data in K-12 Classrooms: Proceedings from a Workshop Exploring the Merit and Feasibility of Developing a National Ocean Observing Systems (NOOS) Education Product

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Abstract - **Ocean engineers and scientists are transforming the way we experience and understand the ocean through the Integrated Ocean Observing Systems (IOOS). For the first time, there will be continuous, sustained, near-real-time, multi-dimensional data available from the oceans, collected both from within the oceans using sensors systems and above using remote sensing methodologies. These data make possible inquiry-driven questions concerning the dynamic nature of the ocean's physical, biological and chemical characteristics in both time and space. These data provide unique and meaningful access to the ocean for a broad range of users. One major expected user group is K-12 educators and their students, who will be able to explore and utilize data and information from coastal observing systems in real time from the classroom.**

The National Science Foundation (NSF) sponsored Center for Ocean Science Education Excellence – Mid Atlantic or COSEE-MA, is focused on coastal observing systems and the development of products and services that bring real time data to a broad range of user groups. COSEE-MA currently partners with a broad range of stakeholders to explore the development of lesson plans and resources that use observing data in meaningful ways that promote science inquiry in the classroom. In this session, we will discuss the results of a July 2005 workshop sponsored by the Monterey Bay Aquarium Research Institute (MBARI), the Monterey Bay Aquarium (MBA), the Center for Ocean Science Education Excellence – Mid Atlantic (COSEE – MA), and Ocean.US to explore the merit and feasibility of developing a national ocean observing systems (NOOS) education product.

I. INTRODUCTION

In July 2005, the Monterey Bay Aquarium Research Institute (MBARI), Monterey Bay Aquarium, the Center for Ocean Science Education Excellence Mid-Atlantic (COSEE Mid-Atlantic) and Ocean.US hosted a workshop to discuss a national Integrated Ocean Observing System or IOOS-based education product. For the purposes of this workshop, an NOOS educational product was loosely defined as a collection of resources, tools, and/or classroom applications that use NOOS data and resources to promote ocean literacy and supplement classroom learning and understanding of the ocean environment.

The workshop, *Planning for the Future of IOOS Education: Development of national instructional materials using ocean observing systems data*, was held at MBARI on July 7 & 8, 2005. It was designed to build on the results of the ORION workshop [1] and the Integrated Ocean Observing Systems (IOOS) education meetings [2] and community meetings [3]. During the MBARI sponsored workshop, participants discussed the need for national ocean observing systems (NOOS) educational product(s) that take advantage of the IOOS network of data streams and meet national science standards.

The goals of the workshop were to:
1) Gain consensus on the need/desire for a coordinated effort to develop NOOS educational materials.
2) Develop a plan on how such a coordinated effort should happen (next steps).
3) and, to begin to brainstorm content focus and template format for such materials.

The planners organized this workshop because they believe it represents an unpresidented opportunity to advance collaborations between scientists and educators to create a product that is equally useful in the research and education communuty. This effort also would help avoid the regional reinventing-of-the-wheel syndrome and, since the development of materials are time consuming and challenging, a national product generated from/by the IOOS regions will save money and time. Finally, this effort could potentially allow marine educators involved in observing systems education to collectively and collaboratively develop and market a high-quality, branded national product with high visibility.

II. RESULTS

A. Front End Evaluation

Thirty-five people, including educators, scientists, and agency representatives attended the workshop. They included those from ocean observing system regional associations, several of the COSEE centers, the agencies involved in ocean observing systems [National Science Foundation (NSF), National Oceanic & Atmospheric Administration (NOAA) including the National Estuarine Research Reserve Program and National Marine Sanctuaries], informal education institutions such as aquariums, technology savvy classroom educators with experience using real time data as part of MBARI's Earth Program, and staff from non profit groups involved in planning efforts associated with observing systems [Ocean.US, and Consortium for Oceanographic Research & Education (CORE)].

In preparation for the workshop, we conducted a front-end evaluation using an online survey. On May 5, 2005 a web-based survey went to the 27 people who (at that date) had agreed to attend the workshop. Twenty-two people responded before the closing of the survey on May 20. The survey used a mix of questions (items) to collect quantitative and qualitative data. Quantitative responses (to yes/no, rating-scale, restricted choice questions) were reported as frequencies and percentages. Table 1 illustrates the participant's professional motivation for attending the workshop.

TABLE 1. Response to Question #1 (n=22)
Given what you know about this workshop, how does it relate to what you do and why have you agreed to attend?

Responses	Frequency	%
relates closely to primary job and institution/agency role	12	54
interested in developing better education & outreach (classroom lessons/professional development/other activities) for teachers	11	50
interested in integration/coordination of similar efforts	5	23
Want to know more about what's happening with OOS and/or what works (best practices) for lessons/curricula	5	23

Note: This was an open-ended question and some respondents offered more than one response. As a result the total equals more than 100%.

Through the front-end evaluation, we learned that the majority (86%) of the workshop participants felt that the observing systems community can and should develop a national education product. Workshop participants were asked to articulate what their concerns or reservations were (if any) about the development of a national education product (Table 2). The top concerns included ensuring that a national product was relevant to local efforts, issues, and needs. Participants felt it was important to ensure that the educational product was relevant to local audience needs, takes advantage of local partnerships, and tells regionally relevant stories with the data. A second concern was the ability of a national product to meet local educator needs. The participants noted that any education product should be driven by the needs of the classroom educator and topics that are not relevant or useful should not be pursued in a national product development. Careful consideration must be given to how a NOOS education product would be useful in meeting educational needs at all levels. Finally, participants also noted that the accessibility and user friendliness of the data stream is extremely important. Efforts must be made between the data managers, scientists, and educators involved in NOOS to produce easy and engaging tools for accessing NOOS data.

TABLE 2. Responses to question about concerns (n=21)

Questions 5 & 6. What are your concerns (if any) about the development of a national ocean observing systems curriculum?

Responses	Frequency	%
issues related to local efforts/interests/relevance	8	38
meeting teachers' needs	6	29
easy-to-use, accessible, reliable data streams	5	24
Flexibility (with teacher/student needs, regional issues, changing technology)	4	19
Other		

Note: This was an open-ended question and some respondents offered more than one response. As a result the total equals more than 100%. Also, the one response to question 6 (which was the same as question 5 but for those who answered no to the previous questions) is not included because the response was gibberish.

In summary, the front-end evaluation indicated that the majority of the workshop participants acknowledge the challenge of building consensus among various stakeholders (educators, data managers, and scientists) on a unified approach to utilizing NOOS data resources in K-12 education. However, participants all agreed that there is value in discussing the development of a unified "backbone" or set of educational resources and that the goal of building regional partnerships and avoiding duplication of effort is worthy of pursuit.

B. Workshop Results

One of the first major tasks of the workshop was to brainstorm a list of key characteristics of an ideal NOOS education product. This visioning exercise was designed to use the expertise of the workshop participants to determine the

essential elements of a NOOS education product. The participants spent some time ackowledging the difference between a national curriculum, which implies a prescribed set of courses required for completion of a program/degree and an educational product, which is a collection of tools, resources, and lesson plans that can be used more as a supplement or enrichment to a science or mathematics program.

The workshop participants developed the following list of key characteristics to define a NOOS educational product.

1. *A NOOS education product should provide accessibility to NOOS data/information and should have appropriate learning tools.* Participants noted that a NOOS education product should have a flexible format that allows access to both real time and archived data. The data should be accessible to all audiences in a way that allows the user to search and sort the data. Participants also noted that a standard applied data format would allow for valuable comparisons from one region to another and for students to compare data at different scales.
2. *The data products generated from the NOOS should be free and accessible to all audiences including students and educators.* The participants suggest that the NOOS data platform be uniform, user friendly, and have standards metadata descriptions. The products should be integrated, manageable and scaleable. Educators participating in the development of a NOOS education product should be working closely with data managers and scientists to account for changing technology and the evolving structure of the IOOS and ORION networks.
3. *An effective NOOS educational product would accommodate for a variety of learning styles.* The workshop participants noted the importance of having multiple entries into the NOOS data, such as through sound, visual, or kinesthetic learning mechanisms. Careful consideration should be given to the use of short video clips, tutorials, and archived data sets, that will appeal to a range of learning styles and intelligences [4]. Products should reflect advances in cognitive research in how people learn. The participants noted it was very important to develop a NOOS education product that factors in the developmental abilities of the audience(s). Materials should be developed that can be scaled up or down based on the audience need. The participants also felt the products developed should be multilingual and should stimulate continued learning. Finally, it was recommended that there be a companion educator professional development program that would assist the educators in the classroom application and integration of NOOS education products.
4. *A NOOS education product should allow for the personalization and customization of the learning experience to the individual student.* Participants felt that the NOOS data needs to be placed in a context that supports direct field experiences when possible. The participants cautioned against using NOOS data as a substitute for environmental learning experiences. A NOOS education product will allow for students to understand real time natural phenomena such as storms and other weather related events. The participants encouraged the use of storylines that use the data to demonstrate how the oceans are the driving force to all systems on the Earth. It was noted that the Weather Channel does this very effectively and can be used as a model for the development of the NOOS education product. The National Estuarine Research Reserve (NERR) and National Marine Sanctuaries (NMS) network of sites can be used as case studies to highlight specific key concepts. It also was noted that the NOOS data will allow students from non-coastal regions and from around the world to access coastal information in unprecedented ways.
5. *NOOS educational products should be developed with an Earth Systems Science approach.* Ocean observing systems provide a unique opportunity to help us understand the Earth as a system. A NOOS education product should start with simple concepts/levels that provide opportunities to explore advanced levels. The goal is to develop materials that teach about the process of science and that take advantage of the fact that scientists and students utilize the data in parallel. This emphasis will reflect the true nature of science thus encouraging students to think of science not as a "cookbook" series of activities with a definable answer. Participants noted that the product should support the National Science Education Standards and be adaptable to State Standards.
6. *A NOOS educational product should use the educational literature to guide product development.* Participants agreed it would be very valuable to have educational research inform our approach and implementation to ensure effective educational practices are being utilized. It was also suggested that the NOOS educational effort include an education research component when the studies about "best practices' are lacking or non-existent. Participants pointed out that it is important to link people's emotional and practical connections to the ocean.

Almost all of these recommendations generated by the NOOS workshop participants were supported by the principles and values underlying the online Education for Sustainability (EFS) network [5]. EFS has done extensive research in Europe evaluating the educational outcomes of using online communication tools, and has come up with seven principles of a good learning environment. The principles include 1) accessibility to information and learning tools, 2) usability of the learning environment and the information provided, 3) reliability and credibility of information provided as a basis for dissemination of knowledge and educational services, 4)

flexibility of choice, 5) accommodation of different learning styles, 6) facilitation and promotion of communication of information, ideas, and knowledge through motivated interaction and participation, and 7) personalization of the learning experience to the individual student through customizing that experience, and where possible, grounding the learning experience in local content. These principles can be used as guides for the development of the key characteristics of a NOOS education product that is nationally planned and regionally developed with the support of data managers, scientists, and educators working together.

Participants were encouraged to consider a "straw" template for a NOOS product to further brainstorm the necessary elements of a NOOS education product (Fig.1). The template shows multiple forms of entry into an Internet based product. The template includes core topics (e.g. currents, fish species, etc.), a searchable lesson library, the ability to select based on regional associations within IOOS, regional/geographic data sources, and a collection of education products that consider broader core topic (e.g. circulation, human impacts, etc.). The NOOS education product should be designed to provide data access to NOOS data products, and classroom lessons/resources that teach science concepts identified as important for an ocean literate public.

Fig. 1.Conference organizer, L. Hotaling presented a "straw NOOS product template as a discussion point for conference participants [http://www.k12science.org/~lhotaling/GOOS/].

Small groups of workshop participants considered the presentation of the template, the user needs, and the content to include in such a product. With regards to the presentation of the template, most of the groups agreed that there needed to be dynamic links to real world events (eg. recreational use of ocean resources including fishing, boating, commerce, etc., the ocean as a source of food, and how the ocean drives our weather). The "in the news" section would serve as an immediate hook to draw people into the data and make an immediate connection to the power of NOOS data and human interaction with the ocean. At the same time, the small groups articulated the need for the users to access information on local issues of concern. An "in my neighborhood" section would serve to show immediate relevance to users living along the coast or inland.

Participants cautioned that there must be online support in the form of tutorials and help assistance for non "e" users. Despite the pedagogical developments and reasonable connectivity rates nationwide, only 27% of public school teachers engage students in activities that involve using computers or the Internet to "solve problems and analyze data" to a large or moderate extent. Hence, there exists a strong need for educational materials that facilitate classroom use of Internet-based real-world data [6].

Some of the groups suggested that formats such as gaming technologies might be used as a tool of engagement to help young students connect with NOOS data. Games that emphasize problem solving are a way to reflect the process of how scientists utilize data and conduct research.

Most of the small work groups agreed that the data access should be non linear with many options so the user can chose how they wish to access the data products. Different levels of data products, from simple to more complex, and from processed to raw data, were suggested to allow for flexibility in utilization by the user. There should be sufficient background information available that answers questions on why oceans are important and what is value of ocean observing systems. Participants also suggested that the real time data lessons and links be complimented by field trip opportunities both virtual and direct as well as hands on activities.

The work groups felt a NOOS education website should take advantage of media and marketing tools such as animations, visualization tools, and flash products. These standardized marketing tools will help the presentation of the NOOS. However, there are concerns about the use of animated products such as those done in Flash, being inaccessible to schools due to filters placed on computer laboratories.

When defining the key characteristics of a NOOS education product the participants also had recommendations regarding the process of developing and implementing a NOOS education product.

C. Striking a balance between national and regionally developed NOOS education products

Overall, the workshop participants suggested utilizing the strengths of regionally developed education products to create a nationally framework. Educational product development should follow the NOOS science plan development at the global, national, and regional scale (e.g. ORION framework). This global approach will not only increase marketing potential, funding opportunities, and consistency, it will have the potential of making a stronger case for impacting national science and state science education in an organized and coordinated manner. A national product would make it easier to achieve an Earth Systems Science approach, would allow for

stronger linkages to national organizations, such as the National Science Teachers Association (NSTA), and finally would foster collaborations among institutions and organizations within the ORION and IOOS networks.

A nationally planned backbone with regionally implemented lesson plans and examples would increase the relevance to K-12 audiences. Contributions from a distributed network of NOOS educators would ensure connections to local scientist role models and a more manageable mechanism toward generating compelling storylines for the NOOS data.

D. Challenges and recommendations for solutions

The development of a nationally developed education product however will come with some challenges. It will be difficult to overcome the inertia of getting such a large undertaking started. It will likely take time to build effective partnerships and relationships. It has been suggested in both the IOOS and ORION education plans that a central coordinating office should facilitate the development of (a) product(s). It will be important for this office to avoid bureaucracy and minimize the potential disconnect from the stakeholders we are trying to serve. Overall, it will be important to increase "buy in" and reduce the "not invented here" scenario through partnership and network building initiatives. In many cases, some educators might have to give up what they have already done to achieve the benefits of a national product. In addition, this central office will need to be concerned about generating funds to support and sustain such an education product over time.

The flow of funds to the NOOS efforts (ie. often through congressional earmarks) have not made it easy for scientists and educator to work collaboratively. Compounding the earmark issue is a perception in a small percentage of the NOOS scientific community that the inclusion of education in NOOS planning (especially the ORION program) will be a drain on the funds available for research programs.

These problems although significant can be overcome with both short and long term planning. In the short-term, scientists must be presented with engaging education project options for satisfying criterion II. The National Science Foundation (NSF) is working to document the impact of criterion II in research proposals. They hope to answer the questions, Is a good education and outreach plan increasing a PIs chance of funding? Are programs like the NSF Center for Ocean Science Education Excellence (COSEE) providing a positive impact in promoting scientist–educator collaborations and on the ocean literacy of the public?

In the long-term, scientists must see a concrete benefit to spending money and time on education initiatives. If engaged properly, the education community can be utilized as a large base from which to draw support for scientists and their research. We also must fund and conduct evaluation studies that document impacts and change in knowledge, attitude and behaviors as a result of our efforts. Scientists must see concrete results through an increase in the number of students entering the ocean sciences and in the quality of their training at both the undergraduate and graduate levels.

E. Establishing a mechanism to move from data to data products that are wanted, needed, and accessible by broader audiences

Collaborations among scientists, educators, and information technology experts are essential to the success of the NOOS. The essential commodity of the NOOS is the real time and near real time data being generated from the NOOS network. Workshop participants discussed the need for a data management and information translation facility that would be tasked with transforming NOOS research results, technology innovations, and data into ready-to-use forms for a variety of education and communication audiences. This concept was first raised at the ORION meeting January 2004 [1] and again at an IOOS sponsored education meeting March 2004 [2]. Educators, IT, and scientists involved in those previous meetings defined the center are facilitating "data translations that would include real time, near real time, and event-driven data visualizations accompanied by engaging content that can be used in a wide range of venues including classrooms, science center exhibits, Internet, television, and community programs designed for students and adults" [1]. Workshop participants discussed the need for identifying the needs of the target audiences and determining the existing capacity of the regional associations and science community to understand what is out there already and what we still need to create and use. Participants also discussed the need for establishing a mechanism to archive and access data from regional observatories for data mining for translation to broader audiences.

In the short-term, workshop participants agreed we need to develop a working definition and concept of what the data management and translation center will be and how it should function. Additionally, NOOS educators should step up communication with agency representatives regarding the data management and translation concept and collaborate with scientists and IT professionals to identify technologies, existing models, and best practices for data mining protocols and interfaces. It will be critically important to utilize cognitive research on how people learn from temporal and spatial data sets and integrate best practices and recommendations into evolving NOOS data interfaces.

In addition, it will be important for educators and evaluators to develop protocols and ultimately documentation on how the formal education community can and does use NOOS education products in the classroom. Developing close collaborations within the K-12 teaching community will inform our decision making in the evolution and development of a NOOS education product (Fig. 2.)

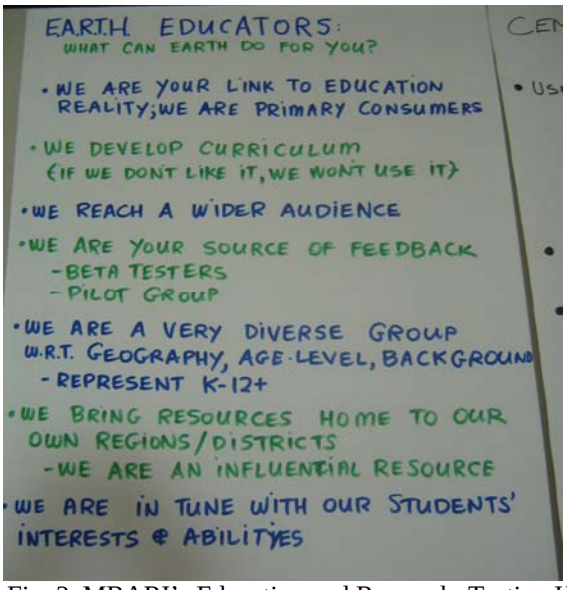

Fig. 2. MBARI's Education and Research: Testing Hypotheses or Earth educators (list their top strenths and assets in contributing to a NOOS education product (http://www.mbari.org/education/earth/2005/EARTHwksp.htm).

Coordinated front-end and formative evaluations will ultimately determine if our efforts in education within the OOS network result in positive student achievement and improved ocean literacy.

III. CONCLUSIONS

In conclusion, the workshop participants spent time discussing how we continue to work together and take advantage of this unprecedented opportunity to promote ocean education through the IOOS. Overall, the following topics are being pursued on a committee level:

1. *A comprehensive literature review of potential approaches and effective educational practices for the development of a NOOS education product.* Participants agreed it would be very valuable to have educational research inform our approach and implementation to ensure effective educational practices are being utilized. It was also suggested that the NOOS educational effort include an education research component when the studies about "best practices' are lacking or non-existent. This information would be critical to ensuring we meet our audience needs and expectations.
2. *Development of a white paper on effective partnerships.* The workshop participants recognized that educators, scientists, IT professionals, data managers, and other stakeholders must work together to create an effective NOOS education product. A small workgroup will identify models of successful partnerships and produce a series of case studies that can be used as concrete examples of how diverse teams of stakeholders can work together for a common goal. The case studies will provide information and recommendations on how to develop and support productive partnerships in IOOS.
3. *Continue planning for a data management and information translation facility.* This facility would be tasked with transforming NOOS research results, technology innovations, and data into ready-to-use forms for a variety of education and communication audiences. A workgroup of participants, outlined the need to refine the definition of the data management and translation facility, identify and investigate existing models, identify technology possibilities, and effective practices for data mining and data interfaces, and finally, provide examples of effective data visualizations. The group decided it would be important to begin communication with agency (NSF) and planning groups (Ocean.US) on these concepts and suggested actions.
4. *Conduct needs assessments to improve our understanding of IOOS K-12 audiences. NOAA's* National Estuarine Research Reserve (NERR) program will fund a series of regional workshops to assess K-12 teachers' capabilities, needs, interests, and concerns about using IOOS-NERRS data resources. A combination of NERR sites and COSEE sites will be selected as hosts for the regional workshops. Geographic region targets include New England, Mid Atlantic, South-North Carolina, Florida, the Gulf Coast, California and potentially the Pacific North West, Alaska, and/or and the Great Lakes region. The Jacques Cousteau National Estuarine Research Reserve (JCNERR), which will lead the study, hopes to get regionally specific recommendations that will help us plan the content for a national infrasture, enriched with locally developed education resources.

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