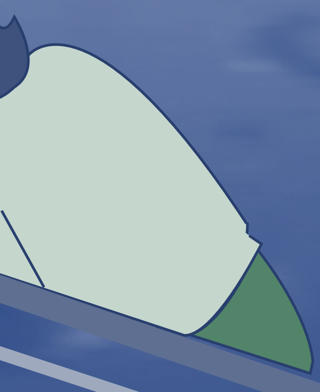
INTEGRATED OCEAN OBSERVING SYSTEM-COASTAL OCEAN OBSERVING SYSTEM
AND EDUCATION WORKSHOP REPORT
CHARLESTON, SOUTH CAROLINA
MARCH 22-24, 2004

PROMOTING LIFELONG OCEAN EDUCATION

USING THE INTEGRATED OCEAN OBSERVING SYSTEM (IOOS) TO SHAPE TOMORROW'S EARTH STEWARDS AND THE SCIENCE AND TECHNOLOGY WORK FORCE



Ocean.US
The National Office for
Integrated and Sustained Ocean Observations
Ocean.US Publication No. 4

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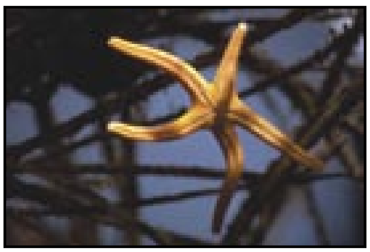

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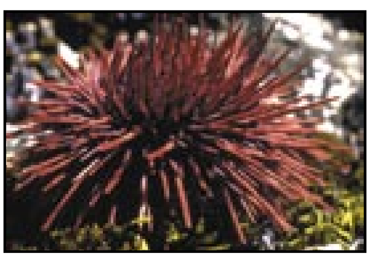

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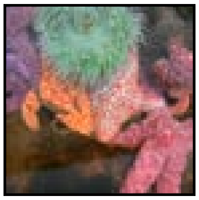
EXECUTIVE SUMMARY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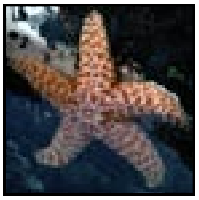
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This report lays out recommendations and a strategic implementation plan for education and communications allied with the Integrated Ocean Observing System (IOOS). Participants at the *IOOS-COOS and Education Workshop* developed these recommendations and helped shape the plan. The plan positions IOOS education and communications efforts as one component of a larger national education effort that promotes lifelong ocean education within the context of Earth and space system education.

The value of ocean education within the context of the Earth system and of science and technology education cannot be overstated. The oceans are fundamental to our very existence—most of the oxygen we breathe comes from the oceans—yet most citizens do not know it. Our nation's economic prosperity depends on an adequate supply of innovative science and technology professionals which we as a nation must develop and sustain. The allure of the oceans as captured by ocean observing systems can be used to successfully address both these issues. The overarching goals of IOOS education and communications address these issues by 1) developing and sustaining a community of educators engaged in informal, formal, and work force and postsecondary education that uses IOOS information (e.g., data, careers, societal uses) to achieve their education objectives and 2) creating the work force needed to develop and sustain the IOOS and to produce the allied information products, services, and tools.

The education plan, like other aspects of IOOS, embraces IOOS design principals.
- Build on the best of what is already in place,
- Pay special attention to quality, sustainability, and scalability of efforts, and
- Use partnerships across federal, state and local government, academia, industry, professional societies, and nonprofit organizations.

This report outlines an education plan that supports local education leadership and provides lifelong learning using the unique information and facilities of IOOS. Citizens of all ages, ethnicities, and locales are encouraged to participate in lifelong ocean science learning. The plan supports learning by youth in formal classroom settings (kindergarten through grade 16); ongoing learning by adults and children through engagement in informal self-directed learning environments found in museums, sanctuaries, youth programs, and multiple media; and learning by adults in preparation for careers in the work force allied with ocean observing systems.

In each education area (informal, formal, and work force and postsecondary education), the plan addresses key national education issues that affect local communities and influence the production and supply of science and technology professionals. The major issues addressed in the plan are 1) expanding the diversity of the ocean science work force to reflect the rapidly changing demographics of the population, 2) aligning formal education learning materials to each state's implementation of the National Science Education Standards, and 3) obtaining active participation of industry and professional organizations in the work force and postsecondary education efforts.

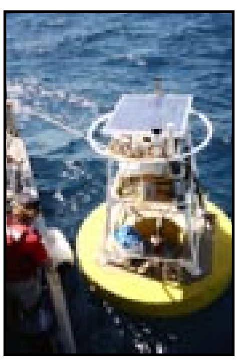
The plan also recognizes and capitalizes on the inherent relationships that exist between informal, formal, and work force and postsecondary education. It recognizes the commonalities between these different education areas and the benefits that accrue from them. These commonalities serve to unite the education program both across education areas and within an area.

These commonalities align along five functional categories: 1) building a community of educators and users, 2) using information technology to support education and communications, 3) planning based on a thorough assessment of user needs and capabilities, 4) developing and using common messages and themes throughout all education and communications activities, and 5) ensuring that all citizens have ample opportunity to engage in ocean careers. Collectively these commonalities provide coherence to the education program, foster coordination and continuity of education efforts between education areas and within an area, and improve program effectiveness and efficiency.

Finally, the plan addresses development of structural and organizational elements that provide the mechanisms for coordination and collaboration, enable sustainability, and foster efficiency. The principal structural element is a national network of regional education offices with a central coordinating office. This national network is embedded within the larger Earth and space science education network as a way to extend the reach of the ocean science education network. Within this structure, each regional office develops a regional network of ocean science and technology educator-leaders with expertise in informal, formal, and workforce and postsecondary education that act locally to develop the professional expertise of their colleagues and to influence local education improvement efforts.

Initial efforts to form this network were taken at the workshop. Participants signed a resolution to participate in its formation. Structurally the network of regional offices participates in the governance of IOOS both at the national level and at the regional level. The network also supports a data translation and story development facility that provides expertise and services to the entire education network. This facility translates IOOS scientific and applied content into stories of interest to informal, formal, and work force and postsecondary educators, creates powerful companion visuals derived from IOOS data, and packages them so that stories and visuals are usable by education and communication professionals.

The end result of this plan when implemented is a coordinated and coherent education effort that 1) enhances the supply of science and technology professionals essential to our Nation's economic prosperity, 2) enhances lifelong science and technology learning with an improved understanding of the ocean's role in our life support system, and 3) provides the educated and skilled work force allied with ocean observing systems.



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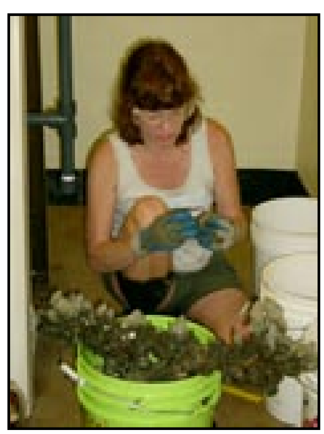

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Chapter 1: Science and Technology Education Essential to Ocean Observing Systems

The National Challenge

For the nation the coming ocean observing system promises an unprecedented opportunity to change both the public perception of our oceans, and to inspire, captivate and motivate our children, our young adults and even our fellow adults to pursue careers allied with the oceans, and to become stewards of this our last most unexplored environment. All Americans are touched by ocean, each and every day, although most do not realize it. From the life-giving regeneration of the air we breathe, to the rainfall on our crops, to transport of our goods to the world and the world's good to us—we depend upon the oceans. Indeed, we could not survive without the oceans.

The national challenge is to use this opportunity to instill an appreciation of the oceans in all citizens and to assist in the development of the science and technology work force of the future, especially the ocean observing system work force. Once mature, the ocean observing system will enable the nation to achieve seven important societal goals more effectively:


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- Predict weather and climate
- Facilitate safe and efficient maritime operations
- Ensure national security
- Manage resources for sustainable use
- Protect and restore coastal ecosystems
- Mitigate natural hazards
- Ensure public health (23).

A critical step is an effective and sustained program to enhance public awareness and understanding of the oceans and development of the work force required to address these goals.

A science and technology literate society and a science and technology capable work force is essential for the Integrated Ocean Observing System (IOOS) to enable solutions to these societal goals. To develop the work force that will create the breakthroughs needed to solve these societal issues, it is essential that citizens value science and technology careers enough to ensure that their sons and daughters, granddaughters and grandsons have the interest, motivation and skills to successfully pursue careers in these fields. For our children to be prepared to successfully pursue coursework that prepares them to create these solutions, we need a society that values and rewards those who educate, nurture, and train these young minds (9). And to realize sustained solutions to these societal issues, we need a vital ocean science and technology enterprise that employs scientists and engineers to transform science and technology innovations into operational applications.

> ***"Quality education in math and science is everyone's challenge and responsibility. The nation's economic welfare and security are at stake"***
>
> *National Science Board (22)*

It is in the vital interest of our Nation and of a sustained ocean observing system to address education. Indeed, it is in the vital interest of all science and technology based organizations (industry, academia and non-profits) and many are beginning to acknowledge this self-interest (9, 10, 20, 22, 27). In ocean science and technology, both the U.S. Commission on Ocean Policy and the National Oceanographic Partnership Program (NOPP) have reiterated the importance of science and technology education and the participation of science and technology organizations in those efforts (16, 27).

The basic research in learning, especially in science and technology, argues strongly for the participation of scientists and engineers and their organizations in science and technology education. The contribution of these professionals, especially in the deepening of content knowledge of educators[c] can have long-lasting and high-leverage impact on science learning. Educators *inspired*, by these professionals, with the excitement and enthusiasm of scientific discovery and technological innovation, pass that inspiration along for many years. As these educators deepen their

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[c] Throughout this report *educators* refers to practitioners in many disciplines and venues including classroom teachers and education administrators in kindergarten through grade 12, faculty members active in grades 13-18 at two and four-year colleges, professionals of continuing education, professionals of adult-basic and adult-secondary education, and education program and exhibit staff at natural and cultural history sites (parks, sanctuaries, reserves, seashores) and informal learning centers (aquariums, museums, coastal learning centers, science and technology centers), leaders and trainers of youth group personnel, science writers, filmmakers, etc.

own knowledge and understanding of scientific and technological concepts, they are also better prepared to help their students, patrons and colleagues develop deeper understandings (10, 18).

> ***"Rapid and extensive improvement of science education is unlikely to occur until it becomes clear to scientists that they have an obligation to become involved in elementary-and secondary-level science."***
>
> *National Research Council (18)*

An Education Workshop Convenes—Workshop Objectives

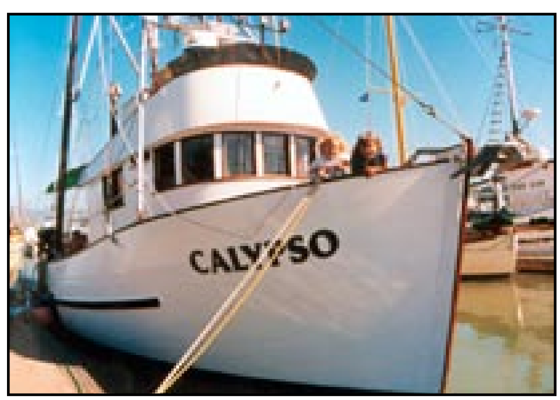
Within this context of national challenges and the emerging involvement of national and regional ocean observing systems in education, the ***IOOS-COOS and Education Workshop*** was held in March 2004 to initiate an education framework associated with ocean observing, and to provide community insight and guidance for education website best practices and for education associated with ocean observing systems. The 63 workshop participants were individuals with knowledge and extensive experience as practitioners, researchers, and program managers in science, technology or education (Appendix A). The specific objectives of the workshop were as follows:

1. To initiate an education network comprised of educators, scientists and technologists associated with ocean observing systems who agree to
   a. further national objectives in science and technology education using the oceans and the IOOS infrastructure as the uniting element,
   b. foster mutual understanding of each others' professions and
   c. advance community understanding of national and local education issues and needs.
2. To initiate an ongoing process to identify exemplary components of existing websites relevant to IOOS-COOS education, especially in the areas of web accessible tools for analysis or visualization of data, and education efforts using scientific data.
3. To develop a set of community recommendations and strategies for formal and informal education efforts associated with ocean observing systems based on the unique contributions these systems can make to education, and for sustained use of Integrated Ocean Observing System (IOOS) for education.

The workshop was structured to create a participatory environment where all attendees contribute and communication, interaction and collaboration continues long after the workshop. The agenda (Appendix B) included presentations, small group brainstorming sessions, and common reporting. Through these mechanisms participants used a detailed facilitation process (Appendix B) to 1) develop a comprehensive understanding of the present environment and the issues the education plan should address, 2) generate a number of options and strategies to include in the optimal education plan that also incorporates the best of educational practices, tools and methods, and 3) select those that best meet the needs of education within the operational and information management framework of the IOOS.

By the conclusion of the workshop

1. *An education framework was formed* through the initiation of an education network, formation of four special interest subgroups, and two short-term working groups (Chapter 2). Understanding between educators, scientists and technologists of their different perspectives was addressed by each providing comments on the utility and educational value of the Gulf of Maine Ocean Observing System (GoMOOS) website.
2. *A process to identify exemplary web components and tools was initiated* through an exercise that simulated the rapid fire, browsing behavior of educators searching the web for materials. A special interest subgroup was formed to extend these efforts to identify attributes of exemplary web components and tools (Chapter 3).
3. *Recommendations for education allied with IOOS were developed* through identification of education issues and development of desired education outcomes (Chapter 4). These recommendations were then translated into a high level, phased implementation plan (Chapter 5).



CHAPTER 2

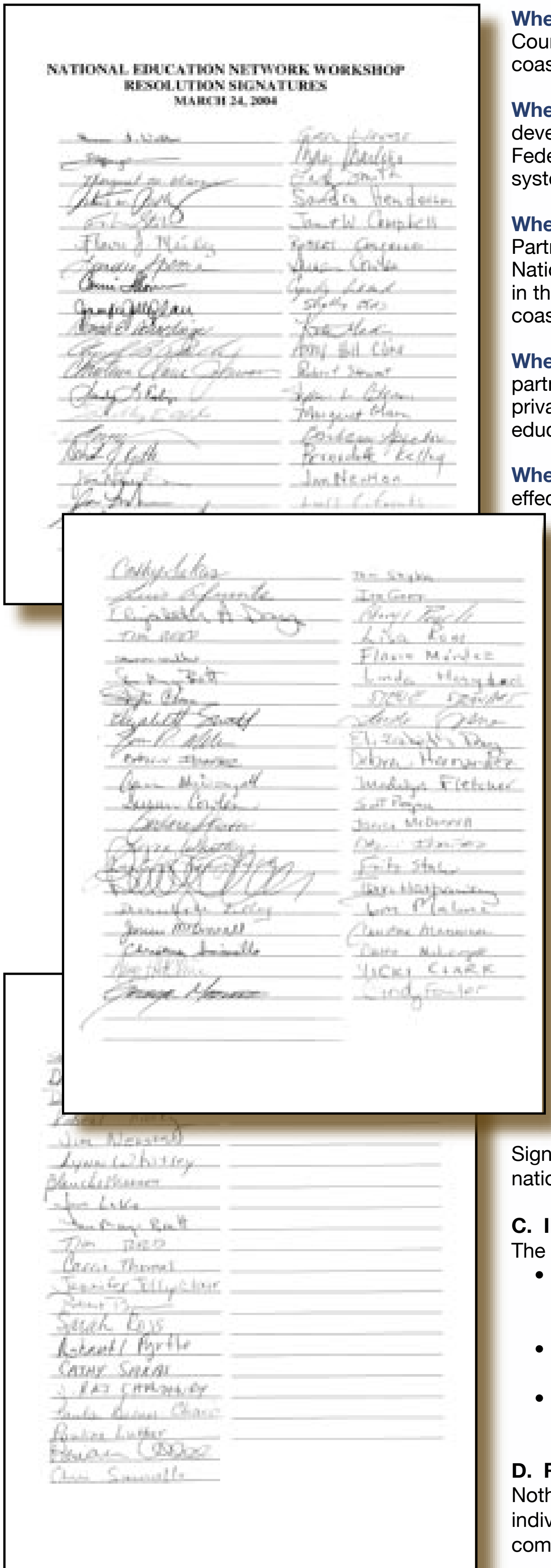
Chapter 2: It Takes a Community

An Ocean Observing System Educator Network Forms

The workshop participants resolved to form a national education community associated with the Integrated Ocean Observing System (IOOS). The resolution (Figure 1) was approved and signed by all participants at the ***IOOS-COOS and Education Workshop***. The signatories agreed to collaborate with Ocean.US to initiate a national education network integral to IOOS whose purpose is to further the national objectives in science and technology education using the oceans and the IOOS infrastructure as the uniting elements. Specifically, they resolved to

- *Collaborate to form an education network to further the national objectives in science and technology education using the ocean and IOOS infrastructure as the uniting elements*
- *Participate in the development of education recommendations and strategies to be incorporated into the planning of IOOS*
- *Advocate participation of IOOS members in science and technology education.*

Figure 1: Resoluton to Establish a National Education Network Assoicated With the Integrated and Sustained Ocean Observing System (IOOS) to Improve Ocean and Coastal Science Education



Whereas the Congress and the National Ocean Research Leadership Council have made development of a sustained, integrated ocean and coastal observing system (IOOS) a high priority; and

Whereas the Congress has directed that the IOOS include the development of an "integrated regional system" (i.e., National Federation of Regional Associations) as vital components of a national system; and

Whereas the Congressionally established National Oceanographic Partnership Program (NOPP) has been directed to establish an effective National Strategy to strengthen science education and communication in the United States through improved knowledge of the ocean and the coasts; and

Whereas the NOPP partners have been directed to establish a partnership between federal agencies, academia, industry, and the private sector to improve ocean literacy, outreach, and science education; and

Whereas the NOPP partners have been directed to ensure that effective use of the ocean and coastal data obtained by the IOOS be used to improve ocean literary and strengthen science and technology education; and

Whereas Earth system, including ocean and aquatic science, education networks already exist at the local, state, and national level, these networks can add greatly to the goal of a national education network associated with the IOOS; and

Whereas it is in the vital interests of the nation that the IOOS infrastructure be viewed as a valuable resource for ocean and coastal science and technology education.

Therefore, the undersigned Signatories hereby resolve to work together to establish a national education network that will further the national objectives in science and technology education using the IOOS infrastructure and the Earth system themes associated with the ocean, coasts, and inland seas.

A. PURPOSE

Collaborate with Ocean.US to initiate a national education network integral to IOOS.

B. SIGNATORY QUALIFICATIONS

Workshop participants have extensive knowledge and experience in ocean observatories and science education efforts. Participants were drawn from state and federal agencies, nongovernmental organizations, and academia. The Signatories to this Resolution are committed to the establishment of a national education network to support the IOOS.

C. IMPLEMENTATION

The Signatories resolve to

- Collaborate to form an education network to further the national objectives in science and technology education using the ocean and IOOS infrastructure as the uniting elements
- Participate in the development of education recommendations and strategies to be incorporated into the planning of the IOOS
- Advocate participation of IOOS members in science and technology education.

D. RESERVATION OF AUTHORITY

Nothing herein shall be construed in any way as limiting the authority of individual Signatories in carrying out their respective responsibilities, or committing the home institution of individual Signatories to any action.

The first action of the community was to use the workshop to strengthen community cohesion by building understanding of each others' professional perspectives (see next section). The second action was to establish four special interest groups to address areas of immediate and ongoing need within the community (see Chapter 4 Figure 2 Recommendations 3, 5, 7, 13 and 17):

1. Develop and shape work force recommendations
2. Develop key messages and themes for IOOS-COOS education
3. Focus on building capacity to use satellite remote sensing in IOOS education
4. Identify website best practices, and assessment and evaluation guidelines.

In addition, two short-term working groups were formed: one, to assist in the publication of a special issue of *Current, The Journal of Marine Education,* on ocean observing systems and education, and two, to assist with the publication of this workshop report. As this publication goes to press, efforts are underway to form these four special interest groups, initial steps have been taken to secure a special issue of *Current*, and the workshop report working group has completed its work.

Community Cohesion Advances

The purpose of this exercise was to strengthen community cohesion by building understanding between scientists, educators and information providers associated with ocean observing systems, groups that interact infrequently and whose collaboration is critical for effective education efforts associated with IOOS. The GoMOOS website (http://www.gomoos.org) was selected as the vehicle to assist each group gain a deeper understanding of the others' interest and perspectives. Prototypical members of each group, a researcher, an educator and an information provider, were asked to provide their assessment of the strengths and weaknesses of this website as a means to illuminate their similar and different perspectives.

The strengths and weaknesses of this website as perceived by our prototypical group members have a few similarities and many differences. These differences highlight the differences in expertise and professional objectives of each profession and reflect the different expectations that each brings to a website. This exercise helped to build community because it built understanding and appreciation of each others' discipline knowledge and the professional respect that is its companion.

Researcher Perspective: Janet Campbell

The researcher focused on the ability to use the site for science or applied uses. Of particular interest were the ability to access the digital numbers, the quality of the data and the availability of other data or information to interpret the data on the website. The researcher particular liked the ability to visually combine or overlay satellite images with ground based (*in situ*) data and that similar parameters for satellite and *in situ* measurements were expressed in the same units of measure. On the other-hand, the researcher could not readily determine the quality of the data nor could she access the digital numbers in the satellite images, an essential capability for the satellite data to be used for near real-time adaptive sampling (a desired use of this website by the research community).

<u>Strengths</u>

- Website meets the needs of multiple audiences.
- A user can use *in situ* data to validate satellite remote sensing data.
- A user can visualize ocean conditions.
- Information is available for image feature interpretation.
- Images are available for several periods – monthly, weekly, daily.
- Common, well understood units of measure are used.
- Several parameters use the same projection (sea surface temperature, ocean color, etc.).
- A user can specify the projection for the data.

<u>Weaknesses</u>

- Quality assurance/quality control (QA/QC) of data are unknown (auto scaling).
- Data behind images are not readily available.
- Knowledge beyond that provided is required to interpret images accurately.

<u>Other issues</u>

- How reliable are the data? Can they be used for publications?
- Can the data be used for non real-time adaptive sampling applications?
- Treatment for anomalous data has not occurred.

Educator Perspective: Janice McDonnell

The educator was most interested in the usability of the site by other educators. She especially liked the ability to visualize geospatial data for many of the same reasons that the researcher liked this feature. She was however concerned that the computer facilities available in many education settings do not support the data visualizers used by this website.

The educator also thought that educators would need more assistance and context for the data than is currently available on the website. Of particular interest is the relevance of the information to the local community in the Gulf of Maine, and how this data and its uses are related to careers. For educators these address the perennial questions of students—When will I ever use this information and who uses this information anyway? Lastly, like the researcher she was concerned about access to additional information or data to help educators interpret the images and graphs on the website. She was also concerned about alignment of the learning materials with national and state learning standards in math, science, geography, etc.

<u>Strengths</u>

- Ability to visualize geospatial data is more useful than data provided in tables.
- Information specific to educators' needs is provided.

<u>Weaknesses</u>

- Old browsers, available in many education settings, do not support these data displays.
- Educators often need tutorials that address the context of data (canned data sets, descriptions of data sets).
- Site needs information on uses of data. Who uses data for what?
- Site needs a section on "What does this mean for Gulf of Maine?"
- More is needed on careers.

<u>Other issues</u>

- Site should identify additional or clarifying information within the data to help educators interpret graphs and images (e.g., provide bathymetry with temperature at George's Bank).
- Many educators are not comfortable with use of real-time, or near real-time data.
- Do the learning materials on the site reference all relevant education standards (math, science, geography, etc.)
- Comparison of data before and after quality checks can be of educational value; however, context and background information are needed. Also need to decide if data should be clean, messy or if there should be an option.
- Information could link to local communities: How would fishermen use this information? How would managers use this information?

Information Provider Perspective: Madilyn Fletcher

The information provider focused on the need for common solutions to infrastructure issues. This collaboration and coordination among information providers is key to the solution. As with the researcher and the educator, issues associated with quality control of the data and access to related data were an important issue and a challenge for information providers. Standards and guidelines that provide consistency while supporting computer platform independence, and system expansion and flexibility were also mentioned as challenges (e.g., metadata standards, use of common symbols for the same parameter, expandable data structures, etc.).

<u>Weaknesses</u>

- Lots of infrastructure problems exist, groups need to work together to solve.
- QA/QC issues abound.
- Data storage issues abound.
- Platform independence is of critical importance – GoMOOS has tested on major operating systems and browser software, but not all versions of both.
- Symbols for the same parameter (e.g., arrows for wind vectors) need to be the same throughout the website.

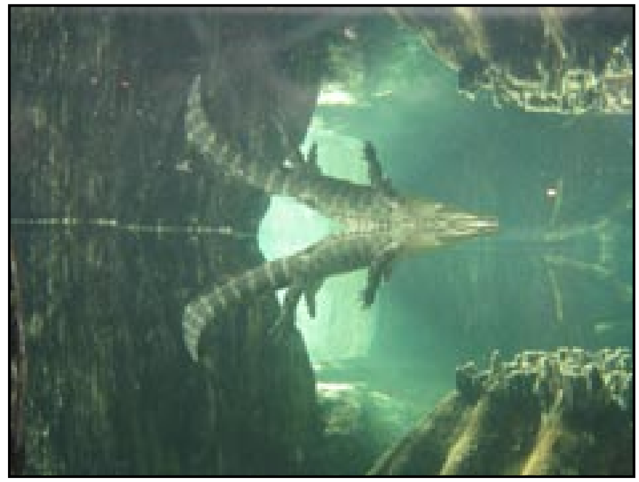
<u>Other issues</u>

- Data structures need to be expandable and flexible.
- Standards for the metadata need to be developed.
- The site needs several different data types (e.g., buoy, shipboard, satellite, etc.) to be useful.
- Are metadata available for the data?
- There needs to be a merging of funding-driven and standards-driven data product efforts.

Taken individually each of these perspectives was quite different and fairly consistent with what might be expected from each profession

1) the researcher was interested in using the data for research and wanted to be sure it was of acceptable quality before acquiring it,
2) the educator was concerned that the typical educator could actually access the information in their work environment and the information was present to make the data useful in that setting, and
3) the information provider was concerned with improving the information system by addressing issues that improve access, data sharing and information distribution.

Because the web was used as the vehicle to highlight perspectives, insight into the translation of these perspectives into specific website concerns was also evident. For example, all were concerned with data quality but from very different perspectives and for different reasons. As a consequence, each wanted to address different aspects of data quality that were important for their use. The salient point here is that the specifics may be quite different even though the general concerns are the same.



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Chapter 3: Using Data on the Web to Enhance Learning of Science

This exercise began the ongoing process to identify exemplary components of websites relevant to IOOS-COOS education, especially in the areas of web accessible tools for analysis or visualization of data, and education efforts using scientific data. The National Science Education Standards specifically address the development of students' and educators' knowledge, understanding, and skills and abilities to make scientific measurements and to use scientific data as evidence in forming explanations, in models and in assessing change. Ocean observing and broadly Earth system science websites that use real-time, near real-time or static scientific data provide a starting point to identify exemplary components that address these standards.

An examination of websites was structured to simulate the behavior of an educator browsing the web in search of materials for use in their education setting. The activity was designed as the first step in an evolving process to identify attributes of exemplary websites that are relevant to ocean observing system education efforts.

Workshop participants were divided into groups with a mixture of educators, researchers and information providers from different geographic areas. Each group was given a list of websites, organized by category (Appendix C), and 60 minutes to identify exemplary components of three websites, one from each of the following categories, using common review guidelines (Appendix D):

1. COOS, COOS type and IOOS websites,
2. Web based dsata sets with education context, and
3. Other data, mapping and display websites.

Ten websites were selected for examination (Table 1). They covered the full spectrum of websites from coastal to global observatories; websites that placed learning within a local, regional and global context; websites that used *in situ* and satellite remote sensing data; and websites that used biological, chemical and physical data.

3. *Provide links on the website to all software tools that will be needed to use the website.* With this capability educators can download required software at home and bring it into the classroom on removable media.
4. *Provide information on the wide range of careers associated with the content of a site.*
5. *Provide data in layers that the user can add or remove at will.* Interpretation of data and symbols used in each layer needs to be readily available.
6. *Provide authentic scientific data for student learning.* The value of real-time vs. static data is unclear. Some felt strongly that real-time data are an important asset for classroom instruction; while others thought static data are more valuable.

Table I: Websites Examined at the IOOS-COOS and Education Workshop

IOOS-COOS	Data with education context	Other data
NOAA Coastal US http://nowcoast.noaa.gov/ nowcoast_intro.htm	Asian Monsoon and Data Assimilation http://csc.gallaudet.edu/monsoon	Oregon Coast Atlas http://www.coastalatlas.net
COOLRoom http://www.thecoolroom.org/data/data_main.htm	COOLClassroom http://www.coolclassroom.org/home.html	Ocean Surface Topography from Space: Education Materials http://topex-www.jpl.nasa.gov/education/education.html
ARGO http://www.argo.ucsd.edu/	The Gulf Stream Voyage http://www.k12science.org/curriculum/gulfstream/index.html	Census of Marine Life and Ocean Biogeographic Information System (OBIS) http://www.iobis.org/
		Pelagic Predators http://www.mbari.org/education/EARTH/Pelagics/pelagics.htm

Several dominant themes emerged from these examinations.

1. *Websites designed to capture the attention of educators should highlight the intended audience and their expertise level.* If there are multiple intended audiences, windows into the perspectives of each audience should be obvious to the browser. Bottom line: skill sets vary among users; the interface should support these differences.
2. *Keep website organization and navigation simple, yet attractive.* Many school systems will not permit downloading of software and images to school computers. The central networking systems often block a large number of common web applications that are supported through plug-ins into the browser software, *e.g., Flash, Quicktime, Real Player, etc.*

7. *Design websites to serve learners with hearing and seeing disabilities including color blindness.* There are websites with information and tools to help a web developer determine if a site serves these learners (2, 5).
8. *State clearly the policy of the website on reuse of website materials.* The statement should address any restrictions and any required citation or attribution.

At the conclusion of this exercise, the community recommended that a systematic analysis of websites, perhaps using a formal assessment tool, be undertaken. In response, a special interest group was formed to address website best practices, and development of assessment and evaluation guidelines. These efforts will contribute to measurement based assessment and evaluation called for in Recommendation 16 (Figure 2).

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CHAPTER 4

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Chapter 4: Developing Recommendations for Education and Communciations

Our Current Knowledge—Navigating Charted Seas

The recommendations developed by the workshop participants and laid out in this chapter are based on their knowledge and extensive experience as practitioners and researchers in science, technology and education. The recommendations are grounded in what research and experience tells us works. They address critical demographic issues for the science and technology work force, generally, and the ocean science and technology work force, specifically. The recommendations (Figure 2) were developed with a clear understanding that ocean observing systems offer unique assets to education. These assets (people, data, facilities and technology) can be used to address known gaps in the national capability to inspire, motivate and nurture effective science and technology learning by youth, educators and parents.

The most obvious among these assets is the scientific data that these observing systems will collect. For the first time there will be continuous, sustained, near real-time, multi-dimensional information available for the oceans, collected both from within the oceans and from above using remote sensing methodologies. These data make possible inquiry into the dynamic nature of the ocean's physical, biological and chemical attributes in both time and space. They provide synoptic views in ways that are meaningful, exciting and challenging to youth and adults, to novices and experts, and to educators and citizen scientists. They enable comparisons of different locations (e.g., a kelp bed off coastal California and a coral reef in the Gulf of Mexico) or events at the same location (e.g., passage of a hurricane) in ways never possible before.

With these data all citizens will be able to participate, in their own way, in the exploration of this last great frontier on Earth. This exploration will help us all understand the Earth system and the profound importance of the oceans in it. They will help us appreciate how the oceans touch us, each and every day, and ensure our survival. And enable each of us, as stewards of the Earth system, to help sustain our life-giving environment.

Education Challenges—Exploring Uncharted Waters

Within the context of the assets ocean observing systems offer education and an understanding of the major challenges facing science and technology education today, five topics were identified by workshop organizers.

1. Work Force Development and Diversity (Careers & Personnel)
2. Contribution to Science Education Improvement
3. Application and Access to IOOS Information Assets for Education
4. Participation of IOOS-COOS Members in Education
5. Building Awareness of IOOS-COOS Education Within the Education Community.

These topics were used to initiate and focus discussions that would lead to community recommendations and strategies for education allied with ocean observing systems. For each of these topics a set of probing questions was developed to guide the identification of issues and possible root causes. Workshop participants worked in breakout groups focused on each of these topics. The complete findings of each group are in Appendix D. For each topic two or three key issues or opportunities were identified and are summarized here.

Work Force Development and Diversity

Two topics emerged

1) recognition that IOOS presents an opportunity to significantly expand both the numbers and the array of careers associated with the oceans and
2) IOOS must capitalize on the demographic changes underway in the country to develop the future IOOS work force.

IOOS and allied enterprises will foster a wide array of careers that will require many levels of expertise: science, technology, engineering, education, communications, management, and administrative (PhD to two year credentials in all these areas), unlike the existing environment where most of the careers are at the high end of the skill spectrum.

Contribution to Science Education Improvement

Three attributes of IOOS were identified as particularly suitable

1) sustained long-term measurements,
2) topics that are relevant to local issues yet connect to large-scale planetary issues, and
3) diversity of careers present opportunities for students with many different interests and skills.

Application and Access to IOOS Information Assets for Education

Discussions stressed the

1) importance of IOOS data assets in creating effective communication pieces that generate awareness of the oceans among the public, educators, scientists and engineers,
2) use of scientific visualizations created using IOOS information assets to communicate the dynamic nature of the ocean system, changing constantly in time and space, and
3) context for these visuals, and the data themselves will be critical if educators are to use them with their students, visitors, patrons, and colleagues in curricula, exhibits, film, radio, websites, public programs, youth programs, etc.

Participation of IOOS-COOS Members in Education

Opportunities and challenges were identified

1) critical importance of promotion, retention, and reward structures that encourage participation by scientists, engineers, and technologists,
2) the need for a distinct funding stream for education, and
3) the need for funding levels that support effective education efforts.

Building Awareness of IOOS-COOS Education Within the Education Community

One issue emerged

1) awareness of IOOS and ocean observing systems among this community does not exist and needs to be built.

The results of these discussions led to identification of key strategic areas that are important to an IOOS-COOS education effort.

Communicating with the Public—Enhance awareness and communicate the importance of oceans, coasts and inland seas in the Earth system and in our lives using IOOS assets.


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Developing Education and Communication Professionals—Identify and target education and communication professionals, identify their needs, and appropriate IOOS content and training for each.

Building Partnerships—Bring diverse groups together to increase awareness and knowledge of the oceans, coasts and inland seas among students, educators and the public.

Using Data and Technology for Education—Ensure that education materials and programs created for IOOS education are used widely by educators.

Building the Work Force—Identify the future work force needs of IOOS, and the mechanisms and activities required to satisfy those work force needs.

Again breakout groups were formed to address each of these strategic areas. Each group used a stepwise process (Appendix F) to identify and then develop community recommendations for high priority items.

Community Recommendations for Education—Mapping Uncharted Waters

The recommendations developed by the strategic area breakout groups were extensive. Similar recommendations were combined. The resulting 30 recommendtions address the infrastructure required to carry out, sustain, and assess the effectiveness of an education program, and specific education efforts that should be undertaken (Figure 2). The recommendations span building a network of education and communication specialists with regional offices across the country and a national coordinating office (Recommendation 1), to building a meaningful reward structure for those who participate in IOOS allied education and communications (Recommendation 30). These recommendations echo those in the recent report by the U.S. Commission on Ocean Policy (28) and address the goals and objectives in the NOPP ten year strategic plan (16) and the draft Ocean Research Advisory Panel education strategic agenda (17).

One group of recommendations is especially significant because they address inclusion of more citizens in the ocean sciences and technology, particularly those in underserved and

Figure 2: Recommendations synthesized from the strategic area breakout groups (communications, education and communication professionals, partnerships, data and technology for education, and work force)—listed by implementation phase (see Chapter 6 Figure 6).

Recommendations

<u>*Phase I*</u>

(1) Create a collaborative ocean education and communication network integral to IOOS with regional education offices throughout the country (at least, in each of the regional associations) and a national coordinating office.

(2) Create, support and sustain a collaborative community of kindergarten through grade 16 educators, adult-basic and adult-secondary educators, informal educators and communications professionals that are knowledgeable about IOOS[1].

(3) Participate in and help form a coordinated national network of state based alliances to promote science, mathematics, geography and technology education improvement and work to infuse ocean, coastal and inland sea examples into the partners'[2] efforts.

(4) Conduct a thorough work force needs analysis for the operational and developmental needs of IOOS; using this analysis, identify needed education and training efforts.

(5) Obtain an audience analysis and needs assessment for IOOS education and communications audiences and use it to establish audience priorities and classes of high priority opportunities; reassess periodically.

(6) Create and deploy a set of key messages and themes based on the seven goals[3] that address the scientific, socioeconomic, and education value of IOOS to society.

(7) Participate in IOOS planning and design committees (e.g., Data Management And Communications (DMAC), etc.).

(8) Create a "Data and technology protocols for education working group" that guides development of standards and protocols in support of education (especially for data) within the context of the broader IOOS effort and the broader education effort by DLESE.

(9) Participate in governance through an education steering committee that reports to the IOOS (Ocean.US) Executive Committee.

(10) Sign a MOU with all IOOS partners for open access to data, tools, and products[4].

(11) Secure adequate funding for education and communications.

(12) Develop a cadre of STEM[5] education and communications leaders who are aware of and prepared to use IOOS based information products, and serve as professional development instructors in ocean, coastal and inland sea processes, technology, socioeconomic issues, and policy.

(13) Craft a national strategy for development and implementation of education and communications associated with IOOS.

(14) Use the concept of "product lines" to coordinate the creation of learning and training materials[6] within formal, informal and post-secondary education areas. Weave the key messages and themes through the formal, informal and post-secondary "product lines" thereby linking these education areas by themes in support of lifelong learning.

(15) Develop a "product launch" strategy to coordinate deployment of products within and across "product lines" so they support each other, and attain maximum visibility and usage among their intended audiences.

(16) Institute measurement based assessment and evaluation at appropriate levels to determine the effectiveness and progress toward all goals.

Phase II

(17) Provide an information translation and story development function staffed with individuals who are professionals in the translation of scientific information (science translators) for the public and for educators, and with individuals who are professionals in bridging science, applications and education disciplines (information liaisons).

(18) Establish a clearinghouse to provide a mechanism for sharing of data, tools and products, and a help desk to assist with their use.

(19) Create learning resources for multicultural audiences. Articulate and deploy the key messages and themes for diverse cultures with attention to language and demography of local populations (e.g., Spanish language and Hispanic ancestry).

(20) Develop programs that are designed to attract, nurture, develop and retain populations underrepresented in the science and technology work force and especially in ocean, coastal and inland sea related careers.

(21) Develop and deploy post-secondary curricula that are aligned with identified work force needs of the ocean observing community (identified from the work force analysis-see recommendation 24).

(22) Develop learning and training materials that incorporate both the National Science Education Standards (NSES) and the Principles and Standards for School Mathematics by using IOOS data and information, and are designed for incorporation into the existing instruction programs of the education and communication leaders' networks.

(23) Produce a national integrated set of science and mathematics learning products[7] that facilitate understanding and comprehension of IOOS and IOOS data, and illustrate the value of an integrated national ocean observing system for science and mathematics instruction and learning.

(24) Develop awareness and knowledge of IOOS information and learning resources among educators and communication professionals.

(25) Develop awareness among industry leaders so they recognize IOOS as a new opportunity for business, and for the associated staffing and career opportunities.

Phase III

(26) Engage professional societies in the need to develop professional certification programs; work with existing efforts (TOS, MTS, AMS, IEEE, ACM, MATE, NSBE, AISES, SACNAS, SHPE[8]).

(27) Develop and adapt occupational classifications to allow for career flexibility.

(28) Track demographic changes and incorporate changes into periodic reassessment of needs.

(29) Develop awareness and knowledge of careers associated with IOOS among students, parents, educators, and workers.

(30) Build a reward structure for all participants in IOOS-allied education and communications.

---

1 Includes science, mathematics, geography, and technology educators; education administrators; education and communication networks–AMS educator network, Adult Numeracy Network (ANN,) ASTC, EPA-NEP, COSEE, GLOBE, MUSPIN, NOAA-NERR, NOAA-Sea Grant, NOAA-NMSP; professional organizations–ACM, AGU, ASLO, ESOL (aka ESL), IEEE, NAGT, NCGE, NCTM, NESTA, NGA, NMEA, NSTA; natural and cultural history sites–parks, sanctuaries, seashores, reserves; community groups; businesses; two and four-year colleges; informal learning centers–aquariums, coastal learning centers, museums, science centers, etc.

2 Includes science, mathematics, geography, and technology educators; scientists; policy makers; education administrators; education and communication networks–AMS educator network, Adult Numeracy Network (ANN,) ASTC, EPA-NEP, COSEE, GLOBE, MUSPIN, NOAA-NERR, NOAA-Sea Grants, NOAA-NMSP; professional organizations–ACM, AGU, ASLO, ESOL (aka ESL), IEEE, NAGT, NCGE, NCTM, NESTA, NGA, NMEA, NSTA; natural and cultural history sites–parks, sanctuaries, seashores, reserves; community groups; businesses; two-and four-year colleges; informal learning centers–aquariums, coastal learning centers, museums, science centers; and others concerned with improving the caliber and scope of ocean, Earth, and space science education.

3 Once mature, the ocean observing system will enable the nation to achieve seven important societal goals more effectively: predict weather and climate, facilitate safe and efficient maritime operations, ensure national security, manage resources for sustainable use, protect and restore coastal ecosystems, mitigate natural hazards, and ensure public health.

4 This agreement may address proprietary issues with some products or software applications.

5 STEM = Science, Technology, Engineering and Mathematics

6 Learning materials and products, training materials and products, and learning resources — general terms for a wide array of items used for learning. These items range from individual graphs or animations with little or no associated contextual information, to 10,000 to 20,000 sq ft of museum floor space that contains an exhibit, to a robust website, to an entire curriculum that includes lessons, data sets and classroom ready experiments and tools that are deployed throughout an entire school district. Learning materials and products and training materials and products usually refer to materials that are ready for use by their intended audience, while learning resources usually refer to the individual pieces that are used to construct the final, audience-ready materials.

7 These products should also address the National Science Education Standards, the National Council of Teachers of Mathematics Principles and Standards for School Mathematics, the Standards for Technology Literacy, and the National Geography Standards.

8 Including for example: The Oceanography Society (TOS), Marine Technology Society (MTS), American Meteorological Society (AMS), Institute for Electrical and Electronic Engineers (IEEE), Association of Computing Machinery (ACM), Marine Advanced Technology Education (MATE), National Society of Black Engineers (NSBE), American Indian Science and Engineering Society (AISES), Society for Advancement of Chicanos and Native Americans (SACNAS), Society of Hispanic Professional Engineers (SHPE).

underrepresented populations (Recommendation 19 and 20). As the demographics of the U.S. population continue to shift, inclusion of these populations becomes increasingly important (20). Recommendations call for a robust set of messages and themes that target these individuals and serve to attract, nurture, develop and retain them in rigorous programs that lead to successful careers in the science and technology work force and in careers allied with observing systems of the oceans, coasts and inland seas.

Synergy of Recommendations Unites Education—Winds and Currents Affect Navigation

The 30 community recommendations (Figure 2) reveal layers of commonality in topics and recommended actions. Among the recommendations, the concept of education product lines (PLs) and uniting, functional categories (UFCs) emerged. The PLs were identified as the three traditional education areas: 1) Formal, 2) Informal, and 3) Work force and Postsecondary (see Recommendation 14 and 15). Five UFCs were identified as:

(1) *Building a community of users*—building a community of IOOS education and communications users—building ownership and partnerships in IOOS;
(2) *Information technology (IT) for education*—supporting learning materials and resources, and data;
(3) *Planning for education and communications*—planning for IOOS associated education and communications strategy and implementation;
(4) *Conveying key messages*—Conveying key messages and themes;
(5) *Ocean careers for all*—providing opportunities for all to engage in ocean careers.

Table II shows that all recommendations (except those that recommend PLs be formed) fall into one of these UFCs while also applying to one or more education PLs. In each UFC, most of the recommendations apply to all of the PLs (e.g., Recommendations 6, 19 and 23 in "Conveying Key Messages"). However, in a few cases recommendations are specific to a PL (shown in the lower half of Table II); for example, Recommendations 25 and 26 apply only to the "Work Force and Postsecondary" PL.

The matrix (Table II) highlights the multiple relationships that exist in education (within UFCs and between UFCs and PLs) and therefore the multiple opportunities for synergy among education efforts. A visual way to grasp the significance of these relationships is to think of this matrix as a piece of cloth (Figure 3). The horizontal threads represent the product lines, the vertical threads the recommendations. The product lines are like the horizontal threads because they lengthen as the cloth is woven and continue until no more cloth is produced. The recommendations are like the vertical threads that knit the cloth together. The UFCs are like clusters of similar colored threads that form stripes in the cloth (i.e., the green, black, purple, yellow and aqua stripes in Figure 3). Each vertical thread then interlaces with the horizontal threads. Some vertical threads interlace only at certain places: these threads represent recommendations that do not apply to all PLs (i.e., those shown in the lower half of Table II). The cloth's pattern results from the clusters of similar colored threads and the interlacing of the individual vertical and horizontal threads. The more the vertical and horizontal threads interlace the stronger the cloth and the more threads in a cluster, the wider the stripe and the greater the color coherence. The same is true for education. The more the recommendations interlace with the PLs and the more recommendations in a UFC, the greater the coherency, and the stronger and more enduring the education effort.

The insights provided by this matrix are key to the development of the goals and the high level implementation plan that follows (Chapter 5). The result is a phased plan that strives to maximize learning, reduce duplicate efforts and encourage synergistic ones through community building, partnerships and reuse of materials, messages, themes and programs.

Table II: Matrix depicting functional relationships between workshop recommendations, functional categories and education product lines. Numbers refer to recommendations in Figure 2. Recommendations listed in the header (e.g., 1, 2, 3, 7, 9, 12, 24, 30 in "Building a community") apply to all education product lines. Some recommendations are listed more than once in the matrix (e.g., Recommendation 22).

Product Lines (14, 15)	Uniting Functional Category				
	Building a community of IOOS education and communications users—building ownership and partnerships in IOOS (1, 2, 3, 7, 9, 12, 24, 30)	**IT for education** (8, 10, 17, 18, 19)	**Planning for IOOS associated education and communications:** strategy and implementation (3, 5, 13, 16, 28)	**Conveying key messages** and themes (6, 19, 23)	**Ocean careers for all** (19, 20, 23, 29)
Informal§		22			
Formal*		22, 23, 27	4		
Work force and Postsecondary†	25, 26	21, 27	4	27	

§ The National Science Foundation describes informal education as the lifelong learning process in which every person acquires knowledge, skills, attitudes, and values from daily experiences and resources in his or her environment. Informal learning is self-directed, voluntary, and motivated mainly by intrinsic interest, curiosity, exploration, and social interaction.

* Product line includes adult-basic and adult-secondary education and kindergarten through grade 12 education.

† Product line includes two and four-year undergraduate education, training, certification, and continuing education programs.

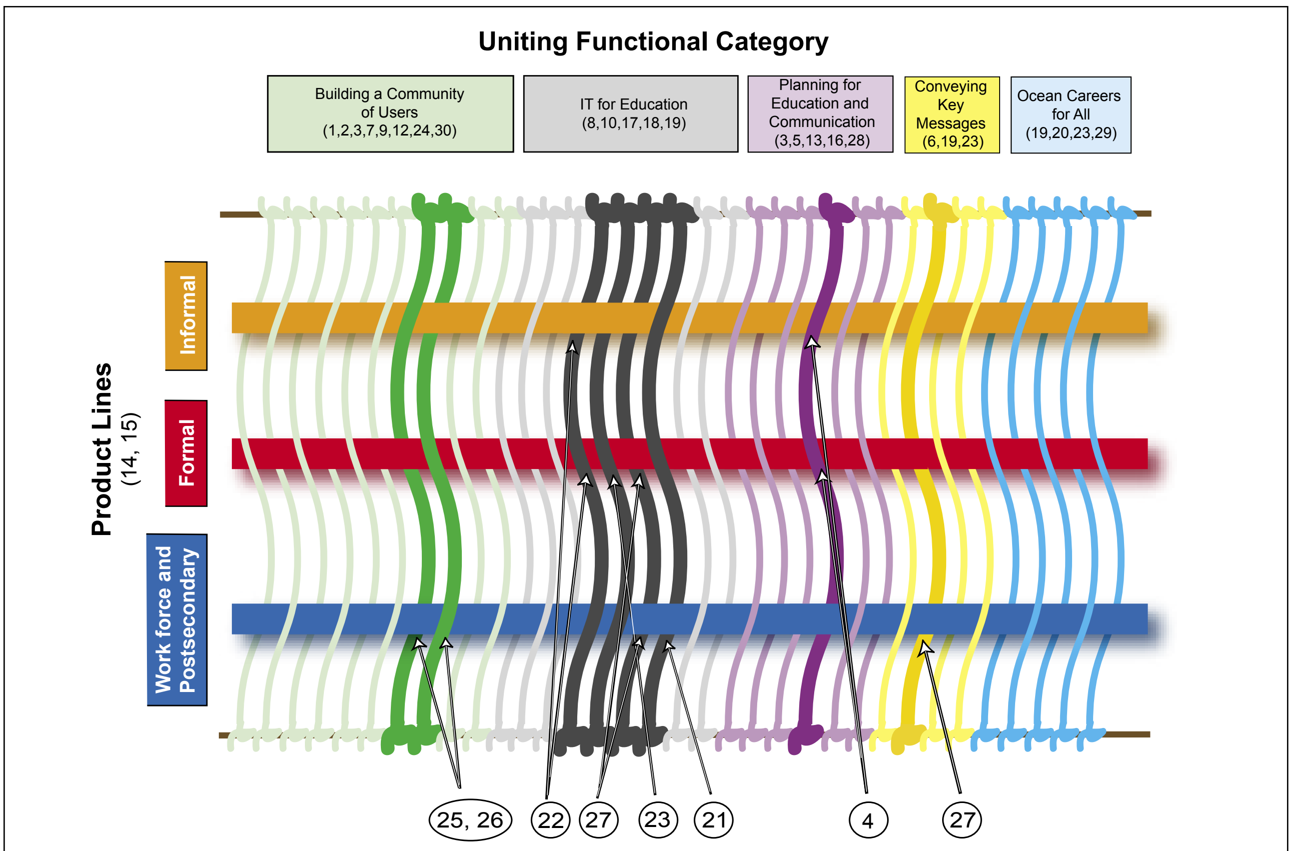


Figure 3: The matrix in Table II is depicted as the threads of fabric as it is being woven on a loom. Recommendations in a uniting functional category (UFC) that apply to all product lines (PLs) are listed in the header. The horizontal continuous threads represent the product lines (PLs) (see Recommendations 14 and 15 in Figure 2). The vertical threads in the illustration represent the recommendations (listed by their number in Figure 2 and organized as in Table II). Each UFC is shown as a colored stripe with each recommendation in a UFC shown as a vertical thread. The darker vertical threads in each stripe represent the recommendations that do not apply to all PLs and therefore do not interleave with all of the horizontal threads. For example, Recommendations 25 and 26, shown in dark green, apply only to the workforce and postsecondary PL and therefore interleave with only this PL. Education has much in common with weaving fabric. As fabric is woven, the continuous threads must interlace with the crosswise threads—the more they interleave, the stronger the fabric. The fabric's overall strength and coherence results from both the interlacing of the individual vertical and horizontal threads and the width of the stripes. The more the vertical and horizontal threads interlace the stronger the fabric, and the more threads in a stripe the wider the stripe and the greater the color coherence. The same is true for education. The more the recommendations associated with each of the UFCs interlace with the PLs and the more recommendations in a UFC, the greater the coherency, and the stronger and more enduring the associated learning and education effort.

Chapter 5: Transforming Recommendations into a Plan

The plan laid out here is based on the community recommendations (Figure 2) and the insights described in the previous chapter. The plan was developed after the workshop with help from workshop participants and federal agency partners who provided review and comment. The plan recognizes, even embraces, the requirement that ocean observing systems contribute to education within a broader national framework of science and technology education, in general, and ocean and Earth system science education in particular (3, 16, 17, 28). There is an established education system in the U.S. and, indeed, within the world; for ocean observing system education efforts to affect learning, they must work within that education system and address critical system gaps.

Learning is a lifelong process beginning with the youngest among us and continuing throughout our lives. Science and technology learning, in particular, must be lifelong. Progress is so rapid that what we learn today is out-of-date tomorrow. To support lifelong learning and man's many different learning styles, science and technology learning opportunities must be many and varied; learning should not, must not, be restricted to youth in classrooms (see highlight below). The plan supports learning in a wide range of venues and situations (Figure 4). Effective learning opportunities must exist for all types of learners (e.g., visual, auditory, kinesthetic, etc.).

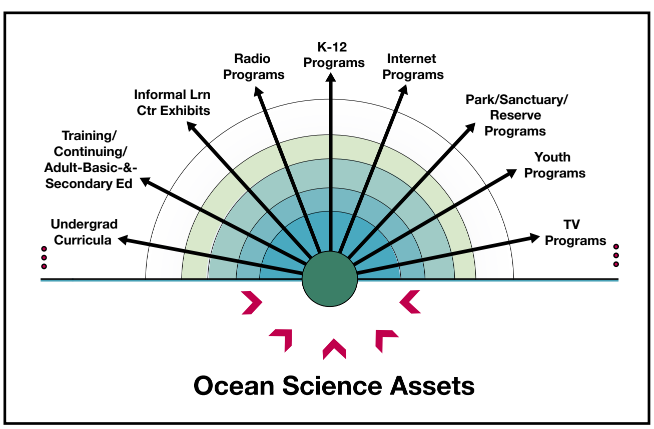


Figure 4: Spectrum of learning venues through which lifelong learning occurs. Most effective learning will occur if the content in the different venues reinforces each other Color transitions indicate progressive refinement and sharing of learning materials, beginning with raw resources (center green circle) to audience ready materials (outer white band). The resulting reuse of content offers multiple and diverse opportunities for learners of all types to encounter the content multiple times.

Learning programs are most effective when they are coordinated, collaborative, coherent and continuous both across learning environments and within an environment (4, 7). For each learning environment, there are organizations and professionals who are experts in using that environment to support learning for all. In ocean science, these groups are quite varied and often utilize multiple environments (Figure 5). To enable lifelong learning, all these organizations and professionals will need to collaborate in ways that support their collective and individual objectives.

Figure 5: The range of potential participants in ocean science education is broad. Participants include research organizations with education programs, nonprofit organizations, school systems at the district and state levels, and others.

The multiple opportunities that reinforce learning across different venues and learning styles are critical. Articulation of these efforts with each other fosters lifelong learning through development of learning environments that simultaneously support learner-centered, knowledge-center, assessment-centered and community-centered learning (7). As detailed in a recent National Academy of Sciences publication, the power of this four-pronged framework cannot be overstated and it is at the heart of the plan laid out below.

> ***"Power of community-centered learning extends beyond the boundaries of the school. Students spend a small percentage of their time in school (during a calendar year only about 14 percent of a student's time is spent in school)."***
>
> ***When combined over a lifetime, about 85 percent of an American's lifetime is spent outside of school.***
>
> ***Clearly, any effort to increase student learning or to maintain and update the learning acquired during these formative years must draw on time spent outside the school, in the community, engaged in lifelong learning opportunities.***
>
> (7, 13, 26)

An Education Plan Emerges—Charting a New Course

The IOOS education plan has two goals: 1) develop and sustain a community of educators in informal, formal and work force and postsecondary education that use IOOS information (e.g., data, careers, societal uses) to achieve their education objectives and 2) create the work force needed to develop and sustain the IOOS and produce allied information products, services and tools. Consistent with IOOS design principles (23), these goals will be achieved by

- building on the best of what is already in place,
- paying special attention to quality, sustainability, and scalability of efforts, and
- using partnerships across federal, state and local government, academia, industry, professional societies and nonprofit organizations to implement this plan.

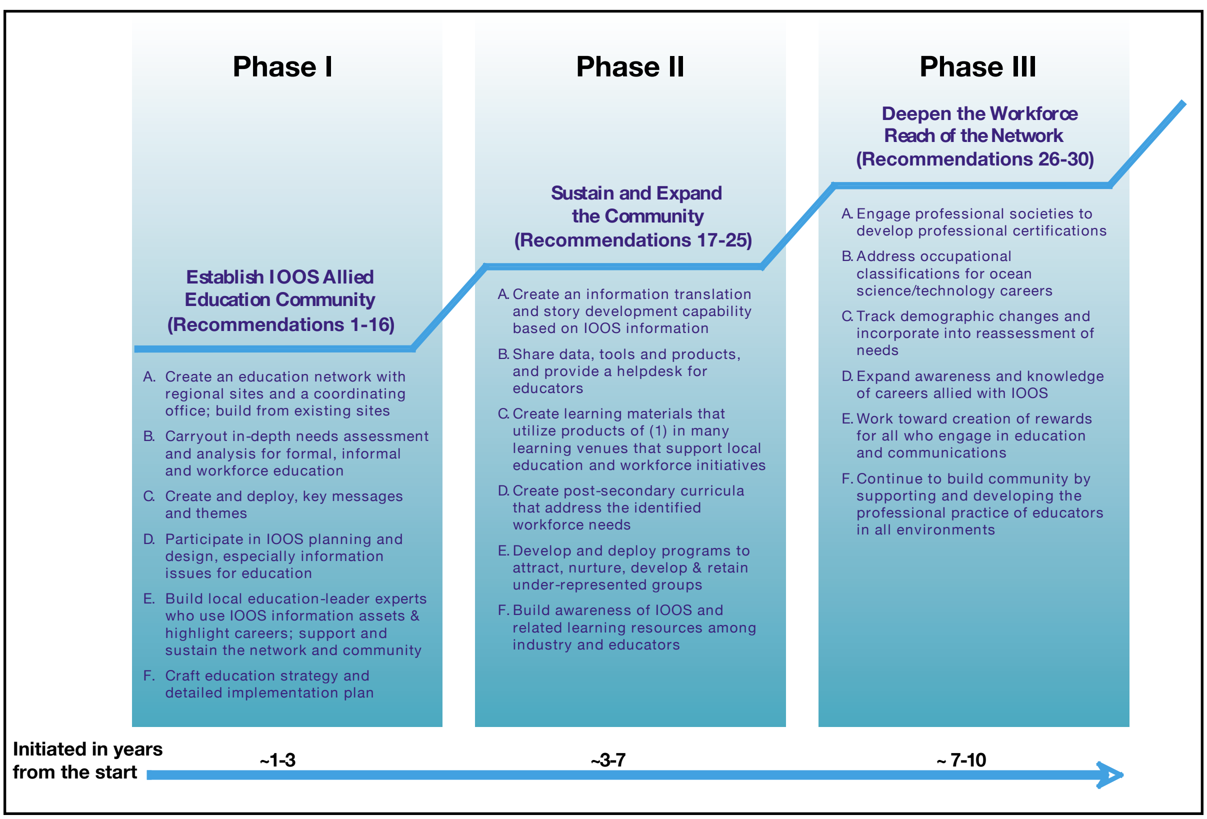
> ***IOOS Education Goals***
>
> ***(1) Develop and sustain a community of educators in informal, formal and work force and postsecondary education that use IOOS information (e.g., data, careers, societal uses) to achieve their education objectives***
>
> ***(2) Create the work force needed to develop and sustain the IOOS and produce allied information products, services and tools***

Each goal is addressed in parallel and in phases with each phase building upon previous efforts and addressing the workshop recommendations (Figure 2). The first phase assesses IOOS work force needs and establishes a community of educators whose work benefits from access to IOOS information (Figure 6). The second phase focuses on sustaining and expanding the community of educators by providing support services, professional development and learning resources, and working with the community to establish postsecondary curricula that address the work force needs of the IOOS. The third phase focuses on expanding the IOOS allied work force and postsecondary programs and credentials, and on expanding awareness of careers.

Establish an IOOS Allied Education Community and Assess Education and Work Force Needs (Phase I, Recommendations 1-16)

The focus of Phase I is to build a nationally coordinated community of ocean educators who serve in the larger geography and Earth and space system education collaborative as the ocean and aquatic education leaders, and to assess the broad based needs of formal and informal education audiences so these needs inform and guide future efforts of the network. The first step to form the collaborative community of educators who use IOOS information and influence its development was taken at the IOOS-

Figure 6: Functional timeline for the development of education allied with IOOS. See Figure 2 for a listing of recommendations 1-30.



COOS and Education Workshop (see Chapter 2 Figure 1). This collaborative education network will be nationally coordinated (Figure 6) and embedded in a larger geography and Earth and space system science education collaborative (Figure 2 Recommendations 1, 2 and 3). This collaborative education network will tightly couple education to observing system assets and give education a reach far beyond the observing system itself.

Initial efforts extend the network begun at the IOOS-COOS and Education Workshop by establishing education offices from existing ones within nationwide education networks that have expressed interest in participation. These include, but are not limited to, NSF-NOAA-Navy/ONR supported Centers for Ocean Science Education Excellence (COSEEs) (6, 12), NOAA Office of Education and Sustainable Development, NOAA Sea Grant, NOAA National Marine Sanctuaries Program (NMSP), NOAA National Estuarine Research Reserves System (NERRS), NSF Digital Library for Earth System Education (DLESE), and NASA Earth Explorers network. Follow-on efforts will extend the reach of the network by embracing regional and state based Earth and space science and geography educator networks, and individual education programs that are supported by several federal agencies and professional organizations[d].

The importance of tapping existing networks and programs and their participation in the larger Earth-geography-space system collaborative cannot be overstated. Because the education system in the U.S. is large, complex, and driven by local issues, and learning is a lifelong process, it is very difficult for any group of educators acting alone to affect measurable improvements in education when the challenges transcend disciplines, departments, agencies and institutions. Building a collaborative education network from existing networks is one way that individual groups can have a positive effect far beyond that possible when they act alone. In addition, as part of a large collaborative network local efforts can be coordinated across the network to provide continuity and coherency of purpose. Highly effective local education practices and exemplary systemic, broad based improvements from one locale are more likely to be propagated throughout the network, thereby improving the likelihood that common education goals will be achieved.

The U.S. education system is very large, complex and driven by different challenges in every community. Too many American children and adults lack basic scientific literacy and are uninformed about the importance of the Earth system in general and the oceans in particular in their lives. At the same time, our economy has become more dependent upon science and technology innovation, and public understanding of ocean and coastal science and technology issues are more important as an increasing percentage of Americans live within 10 miles of our coasts.

- ***47 million public school students*** *(29)*
- ***1.8 million elementary teachers; 300,000 secondary math and science teachers; 35-40% of K-12 math & science teachers lack even a minor in math or science*** *(27)*
- ***3,700 schools of higher education prepare tomorrow's work force (educators, scientists, technologists, policy makers, etc.)*** *(21)*
- ***Latest test scores show that U.S. high school seniors place at or below the international average*** *(21)*
- ***60% of the public lacks basic knowledge about the oceans (e.g., more life in the oceans than on land, most of the oxygen we breathe comes from the sea)*** *(25)*

A coordinating office will be established from existing education networks or programs (Figure 2 Recommendation 1). The role of the office is to foster collaboration across the network, provide a focal point for interaction with IOOS at the national level, and help guide the development of the IOOS affiliated education network. In this capacity, the coordinating office will facilitate a broad based needs assessment and analysis of formal and informal education audiences with a focus on use of IOOS information assets (Figure 2 Recommendation 5). These findings will inform and guide the efforts outlined below.

The coordinating office will work with network participants to agree on a shared set of key messages and themes that all of their constituent networks can endorse and use as one part of their home networks' key messages and themes (Recommendation 6). Initial efforts in this area were begun at the workshop by the formation of a special interest group to develop key messages and themes for IOOS-COOS allied education (see Chapter 2).

[d] Example education efforts: Geography networks–an alliance exists for each state, e.g., Kansas Geography Alliance; Space science network–NASA's Space Science Education and Public Outreach (E/PO) Support Network; Individual projects: EPA–Chesapeake Bay Program Education; NASA–Earth System Science Education Alliance; U.S. Navy–Neptune's Web at Commander, Naval Meteorological and Oceanography Command; NOAA–Office of Ocean Exploration; NOAA-Teacher at Sea; NSF–Ocean Research Interactive Observatory Networks (ORION) education; USGS–regional professional training programs; National Marine Educators Association–regional chapters.

Similarly, a special interest group will be formed to address the management and open access to and use of IOOS data, tools, information products, and learning materials for education (Recommendations 7, 8, 10). This special interest group will also foster early connections to and benefits from the emerging cyberinfrastructure for education initiatives within NSF and electronic education initiatives within NASA, perhaps through DLESE's initiatives that address access to data for educators (11). Addressing information issues early in the IOOS development will maximize early use and adoption of IOOS linked data and learning resources by different education audiences, minimize the need for future retrofitting to meet educators' needs, and provide maximum benefits to IOOS allied education from national education technology initiatives.

Education, like other user groups, will be represented in IOOS governance to ensure that IOOS products and services are in forms that are most useful to educators (Recommendations 9 and 11).

Once the IOOS education network is assembled, efforts will focus on building a community of science, technology, engineering, mathematics (STEM), and geography educator-leaders with expertise in ocean and Earth system and technology[e] concepts (Recommendation 12). These education leaders will serve as expert resources for the broader collaborative Earth-geography-space system education network[f], helping to build capacity to use IOOS information assets (e.g., *in situ* and remote sensing data streams, static data sets, visuals, career information, etc.), and to create and use IOOS related learning resources. First steps were taken at the workshop to form a special interest group on building capacity among educators to use satellite remote sensing information and to develop educator experts in this area (see Chapter 2). In this way, a community of educator-leaders will be established who are users of IOOS information, are resources for professional development of educators in their disciplines and local communities, and act as catalysts for infusion of ocean and Earth system science into their discipline and community's education improvement initiatives at all levels.

Many education and professional networks will ultimately participate in this collaborative. Initially four networks are particularly rich sources of potential educator-leaders for formal, primary and secondary, education efforts: (1) NASA's and NSF's Global Learning and Observations to Benefit the Environment (GLOBE), (2) NOAA's and the American Meteorological Society's DataStreme programs (3) NOAA and the American Meteorological Society's Maury Project, and (4) the state Geography Alliances. Rich sources of educator-leaders for informal education[g], and for work force and postsecondary education[h] can be found in education networks and professional organizations that address professional development in Earth system science, ocean science, environmental science, and in engineering.

In the work force and postsecondary education area, in addition to the community building efforts mentioned above, the primary effort in this initial phase is an in-depth needs assessment and analysis (Recommendation 4). Steps taken at the workshop to form a special interest group to help develop work force recommendations (see Chapter 2) will help shape the requirements for the work force assessment and analysis. The results of this study will guide the future work force and postsecondary efforts. This needs assessment and analysis will enable a systematic and organized approach to work force and postsecondary planning and development efforts so that they are coordinated and coherent. Articulation with formal, primary and secondary education, especially in mathematics and technology, is critical for technology, information technology and engineering based careers. The work force efforts will strive to match the supply of appropriately skilled professionals with the needs of the ocean observing community both in *in situ* and satellite based observations, and information technology products, services and tools.

Last in Phase I, network members, guided by the education coordination office, will develop a strategy and an implementation plan that focuses on establishing and achieving a set of measurable goals and objectives using strategic methodologies that embody the IOOS design principles listed at the beginning of this section (Recommendation 13). The

[e] Technology education implies a very broad range of subject matter that encompasses engineering (e.g., civil, electrical, electronic, hardware and software systems, acoustics, optical, etc.) and many related careers (e.g., computer science, information science, information systems, information analysis, materials science, etc.).

[f] Ocean, coastal and aquatic sciences are a fundamental component of Earth system science (hydrosphere, geosphere, biosphere, atmosphere, and cryosphere).

[g] For example, National Association for Interpretation (NAI), Association of Science-Technology Centers (ASTC), American Zoo & Aquarium Association (AZA), and National Marine Educators Association (NMEA).

[h] For example, NASA's Earth System Science Education for the 21st Century (ESSE-21), American Society of Civil Engineers—Coasts, Oceans, Ports, and Rivers Institute (COPRI), Institute for Electrical and Electronic Engineers (IEEE) Continuing Education Programs, IEEE Computer Society Education and Certification Programs, Association for Computing Machinery (ACM) Education Programs, and Marine Advanced Technology Education (MATE) Center.

plan will prioritize and then sequence the development of specific learning materials and programs within and between the three traditional education areas (formal primary, secondary, and adult-basic and adult-secondary education; informal, self-directed learning; and work force and postsecondary education) to achieve the goals (Recommendation 14). In this way, learning materials and related programs will complement each other for different age groups and audiences, and reinforce each other across the three education areas[i]. This methodical approach makes possible a coordinated and coherent plan for creating and launching education products (Recommendation 15). And it supports local communities and the local education leadership in their education improvement initiatives (Recommendation 3). The strategy and plan will also specify the assessment and evaluation plan designed to track progress toward goals and objectives and to ensure that materials and programs are of high quality (Recommendation 16). The examination of websites at the workshop and the special interest group that formed to continue to identify website best practices, and assessment and evaluation guidelines (see Chapter 2 and 3) are starting points from which this more robust assessment and evaluation plan will develop.

Sustain and Expand the Community via Support Services, Professional Development and Learning Resources (Phase II, Recommendations 17-25)

The intent of Phase II is to enrich the network established in Phase I by expanding participation and enhancing services to the network's participants so their education practice will improve (Figure 6). In this context, a prototype information translation and story development capability will be established as a community support service (Figure 2, Recommendation 17). This service will provide a constant supply of high quality up-to-date content for incorporation into exisitng learning materials and for the creation of new materials. Initially, this service will be modeled after that used by NASA (personal experience B. Meeson). This effort will extend the NASA model by developing a streamlined methodology to identify and translate IOOS information into engaging stories and visuals for use by both education and communications professionals. This effort will also develop an effective process for education professionals to identify and acquire these materials. Initially, information liaisons[j] will act as bridges between the information translators[k] and the diverse education professionals who wish to use the translated resources. Liaisons will identify needs and processes that are common across education professions and those that are unique to individual professions. These commonalities and differences will drive improvements in the translation and story development capability. It is likely that this capability will be a joint IOOS and ORION capability, since the ORION education community has recommended the formation of a similar capability (24).

A clearinghouse for sharing of these story translations and visualizations, data, learning materials, and education tools will be established along with a help desk to provide assistance in accessing and using them (Recommendation 18). The Digital Library for Earth Systems Education (DLESE), an education community resource that provides a clearinghouse for educational resources and a variety of educational services, has committed to being a partner for these efforts and to help provide access to community data, tools and learning products.

Initial formal and informal education efforts will address the gaps identified through the audience needs assessment and analysis described in the previous section. Existing learning materials and programs will be enhanced first, and then new ones will be developed, where there are gaps in ocean and Earth system and technology concepts, and IOOS

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[i] Learning materials and products, training materials and products, and learning resources—general terms for a wide array of items used for learning. These items range from individual graphs or animations with little or no associated contextual information, to 10,000 to 20,000 sq ft of museum floor space that contains an exhibit, to a robust website, to an entire curriculum that includes lessons, data sets and classroom ready experiments and tools that are deployed throughout an entire school district. Learning materials and products and training materials and products usually refer to materials that are ready for use by their intended audience, while learning resources usually refer to the individual pieces that are used to construct the final, audience-ready materials.

[j] Information liaisons: professionals who bridge science, applications and education disciplines through their knowledge of subject matter, available resources within a subject area and the professional practices of scientists, applied users and education disciplines. They broker the stories of information and science translators to education professionals.

[k] Information and science translators: individuals skilled in the translation of complex and abstract scientific and technical concepts into tangible concepts using stories and visual aids that are meaningful to educators and the public.

information can make a unique contribution. Materials produced through the information translation and story development capability will serve as a major source of content for these enhancements and additions. These enhanced and new learning materials and programs will use IOOS information within the context of state and national science, mathematics, technology and geography standards[l]; will be developed to be incorporated into existing learning programs within the broader Earth-geography-space system education community; and will support the needs of local education leaders (Recommendation 3 & 23). Resulting exemplary systemic education efforts and education practices that support local communities will guide subsequent systemic education efforts that incorporate ocean and Earth system data and concepts. They are prime candidates for propagation throughout the network (Recommendation 22).

At the postsecondary level, curricula will be developed and deployed that are aligned with the documented work force needs (Recommendation 21). Industry innovators and professional organizations representing current and future employers will be encouraged to help shape the curricula within the documented needs. Members of the community and organizations like those listed in footnote "i" will be key to developing and deploying these curricula materials. A wide array of allied industries will also be exposed to the potential business opportunities associated with IOOS and introduced to companion career development and staff training programs (Recommendation 25). The intent is to match the growth of the work force demand to the supply of skilled professionals, and to assist employers and skilled professionals find each other, especially in the early stages when the opportunities and skilled work force are limited.

Special attention will be given to developing materials and programs that will attract, nurture, develop and retain populations underrepresented in the science and technology work force.

During creation and enhancement of all learning materials, at all learning levels and in all learning environments, special attention will be given to developing materials and programs that will attract, nurture, develop and retain populations underrepresented in the science and technology work force and in ocean careers specifically (Recommendations 19 and 20).

The community will also develop and deploy materials to build awareness among STEM and geography educators about the education network and learning resources available for IOOS information assets (Recommendation 24).

Expanding the Work force and Postsecondary Community; Developing Awareness of Careers (Phase III, Recommendations 26-30)

At this phase, education efforts will expand the work force and postsecondary education area (Figure 6). Specifically, professional societies will be engaged to sponsor, and develop with others, professional certification programs for specific career areas[m] and to offer short courses in these areas (Recommendation 26). Once the demand for this work force is established, efforts with the U.S. Department of Labor will strive to develop and adopt occupational classifications that align with the developing ocean science and technology career fields (Recommendation 27). These changes will permit, for the first time, routine tracking of careers allied with ocean science and technology at the national level[n]. The demographic changes in the country will be tracked, and learning materials and programs will be adjusted, as needed, to address these changes in demography (Recommendation 28). Efforts to develop the awareness and knowledge of careers associated with IOOS will be expanded among students, parents, educators and workers as these careers and the required skills and abilities mature (Recommendation 29). Efforts to identify and implement reward structures for observing system staff and community members who contribute to or participate in education will be refined and intensified (Recommendation 30). Finally, efforts that build community, support and develop the professional practice of educators, and infuse new content into learning programs and materials will continue to be developed, improved and expanded.

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[l] Most states have learning standards in science, mathematics, technology and social studies and geography (http://www.statestandards.com/ or http://www.education-world.com/standards/index.shtml) that are based on companion national standards: National Science Education Standards (NSES) (19), National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics (15), National Educational Technology Standards (1), and the National Geography Standards (8).

[m] Including for example, The Oceanography Society (TOS), Marine Technology Society (MTS), American Meteorological Society (AMS), Institute for Electrical and Electronic Engineers (IEEE), Association of Computing Machinery (ACM), American Society of Civil Engineers (ASCE), Marine Advanced Technology Education MATE), National Society of Black Engineers (NSBE), American Indian Science and Engineering Society (AISES), Society for Advancement of Chicanos and Native Americans (SACNAS), Society of Hispanic Professional Engineers (SHPE). Most are currently active in this area and all have a vested interest in certification programs.

[n] Our current ability to project work force needs (size, location, skills, supply, salary, etc.) for ocean science and technology careers is extremely limited because there are no occupational classifications for these careers and, therefore, they are not tracked in the national labor statistics.

Chapter 6: Achieving Lifelong Ocean Learning

When the recommendations and plan laid out in the previous two chapters (Chapters 4 and 5) are fully implemented there will be a vital and extensive network of educators who are knowledgeable and actively engaged in using ocean observing assets to further lifelong learning of the oceans and aquatic systems within the Earth system. Americans of all ages, geographic locations, and socioeconomic backgrounds will have multiple, daily opportunities to experience the ocean. Through these educators an expanding number of Americans will have developed an understanding of the importance of the oceans and the allied science and technology in their lives. The actions of these informed Americans will reflect this understanding through stewardship of our Earth system and its oceans, and they will encourage their children and grandchildren to successfully master subjects required to pursue ocean science and technology careers. The work force development effort will be well underway and beginning to produce the skilled work force that is needed to build, sustain and evolve all aspects of the integrated ocean observing system, including the education efforts in this plan, and the spin-off, for profit enterprises that will rely upon this observing system.

This is an ambitious yet feasible long-term plan that can be achieved with modest new investments. It contains a sustainable long-term strategy that engages communities at all levels (local, regional and national) to address long-developing and slow-to-reverse challenges in our labor markets and to our national economic welfare and security.

"Children (of the baby boom generation) are not choosing careers in science and engineering in the same numbers as their parents" while the "number of jobs in the U.S. economy that require science and engineering training are growing…."
National Science Board (22)

Because IOOS is a sustained, long-term effort with significant local involvement, there is a real opportunity to achieve the IOOS education goals. One of the nation's biggest education challenges is sustaining, expanding and updating exemplary education efforts and facilities. IOOS education will serve in a small way as a demonstration of the benefits that can be achieved by a sustained education effort, that starts small and expands with time, that is allied with a major national operational science and technology capability, that is strategically focused and implemented, and nationally coordinated.

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"Any significant increase in the number of U.S. citizens who become scientists and engineers requires sustained long-term commitment."
(National Science Board) (22)

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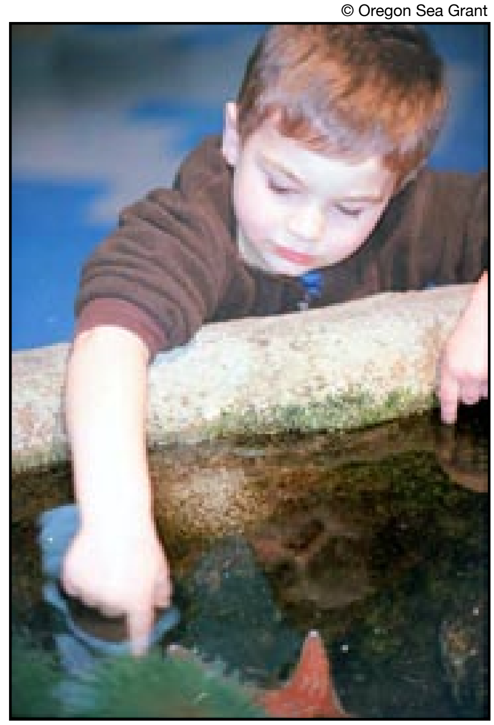
ACRONYMS

Acronym	Meaning
ACM	Association for Computing Machinery
AGU	American Geophysical Union
AISES	American Indian Science and Engineering Society
AMS	American Meteorological Society
ANN	Adult Numeracy Network
ASCE	American Society of Civil Engineering
ASLO	American Society of Limnology and Oceanography
ASTC	Association of Science-Technology Centers
AZA	American Zoo and Aquarium Association
COOS	Coastal Ocean Observing System
COPRI	Coasts, Oceans, Ports and Rivers Institute
COSEE	Center for Ocean Science Education Excellence
DLESE	Digital Library for Earth System Education
DMAC	Data Management And Communications
EPA	Environmental Protection Agency
ESL	English as a Second Language
ESOL	English Speakers of Other Languages
ESSE-21	Earth System Science Education in the 21st Century
GLOBE	Global Learning and Observations to Benefit the Environment
GoMOOS	Gulf of Maine Ocean Observing System
IEEE	Institute for Electrical and Electronic Engineers
IOOS	Integrated Ocean Observing System
IT	Information Technology
LEO-15	Long-Term Ecosystem Observatory
MATE	Marine Advanced Technology Education
MTS	Marine Technology Society
MUSPIN	Minority University SPace Interdisciplinary Network
NAGT	National Association of Geoscience Teachers
NAI	National Association for Interpretation
NASA	National Aeronautics and Space Administration
NCGE	National Council for Geographic Education
NCTM	National Council of Teachers of Mathematics
NERRS	National Estuarine Research Reserves System
NEP	National Estuary Program
NESTA	National Earth Science Teachers Association
NGA	National Geographic Alliance
NMEA	National Marine Educator Association
NMSP	National Marine Sanctuaries Program
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NSBE	National Society of Black Engineers
NSDL	National STEM Digital Library
NSES	National Science Education Standards
NSF	National Science Foundation
NSTA	National Science Teachers Association
ONR	Office of Naval Research
ORION	Ocean Research Interactive Observatory Networks
PL	Product Line
QA/QC	Quality Assurance/Quality Control
SACNAS	Society for Advancement of Chicanos and Native Americans
SHPE	Society of Hispanic Professional Engineers
STEM	Science, Technology, Engineering and Mathematics
TOS	The Oceanography Society
UFC	Uniting Functional Category
USGS	United States Geological Survey



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APPENDICES

Attendees

IOOS, COOS and Education Workshop
March 22-24, 2004 – Charleston, SC

Name	Institution
Brian Allee	University of Alaska
Janet Campbell	University of New Hampshire
Raj Chaudhury	Norfolk State University
Luis Cifuentes	Texas A & M University
Vicki Clark	Virginia Sea Grant
Robert Costello	Smithsonian Institution
Stephen Coleman	Monument School
Susan Cowles	National Institute for Fluency and Literacy-Science & Numeracy
Beth Day	NOAA
Annette deCheron	Bigelow Laboratory for Ocean Science
Sandy Eslinger	South East Coastal, Ocean Observing Regional Association
Madilyn Fletcher	University of South Carolina
Ira Geer	American Meteorological Society
Terri Hathaway	North Carolina Sea Grant
Linda Hayden	Elizabeth City State University
Sandra Henderson	University Center for Atmospheric Research
Debbie Hernandez	State of South Carolina
Lynne Hinkey	NOAA
Amy Holt-Cline	University of New Hampshire
Atziri Ibanez	NOAA
Claire Johnson	NOAA
Jennifer Jolly Clair	South Carolina Sea Grant
Paula Keener-Chavis	NOAA
Bernadette Kelley	Florida A & M University
Cyndy Leard	University of Florida
Jon Luke	Oregon State University
Pauline Luther	Environmental Distance Learning
Kate Madin	Woods Hole Oceanographic Institution
Christine Manninen	Great Lakes Commission
Mary Marlino	University Center for Atmospheric Research
George Matsumoto	Monterey Bay Aquarium Research Institute
Jean May-Brett	State of Louisiana
Janice McDonnell	Rutgers University
Carrie McDougall	NOAA
Blanche Meeson	Ocean.US
Flavio Mendez	Maryland Science Center
Jim Nelson	Skidaway Institute of Oceanography
Jan Newton	State of Washington
Shelley Olds	University Center for Atmospheric Research
Margaret Olsen	University of Georgia
Cheryl Peach	University of California/Scripps Institution of Oceanography
Scott Pegau	National Estuarine Research Reserves
Ashanti Pyrtle	University of South Florida
Tim Reed	San Francisco State University
Bob Ridky	U.S. Geological Survey
Lisa Rom	National Science Foundation
Sarah Ross	NOAA
Cathy Sakas	NOAA
Sarah Schoedinger	Consortium for Oceanographic Research and Education[1]
Tom Shyka	Gulf of Maine Ocean Observing System
Chris Simoniello	University of South Florida
David Smith	US Naval Academy
Liz Smith	Old Dominion University
Barbara Spector	University of South Florida
Lundie Spence	North Carolina Sea Grant and South East COSEE
Fritz Stahr	OceanInquiry
Bob Stewart	Texas A & M University
Stephen Stewart	Michigan Sea Grant
Deidre Sullivan	Marine Advanced Technology Education Center
Carrie Thomas	North Carolina State University
Sharon Walker	University of Southern Mississippi and J.L. Scott Aquarium
Lynn Whitley	University of Southern California
Eric Wiebe	North Carolina State University

1 Now at NOAA Office of Education and Sustainable Development

IOOS-COOS and Education Workshop
March 22-24, 2004
NOAA Coastal Services Center, Charleston, SC

OBJECTIVES
- Initiate an education network associated with IOOS-COOS
- Develop a set of community recommendations and strategies for formal and informal education efforts, and for sustained incorporation of those efforts into the Integrated Ocean Observing System
- Identify exemplary components of existing websites relevant to IOOS-COOS education.

DELIVERABLES
- Report of community recommendations and strategies to be incorporated into the planning for the U.S. Integrated Ocean Observing System.
- Report on Web accessible data analysis and visualization tools applicable for education and identification of exemplary education efforts using scientific data
- Community resolution: Agree to form a network to further the national objectives in science and technology education using the oceans and the IOOS infrastructure as the uniting element

SPONSORS
- Ocean.US
- SouthEast Center for Ocean Sciences Education Excellence
- SouthEast Atlantic Coastal Ocean Observing System
- NOAA Coastal Services Center
- South Carolina Sea Grant Consortium

IOOS-COOS and Education Workshop
AGENDA

Monday, March 22

7:45 AM *Gather in lobby of the Hampton Inn on Meeting St. for transport to NOAA Coastal Services Center*
- Vans DEPART at 8:00 a.m.
- Directions to the Center are at www.csc.noaa.gov/text/direct.html

8:30 *Arrival, sign-in, and continental breakfast*

9:00 *Welcome and Workshop Overview*
Purpose: Participants know what is expected of them and how their efforts fit into the larger IOOS context.

9:35 *What is the Integrated Ocean Observing System?* — *Tom Malone, Ocean.US*
Purpose: Establish a common background.

10:15 *Break*

12:00 Lunch

1:00 PM *The Manipulatives of Geoscience Education: Data Visualization Tools and Technologies in the Classroom* — *Raj Chaudhury, Norfolk State U*

1:40 *Identification of Web Capabilities Suited for IOOS-COOS Education*
Purpose: Examine websites to expand exposure to existing capabilities and to identify capabilities for potential use in IOOS-COOS education.

3:15 *Break*

3:30 *Report Out from Web Exercise*
Purpose: Share, compare, and contrast different groups' findings

4:50 *Summary of Day's Events*
Purpose: Summarize progress and conclusions

5:05 *Break*

5:30 *Dinner followed by*
Science Education: Charting Tomorrow's Course Today — *Jean May-Brett, President, National Marine Educators Association*

8:00 PM *Van transportation back to the Hampton Inn*


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Tuesday, March 23rd

7:45 AM — *Gather in lobby of the Hampton Inn on Meeting St. for transport to NOAA Coastal Services Center*
- Vans DEPART at 8:00 a.m.
- Directions to the Center are at www.csc.noaa.gov/text/direct.html

8:30 — *Coffee and Refreshments at NOAA*
Sign-up for Airport Shuttles on Wednesday

9:00 — *Review and Preview*

9:15 — *Education and Communications Framework for Ocean Education*
Purpose: Provide the context for the group's recommendations and strategies for IOOS-COOS education

9:50 — *National Education Issues and Opportunities: What Are They and Where and How Can IOOS-COOS Make a Meaningful Contribution?*
Purpose: Participants identify, within the ocean education framework, the national education issues and challenges that IOOS and COOS are uniquely suited to address

10:30 — *Break (during break out session)*

12:00 — *Lunch and Speaker*
Blending Ocean Research & Education: A View from the Bottom of the Food Web — *Annette deCheron, Education Director, Bigelow Lab for Ocean Science*

1:30 PM — *Report Out of Education Issues and Opportunities*
Purpose: Exchange results from each groups' discussion, and stimulate ideas and dialog on those findings

2:45 — *Break*

3:00 — *Recommendations, Strategies, and Goals that Enable IOOS-COOS Education to Address National Education Issues*
Purpose: Groups develop recommendations and strategies to address critical issues and challenges from previous brainstorming session

4:45 — *Reflection and Wrap-up*
Purpose: Ensure that everyone is still on the same page. Identify if we are on track. Have any items surfaced that require a change of plans?

5:00 PM — *Adjourn. Van transport to Hampton Inn. Dinner on your own in Charleston*

Wednesday, March 24th

7:45 AM — *Gather in lobby of the Hampton Inn on Meeting St. for transport to NOAA Coastal Services Center.*
- Vans DEPART at 8:00 a.m.
- Directions to the Center are at www.csc.noaa.gov/text/direct.html

8:30 — *Coffee and Refreshments at NOAA*
Verify Airport Shuttle Transport for Today

9:00 AM — *Review of the Day's Objectives*

9:15 AM — *Building the Network: Future Involvement and Roles of the Participants*
Purpose: Participants outline how they would like to contribute in the future and what they would like their role to be in building the network. Show support for building the network by signing the community resolution.

9:45 — *Return to Breakout Groups from Previous Day: Continue Developing Recommendations and Strategies*
Purpose: Complete draft documents of workshop deliverables

10:00 — *Break as Needed*
Continue Drafting Recommendations and Strategies

12:00 — *Lunch*

1:00 — *Share Recommendations and Strategies, Review Collection, and Define Next Steps*

2:00 PM — *Conclude*

IOOS-COOS and Education Workshop
FACILITATION PROCESS

The workshop used a facilitated participatory process that allows the participants to develop a comprehensive understanding of the issues that the IOOS Education Implementation Plan should address, generate a number of options and strategies to include in the education strategy, and select those that best meet the needs of education within the context of the IOOS environment. The process incorporated methods to promote future communication and interaction among participants.

The facilitation process involved three steps.

1. *Understanding the Present Situation.* Presentations and discussions provided an overview that moved participants toward a common understanding and vocabulary of ocean observing systems. Participants experienced firsthand the different perspectives of educators, data providers, and researchers through discussions and demonstrations of the utility of observing system information and tools. This information was used to ensure that all of the necessary perspectives were addressed and incorporated into the planning efforts.

2. *Identification and description of the desired, or optimal, education plan for IOOS.* Participants reviewed existing observing system tools, information, and delivery methods. Using this information, and the needs of the user and provider groups (from the previous step), the group identified required components and features of an IOOS education program.

3. *Selection and development of strategies to incorporate the best practices, tools, and methods into the IOOS education efforts.* Participants incorporated their knowledge of IOOS education needs and existing tools, issues, and challenges to select those features, characteristics, and strategies that should be included in a IOOS-COOS education plan. Subgroups then developed recommendations for the IOOS-COOS education plan.

Websites and Display Tools for Examination

The websites listed here are illustrative of the scope of sites that display georeferenced scientific data and analysis tools ready for the classroom or use by the public. They are sorted into four categories based on site contents.

Select three websites, one from each of the first three categories. You will have 60 minutes to review all three sites. If you finish early, select another site from the list. Use the review guides (Appendix D) to identify components in each site that are of particular value to IOOS and COOS education.

COOS, COOS-Type and IOOS Sites

Southeast Region

- *South East Atlantic Coastal Ocean Observing System (SEACOOS)*
  http://www.seacoos.org/
- *Coastal Ocean Research and Monitoring Program (CORMP) (NC, Cape Fear River)*
  http://www.uncw.edu/cmsr/cormp/
- *Sustained Ecological Research Related to Management of the Florida Keys Seascape (SEAKEYS) (primarily biological data)*
  http://www.coral.noaa.gov/seakeys/index.shtml
- *Coastal Ocean Modeling and Prediction System (COMPS)*
  http://comps.marine.usf.edu/
- *South Atlantic Bight Synoptic Offshore Observational Network (SABSOON)*
  http://www.skio.peachnet.edu/research/sabsoon/

Mid-Atlantic Region, including Bermuda

- *Bermuda Test Bed Mooring (Ocean Physics Lab, UCSB)*
  http://www.opl.ucsb.edu/btm.html
- *COOLroom (Rutgers University and Project Leo)*
  http://www.thecoolroom.org/data/data_main.htm
- *Chesapeake Bay Observing System (CBOS)*
  http://www.cbos.org/

Northeast Region

- *Gulf of Maine Ocean Observing System (GoMOOS)*
  http://www.gomoos.org/
- *Coastal Ocean Observation and Analysis (COOA)*
  http://www.cooa.unh.edu

Great Lakes

- *Great Lakes Observing System (GLOS)*
  http://www.glc.org/glos/
- *Great Lakes Environmental Research Laboratory*
  http://www.glerl.noaa.gov/data/
- *Great Lakes Information network (GLIN)*
  http://www.great-lakes.net

Coastal California

- *Center for Integrative Coastal Observation, Research and Education (CI-CORE)*
  http://www.mlml.calstate.edu/cicore
- *Center for Integrated Marine Technologies (CIMT)*
  http://cimt.ucsc.edu/siteNew/about.html

Gulf of Mexico Region

- *Texas Automated Buoy System (TABS)*
  http://tabs.gerg.tamu.edu/Tglo/
- *Texas Coastal Ocean Observing Network*
  http://dnr.cbi.tamucc.edu/wiki/TCOON/HomePage

National in situ Observing Databases

- *NOAA Coastal US*
  http://nowcoast.noaa.gov/nowcoast_intro.htm
- *NOAA Coastal Ports U.S. (Physical Oceanographic Real-Time System)*
  http://www.co-ops.nos.noaa.gov/d_ports.html

Open Ocean

- *Hawaii Air-sea Logging Experiment, A Long-term Oligotrophic Habitat Assessment*
  http://hahana.soest.hawaii.edu/hot/hale-aloha/ha.html
- *ARGO Part of the Integration Global Observation Strategy*
  http://www.argo.ucsd.edu/
- *Tropical Atmosphere Ocean Project*
  http://www.pmel.noaa.gov/tao/

WebBased Data Sets with Educational Context

- *EARTH Project*
  http://www.mbari.org/education/EARTH/
- *Pelagic Predators*
  http://www.mbari.org/education/EARTH/Pelagics/pelagics.htm
- *River Run COOS data and water quality monitoring*
  http://www.uncwil.edu/riverrun/
- *Ocean View Ocean buoy data with archive retrieval and comparison*
  http://www.uncw.edu/oceanview/
- *Investigating the Ocean Inquiry based learning materials using remote sensing data*
  http://www.science-house.org/nesdis/
- *Water on the Web Uses water quality data collected by volunteers*
  http://wow.nrri.umn.edu/wow/
- *CoolClassroom Uses COOS and satellite remote sensing data*
  http://www.coolclassroom.org/home.html
- *Discover Our Earth Section on sea level rise*
  http://atlas.geo.cornell.edu/education/student/getting_started.html
- *The Gulf Stream Voyage Inquiry based learning materials*
  http://www.k12science.org/curriculum/gulfstream/index.html
- *Global Learning and Observations to Benefit the Environment (GLOBE) (Student collected data and remote sensing data at participating schools; International)*
  http://viz.globe.gov/viz-bin/home.cgi
- *Monterey Bay National Marine Sanctuary (Learning materials and visualizations)*
  http://www.mbnms-simon.org/
- *Watersheds (Learning materials for teachers, parents and students)*
  http://www.watersheds.org/

- *Interactive Environment–Watersheds Weather broadcaster on-line program; (Sections on coasts and coastlines using Chesapeake Bay)*
  http://wrc.iewatershed.com/
- *Exploring Earth (Companion website to high school Earth system science textbook; lessons, data, visualizations, etc.)*
  http://www.classzone.com/books/earth_science/terc/navigation/home.cfm
- *Mission Geography (A comprehensive geography curriculum for k-4, 5-8, 9-12)*
  http://missiongeography.org/mgonline.htm
- *Learning from Satellites–Space Available (Gulf of Maine Aquarium)*
  http://octopus.gma.org/surfing/
- *Event Based Science Remote Sensing Activities (Middle school Earth system science curriculum that uses events to establish relevance of science topics; inquiry through images, data and activities)*
  http://mcps.k12.md.us/departments/eventscience/rs.index.html
- *The Asian Monsoon and Data Assimilation (Password for Teacher's Guide is raindrop)*
  http://csc.gallaudet.edu/monsoon/
- *OBIS Sea Map (Tracking of sea turtles tagged with GPS transmitters)*
  http://obis.env.duke.edu/outreach/
- *Loggerhead Sea Turtle Tracking*
  http://www.graysreef.nos.noaa.gov/turtletag.html
- *Signals of Spring (Middle to high school classroom program; students use current Earth mission data to explain the movement of animals tracked by satellites)*
  http://www.signalsofspring.net/

Other Data, Mapping and Display Sites

- *Chesapeake Bay Buoy Data (Local to Virginia with education materials)*
  http://www.vims.edu/resources/realtime.html
- *Oregon Coastal Atlas*
  http://www.coastalatlas.net/
- *Census of Marine Life and Ocean Biogeographic Information System (OBIS)*
  http://www.iobis.org/
- *Ocean Surface Topography from Space (Education materials)*
  http://topex-www.jpl.nasa.gov/education/education.html
- *El Nino*
  http://www.jpl.nasa.gov/earth/ocean_motion/el_nino_index.cfm
- *Earth Observing System Data Gateway (Access to satellite data from NASA Earth science missions)*
  http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/
- *NASA: Scientific Visualization Studio (Click on Science Stories for images and animation, e.g., Hurricane Isabel)*
  http://svs.gsfc.nasa.gov/stories/index.html
- *NOAA NESDIS*
  http://www.nesdis.noaa.gov/datainfo.html
- *Earth Observatory (Earth system science stories with visuals and animations)*
  http://earthobservatory.nasa.gov/
- *SeaWiFS (Ocean color data and related materials)*
  http://seawifs.gsfc.nasa.gov/

Data Display and Analysis Tools for Downloads

- *WorldWatcher (Simple What if modeling scenarios can be created and run by students)*
  http://www.worldwatcher.nwu.edu/software.htm
- *MyWorld (Designed for use in middle school through college classrooms; adaptation of GIS software)*
  http://www.worldwatcher.northwestern.edu/myworld/
- *NIH Image (A public domain image processing and analysis program for the Macintosh)*
  http://rsb.info.nih.gov/nih-image/Default.html
- *Image J (The Java version of NIH Image that runs under all popular operating systems)*
  http://rsb.info.nih.gov/nih-image/Default.html
- *STELLA (A student data and modeling tool designed to build students' skills in developing understanding—utilizes simulation to engage students and an icon-based language to describe models)*
  http://www.hps-inc.com/stellaVPed.htm
- *Studying Earth's Environment from Space (SEES) (Designed for high school and undergraduate educators and students)*
  http://www.ccpo.odu.edu/SEES

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Guiding Questions - Web Examination

The purpose of this exercise is to identify websites with scientific data and Web features that are of potential use in IOOS and COOS education materials.

Website Title_______________________________ **Website/URL** _________________________________
Team Members____

Part A: primarily Ocean Observing System sites that provide data

1. Website Target
a. Who appears to be the target audience for this website?
b. Can educators use this website as it is?
c. Does this website provide data in a form that a curriculum developer could use for curricula, or that an informal or "free choice" educator could use in learning materials?
d. Can you determine from the website the source of data (i.e., platform, instrument, and sensor) and how these data were handled?
e. What do you like or dislike about this site for use in education?
2. Dynamics of the Site
a. Are there special features on this website that you find valuable for education, such as interactive animations, graphical organizations, concept maps, graphs, etc?
b. Can you easily find your way around the site, i.e., are the functions of the options and buttons clear?
c. How difficult is it to use the tools or software on the site? Do you have any estimate of the scale-up time to learn to use the site or tool?
d. Were there parts of this site that just did not work or function for you?
3. Data and Image Visualization
a. Do you think that any of the visualizations are appropriate for students or youth? Can you select an area or a time span to examine in detail?
b. Are the images clearly displayed and can you determine what the symbols mean? Can you tell what you are looking at?
c. On this Are archival data available?

Part B: Webbased data sets with educational context

1. Website Target
a. Who appears to be the target audience for this website, e.g., teachers, precollege students, the public, etc?
b. How easy can this website be used in the classroom or in a free-choice venue? Is it designed for independent use by youth, teachers or adults?
c. Does this website provide data in a form that a curriculum developer or an informal or free-choice educator could use in learning materials?
d. Can you determine from the website the source of data (i.e., platform, instrument, sensor) and how these data were handled?
e. What part of this site could be reused for IOOS-COOS education?
2. Dynamics of the Site
a. Are there special features, in this website, that you find valuable for education, such as interactive animations, graphical organizations, concept maps, graphs, etc.?
b. Can you easily find your way around the site, i.e., are the functions of the options and buttons clear?
c. How difficult is it to use the tools or software on the site? Do you have any estimate of the scale-up time to learn to use the site or tool?
d. Were there parts of this site that just did not work or function for you?
3. Data and Image Visualization
a. How well do you think the visualizations or other features support the learning objectives of this site?
b. Can a student explore the topics, on this site, in greater depth? Is there a glossary and background materials, etc?
c. Are the images clearly displayed, and can you determine what the symbols mean? Can you tell what you are looking at?
d. Can the student or user interact with the site (e.g., select parameters, dates, times, etc.)?
e. Does this site contain archival as well as real-time or near real-time data?
f. If this site is intended for K-12 use, is there any reference to national or state standards?

Part C: Other Web based uses of scientific data sets

1.	**Website Target**
a.	Who appears to be the target audience for this website?
b.	Can educators use this website as it is?
c.	Does this website provide data in a form that a curriculum developer, or an informal or free-choice educator could use in learning materials?
d.	Can you determine from the web site the source of data (i.e., platform, instrument, sensor) and how these data were handled?
e.	What do you like or dislike about this site for use in education?
f.	What on this site could be applied to COOS/IOOS education efforts?
2.	**Dynamics of the Site**
a.	Are there special features that you find valuable for education on this website, such as interactive animations, graphical organizations, concept maps, graphs, etc.
b.	Can you easily find your way around the site, i.e., are the functions of the options and buttons clear?
c.	How difficult is it to use the tools or software to handle the data? Is it an appropriate tool for education audiences? Do you have any estimate of the scale-up time to learn to use the site or tool?
d.	Were there parts of this site that just did not work or function for you?
3.	**Data and Image Visualization**
a.	Do you think that any of the visualizations are appropriate for students or youth? Can you select an area or a time span to examine in detail?
b.	Are the images clearly displayed and can you determine what the symbols mean? Can you tell what you are looking at?
c.	On thi□ Are archival data available?

Modified from Janice McDonnell: CoolClassroom

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Education Issues and Opportunities: Topics, Guiding Questions and Group Responses

Work force Development and Diversity (Careers & Personnel)

How do we recognize that a position is marine relevant? One in six positions are marine relevant.

What types of skills and knowledge will be needed to build, maintain, and use IOOS?

1. Ocean sciences (physical, biological, and chemical oceanography; fisheries; remote sensing; etc.)
2. Data specialists (management, analysis, statistics, etc.)
3. Ocean engineering (design, technical support, electronics)
4. Aeronautical engineering
5. Communications (Web, media, videography, journalism, evaluation)
6. Social science (organization skills, facilitation and mediation, cultural, political sciences, teamwork, etc.)
7. Navigating bureaucracy, policy, law
8. Education (pedagogy)
9. Administrative support
10. Modeling at undergraduate level

What careers and jobs will be available now and in the future?

Now: Administrative, ocean field support, materials engineering, 2-year technical to PhD positions
Future: Same as above but significant increase in opportunities, there is a mis-match in time.

How will individuals find out about these careers?

1. Web: online job data base
2. Networking: e-mail lists and networks, mentors, contacts
3. Education system: university outreach programs, faculty classroom visits (k-14), high school guidance counselors
4. Demonstrate opportunities: provide information where interested individuals will go
5. Media and publications
6. Job fairs
7. Advertise that numerous opportunities exist at 2-year undergraduate and above levels
8. Need to begin with children to increase awareness of the oceans
9. Work force size, stability, and number of jobs are issues because these are significant unknowns
10. Private sector may be important employer (value added products), mentoring via private sector, non-US citizen education; global IOOS assets, inquiry based testing
11. Issues that will impact the above efforts are stability of funds and ability to maintain the functions.

What sort of education or training might be required?

1. Same as above but significant timing mismatch in increased opportunities
2. Previous emphasis on PhDs (oceanography at graduate level mainly)
3. Community Colleges—Marine Technology and Education Center (MATE)
4. Other avenues of training through agencies
   (1) Dept. of Labor ($$): worker retraining and various acts
   (2) Dept. of Agriculture with fishermen and retraining
5. Teacher undergraduate education and continuing education and professional development
   (1) Need to be multigrade level and multidisciplinary
   (2) New paradigm: Teaching + Learning + Assessment creates a new emphasis on assessment
   (3) Changes in education teaching methods: focus on testing learning and understanding (an inquiry based approach) rather than on testing facts
   (4) Turnover rate and mobility of educators creates problems and increased opportunities for education through ocean science
   (5) Need for teacher education programs for undergraduate science majors

How does the current demographic in science and technology careers compare to the current demographic of the US work force, and what is the trend over the next 5 to 10 years?

It doesn't: Technical is skewed—white male
Education (K-12)—female

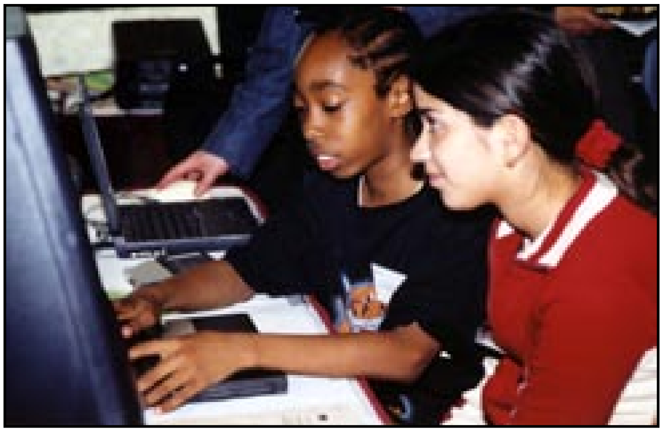
Trends:
(1) Many females in biology; few in engineering, remote sensing, and physical sciences;
(2) More females are getting PhD degrees, few are getting and retaining faculty positions
(3) Overall impression: data exist to determine trends

What are the underlying causes of any disparity?

1. Academia may not be appealing to women: tenure vs. family
2. Lack of exposure to those with ocean jobs
3. Math education is not sufficient
4. Financial incentives have not kept pace with other career opportunities
5. High achievement students targeted
6. Few connections to community colleges
7. Access to technology and computers is limited in many environments
8. A small work force with few role models and therefore limited exposure to ocean careers
9. Lack of sustained funding (federal and state) for schools in economically depressed areas
10. Today most ocean science and technology positions are at advanced levels (not basic level)
11. Highly competitive field
12. Primary and secondary education does not include ocean science in most of the country; many teachers lack the knowledge to make the connections between the oceans and the learning standards
13. Lack of financial incentives
14. Lack of exposure to oceans
15. Lack of technical access.

What incentives or motivations exist to attract individuals of all types to IOOS related careers?

1. Mentoring and near-peer; intensive and expensive per capita; limited in number of participants



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2. Role models are needed
3. Training and education: focus is on college students. This is probably too late because the socioeconomic filter has already kicked in   Performance based encouragement
4. Ocean Science Bowl (take advantage like Alaska and others—applied sciences; students are mentored by teachers; involve native villages (high school)
5. Precollege institute (6th grade programs that start students on a college track)
6. Informal learning opportunities and experiences: SeaWeek—brings kids to the seashore and builds upon that experience; youth groups—4-H, Girl Scouts, Boys & Girls Clubs; aquaria and museum programs.

Contribution to Science Education Improvement

The National Science Education Standards (NSES) spell out the science education areas that need improvement and they detail the improvements that are needed. Are there areas where IOOS-COOS[1] is uniquely suited to contribute?

1. Challenge of incorporating inquiry—*messy (intellectually various types of inquiry)*
2. Investigations over extended periods of time
3. Integration of science concepts and process skills within a context that is relevant to the learner
4. Has to matter to the learner
5. Apply result of experiments to scientific arguments/ explanations
6. Understanding from global perspective; regional context can provide a gateway to global perspective; *incorporate* physical, biological and social components
7. Identify useful products derived from national data sets
8. Teachers need confidence in their knowledge and inquiry ability; requires multiple skills

Which IOOS assets might be used to influence science education at the local, state and national levels (i.e., purpose, policy, programs and practice)?

1. Ability to compare and contrast local to regional to global perspectives
2. Technology: instrumentation, communications, data management, product creation
3. Cross-disciplinary integration
4. Seven goals of IOOS define topics of socioeconomic relevance
5. Education is integral part of IOOS planning process—*ocean and coastal community is invested in IOOS*
6. Provide vehicle for bridging instruction into nonscientific disciplines for broader audience appeal
7. Visualizations and their impact
8. Oceans of interest to all
9. IOOS program to be user driven; regional associations engage local communities
10. Data
11. Promotes understanding of phenomena; interpreting data, adding context, and addressing "So what?"
12. Enhanced relationship between colleges of education and research enterprises within academia

Are the assets more appropriate for a particular grade level, learning venue or sector of the education system?

Formal (Grade)

K-4: Oceans of interest to all; engaging students at local level lends itself to cross disciplinary learning; ability to compare and contrast local to regional; connect to topics of local (i.e., backyard) interest

5-8: Technology; visualizations at local, regional and global scales; ability to compare and contrast regional to global; connect to topics of local interest

9-12: Seven goals of IOOS define topics of socioeconomic relevance; provide vehicle for bridging instruction into non-scientific disciplines for broader audience appeal; connect to topics of local interest; Access to data.

13-Graduate: Cross-disciplinary connection to scientists; Ocean and coastal community is invested in IOOS; promotes understanding of science in a context that matters thereby bridging instruction into nonscientific disciplines for broader audience appeal; connects to topics of interest; access to data; promotes understanding of phenomena; interpreting data, and addressing "So what?"

Educator Professional Development: Visualizations; local engagement promotes understanding of science in a context that matters; promotes understanding of phenomena, interpreting data, adding context, and addressing "So what?"

Work Force

Vocational: Technical connection to science and scientists; technology through instrumentation, communications, data management, product creation; education is integral part of IOOS planning process—ocean and coastal community is invested in IOOS; regional associations engage local communities

Continuing Education for Local, State and Regional Decision Makers: Visualizations; seven goals of IOOS define topics of socioeconomic relevance; promotes understanding of phenomena and interpreting information in context that matters

[1] Ocean means ocean, coastal, estuarine, and watersheds feeding the ocean

Informal

Learning Centers: Visualizations; seven goals of IOOS define topics of socioeconomic relevance, promotes understanding of phenomena and interpreting data in context that matters

Multiple Media: Visualizations; seven goals of IOOS define topics of socioeconomic relevance, promotes understanding of phenomena and interpreting data in context that matters

Youth Programs: Visualizations; seven goals of IOOS define topics of socioeconomic relevance, promotes understanding of phenomena and interpreting data in context that matters; ability to compare and contrast local to regional to global perspectives

Application and Access to IOOS Information Assets for Education

How might education use IOOS-COOS information assets?

1. International observing systems focus on Earth's climate and ecology
2. Case studies to translate why we should be studying oceans
3. Ocean sciences contribute to and demonstrate standards
   a. Science content areas: Physics, biology, chemistry, Earth science, geography and social studies, mathematics
   b. Biotic and abiotic factors
   c. Systems fitting together
   d. Context for educators in the standards
   e. Regional associations might translate the NSES to state standards
4. Gap: taking research into informal education
   a. Exhibits, brochures, educational materials
5. Career paths to be defined
6. Equipment – what it is? How to use it?
7. Gap: Communication: stories are not there
   a. Press releases, etc.
   b. Coordinated effort across IOOS is needed
   c. Marketing
   d. Policy makers (targeted and coordinated approach to ensure a consistent message)
8. Hands-on *citizen scientists* using the assets
9. Brief information messages on the equipment (land based), who to contact for more information
10. Visibility to the public
11. Ocean public engagement is a gap and a solution
12. Congress should be informed about what is happening in their district or state and how IOOS affects them. A consistent message is essential.

Where or whom in education might use these assets?

Everyone: Kindergarten through retired persons
(See Figure 4 in Chapter 4)

What are the benefits and opportunities to the education community that uses IOOS-COOS information assets?

1. Using educators to spread *science* to the public
2. The oceans are the *last unexplored frontier* on Earth
3. Comparison from region-to-region (e.g., ecosystem-to-ecosystem)
4. IOOS provides a view into our own backyard while linking our backyard to the whole Earth system
5. Use IOOS to address NSES and state learning standards by formal and informal educators
6. Opportunity for positive messages about the ocean rather than the negative messages often conveyed (e.g., pollution, global warming, coral bleaching).
7. IOOS-COOS provide opportunity to promote personal ownership and stewardship of the oceans. Need to clearly distinguish between stewardship and advocacy.

What are the limitations or constraints affecting the use of IOOS-COOS information assets by education? And why?

1. Technology capabilityand limitations of educators and education and communication audiences
2. Lack of ocean science integration in NSES
   a. Textbooks, other materials, etc
   b. Lack of professional development of teachers who are not prepared to teach ocean science
3. Context: Data alone are not interesting or relevant
4. Most scientists are not interested in ocean education
   a. This is an important systemic issue and should be addressed by many groups, e.g., COSEE, CORE, etc. (see issues of group addressing *Participation of IOOS-COOS Members in Education* for details)
   b. Scientists and technologists need to be receptive and supportive, and they need to be supported and rewarded for their efforts.
5. Time and money (for both educators and scientists)
   a. No unfunded mandates
6. Lack of up front collaboration with educators when writing proposals.
   a. Funding agencies must walk-the-talk. Education criteria must be an integral part of proposals and proposal writers must be strongly encouraged to use educators when writing the proposals
   b. Agencies do not adequately cover educational components of funded work (proposals need to budget adequate funds for education)
7. Mutual limited awareness of unique language, acronyms, terminology, and lingo of science and education
8. Proprietary use of data
   a. Scientist may limit access to data so educators can't use it. This is an important issue and it needs resolution at a much higher level. For example, categories of data could exist such that core data streams have unrestricted access, while those from investigators' individual scientific instruments have proprietary access
   b. There are national security issues for some data
9. Recognition of education and service activities of scientists and engineers by academic institutions in promotion and retention (e.g., tenure decisions).

Participation of IOOS-COOS Members in Education

In what education activities do IOOS-COOS members (e.g., individual researchers, data managers, or associations) participate?

1. Technical support (data, managers, marine, physical, etc.)
2. Science community (researchers + engineers)

3. Professional societies and foundations
4. Industry
5. Citizen groups–contribute data.

What are the benefits to education from this participation?
1. Improving citizen literacy of ocean and Earth systems
2. Infusion of current research into education
3. Making education more relevant to work force needs
4. Curriculum enhancement, reform methodology
5. Define Earth system science (Earth science and ocean science)
6. Increase internship opportunity and provide externships and mentors
7. Teacher professional development
8. Technical infusion to education (applied)

What are the benefits and motivations to individual IOOS-COOS members for this participation?
1. Builds consistency, increase supports and visibility, advocacy, and policy
2. Science gets out faster to a wider audience
3. Builds awareness for careers to attract good people, to ultimately improve Ocean Observatory Systems
4. Financial benefit to satisfy criteria of funding agency or federal mandates
5. Support and visibility for agency
6. Seeing affects and results
7. Audience enthusiasm and appreciation

What are the issues or obstacles that limit and prevent participation of IOOS-COOS members in education?
1. Ability to sustain participation; funding
2. Researchers lack reward for outreach activity
3. Mismatch between research field of expertise (language and focus)
4. Education seen as add-on—need to revise paradigm
5. Lack of educators with expertise in math and science
6. Reluctance of researchers to release data
7. Researches understanding of appropriate detail

Building Awareness of IOOS-COOS Education Within the Education Community

What is the current awareness level of IOOS-COOS education assets within the education community?

Awareness matrix (awareness from low to high)
Motivation and flexibility vary from Formal education to Public Engagement

Audience	Ed Assets	Assets
Formal	low	low
Informal	low-med	med
Non-formal	low	low-med
Stakeholders (users)	med	high
**Public Engagement*	low	low

* Take advance of the media

What actions by IOOS-COOS members (e.g., individual researchers, data managers, and associations) have contributed to this awareness?
1. Pilot programs—LEO 15, CoolClassroom
2. Engage COSEE—Web, newsletters, regional workshops
3. Press releases and websites with releases
4. Clearinghouses with data—NSDL, DLESE, COSEE
5. Partnerships—Networks with informal and non-formal educators
6. Criteria 2 @ NSF—NSF proposals
7. Workshops—community (this one), science and technology professional society meetings (e.g., ASLO, MTS, AGU, etc.), NSTA, NMEA, Teacher Leader Institute (train the trainers)
8. More education translators

What prevents or limits awareness of, and participation in, IOOS-COOS education efforts by the education community?
1. Inertia; human resistance to change and bureaucratic nature of education in USA
    a. Researchers and data
        i. Not public until *published.* Internal reward structure for researchers is missing
        ii. Not read by teachers
        iii. Lack of awareness of public archives and published data
    b. Teachers
        i. Lack of understanding of science, process, and technique or who does what
        ii. Lack of "Curriculum" definition—people to develop materials
        iii. Needs a team of skilled curriculum writers and contributors not individuals
        iv. Who will teach the teachers? Help them to learn and have the confidence to ask questions (See Jean-May Brett's talk, online at Ocean.US website).

Strategic Areas Planning Worksheets
Guiding Questions

1. **Current topic or issue.** Provide a 2-3 word "title" and briefly describe (2-3 sentences) the issue to be addressed.

2. **Final status.** What is the desired future condition of this issue or topic when it is resolved through IOOS-COOS education efforts?

3. **Intermediate steps.** What are the intermediate changes that will be needed in order to address this topic thoroughly? Number each one of these. If appropriate, identify the chronological order or a sequence in which these activities have to take place.

4. **Prioritize the changes listed in #3.** Changes that would contribute more towards moving the current situation toward the situation as described in #2 should receive higher priority than items that do not contribute as much. Changes that must occur in a particular sequence should be addressed as a single item. (Use multiple votes – each person gets 3-5, depending on the length of the list).

5. **Priority actions or strategies.** Starting with the change that received the most votes, brainstorm possible actions that IOOS and COOS could take to make each change. Once you have completed a list of actions for that change, move on to the change that received the second most votes, etc. Get as far as you can in the time allotted.

6. **Rank the actions.** If time allows, rank the actions according to how feasible they are given the constraints of time, money, political will, and technological capabilities. Each person gets 3 votes.

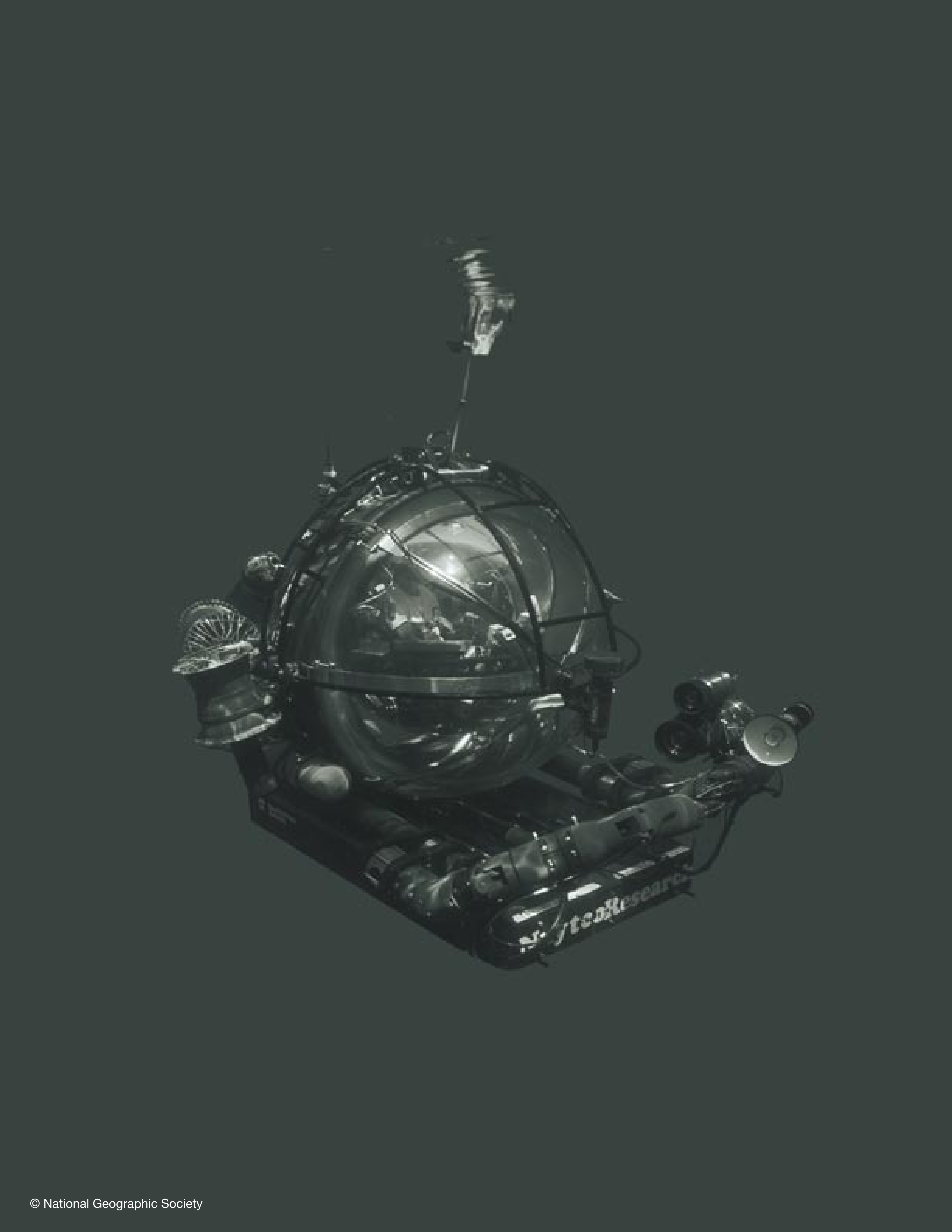
Recommendations and Strategies to Address Each

From the worksheet that was completed on each topic, fill in the following information as directed.

GOAL
The **goal** of IOOS and COOS education strategies to address ______________________________ (topic or title from #1 on worksheet) is (complete with the description of the resolved situation from **#2** on the worksheet) ____________________
____
____

STRATEGIES
In order for IOOS and COOS education strategies to address (topic) ______________________________, the IOOS and COOS education efforts may use the following **strategies** or actions (list these from the top selections in **#5** on the worksheet; including a brief
1-2 sentence description) ___________________________
____

OUTCOMES OR RESULTS
so that (list the most important changes that will occur in the issue or topic because of these strategies, as listed in **#3** of the worksheet) ___________________________________
____

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