

CENTER FOR OCEAN SCIENCES

EDUCATION EXCELLENCE

(COSEE):

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Executive Summary

The reform of science education during the past decade has called for the sciences to step forward with innovative pedagogy, particularly the integration of research and education. The Ocean Sciences community did not answer the call, even though their discovery that the ocean was a more critical driving force in the natural environment than previously thought possessed great educational significance. At the same time, the change in the nature of scientific problems toward more interdisciplinary formulations called for such naturally interdisciplinary sciences as the Ocean Sciences to step forward with new integrative concepts for teaching science. Once again, the Ocean Sciences community did not answer the call, even though they integrate the scientific study of almost three-fourths of the Earth's surface. Rich opportunities have been missed to provide the nation with high-quality education for all and to bring national attention to the role of the ocean in the quality of life, the economic development of the nation, and the national defense. A workshop held on May 23-26, 2000, was charged to recommend strategies by which the National Science Foundation (NSF) could develop a nationally coordinated effort to address this problem and improve and promote Ocean Sciences education for the benefit of society.

The collective recommendation of the workshop participants is for the establishment of a Center for Ocean Sciences Education Excellence (COSEE) as a nationally coordinated program for Ocean Sciences education in both formal and informal educational sectors. The workshop further recommends that COSEE consist of regional centers and:

- facilitate the integration of research into high-quality educational materials to engage the minds of students in the excitement of discovery and develop their interest into a mature understanding of the relevance of the ocean to their lives;
- promote the education of the public about the ocean and its influence on the quality of their lives and the prosperity of the nation;
- assist in developing curricula with core competencies for more effective education;
- encourage the investigation of teaching and learning in integrated sciences;
- foster the inclusion of groups traditionally underrepresented and underserved in science in order to draw on their new ideas and perspectives;
- encourage the sound preparation of teachers;
- provide opportunities for professional development of inservice teachers, undergraduate faculty, and administrators;
- assist in improving the reward structure for teaching, including faculty and graduate student teaching;
- encourage the effective use of information technology;
- establish internships;
- provide career information across the spectrum of the Ocean Sciences community;
- effect many of these changes by fostering collaborations and partnerships both among people and between organizations; and
- formulate strategies to evaluate these initiatives.

COSEE is envisioned as a portal, both physical and virtual, to information in the Ocean Sciences for educators, the public, and the news media. It would be the advocate for Ocean Sciences Education, from informal, through K-12 and undergraduate, to graduate education. It should be funded as a long-term commitment to educational change. Ocean Sciences educators need a portal to access ideas, information, and resources that connect and celebrate Ocean Sciences teaching, learning, and scientific discovery for all the education sectors. The COSEE portal should have high visibility and be identified as "the place to go first" for directions to opportunities and resources in Ocean Sciences education and professional development. Entrance to the portal should be available both "virtually" by the Internet and in person at a COSEE regional center. One recommended resource destination inside the portal is "Educational Materials." COSEE needs to establish broad goals and guidelines for a large

resource of educational materials before either inventorying existing Ocean Sciences education materials or fostering collaborations to develop new research-based materials. These goals and guidelines should be established in association with organizations experienced in this type of educational enterprise. The National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) are excellent examples of Ocean Sciences education. The Digital Library for Earth System Education (DLESE) provides technology for discovery and access of Ocean Sciences educational materials. COSEE could also benefit from collaboration with DLESE in developing review criteria for educational materials and other resources that are appropriate for Ocean Sciences materials. Further coordination with DLESE could ensure the accessibility, through DLESE, of Ocean Sciences data sets that are identified with the aid of COSEE facilitation as being useful educational materials. In fact, COSEE should explore the possibility of becoming a federated partner of DLESE. Another recommended destination through the COSEE portal is "Curricula" that bring the excitement of Ocean Sciences research into the classroom. Yet another destination should be a much-needed research-based technical assistance pathway for "Professional Development." Other destinations recommended are a highly visible "News Source" for the Ocean Sciences, particularly to the news media, and the "Promotion of Ocean Sciences Education" to foster a diversity of ways to bring knowledge about the ocean to the attention of the public. In short, this portal should be the entrance to a "meeting place" for all who share an interest in, and a passion for, the aquatic environment, both marine and freshwater.

The need for scientists to work with educators to enhance the general public's understanding of science has been promulgated for years in reports such as Science for All Americans and NSF in a Changing World. More recently, reports such as that by the Cabinet to the President of the United States, Turning to the Sea: America's Ocean Future, have stressed the need for ocean scientists and educators to improve the general public's understanding of the ocean and its role in their lives. To meet this challenge for informal education, COSEE should utilize the network ability of informal science institutions, such as aquariums, museums, zoos, and the National Estuarine Research Reserves, National Parks, and National Marine Sanctuaries, to enhance the Ocean Sciences literacy of the general public. This ability has been proven; COSEE coordination could supply added value. Although formal educational institutions also work to improve science literacy, the informal institutions are more neutral and non-threatening locations to the general public than are formal educational institutions, and they provide lifelong learning opportunities not always available through formal educational institutions.

The reform of science education has centered on grades K-12. The National Science Education Standards (NSES) provide the criteria for achieving the desired science literacy for all students. Yet, the Ocean Sciences are not represented in the examples of lessons and teachers in the NSES, even though one-half the population of the nation lives in the coastal zone. The Ocean Sciences are represented, however, in the American Association for the Advancement of Science's (AAAS) Benchmarks for Science Literacy, which is aligned with the content standards of the NSES. COSEE should assist teachers in involving students in the excitement of Ocean Sciences learning and discovery by assessing the availability of ocean research-based curricular materials, identifying exemplary materials aligned with the NSES and the Benchmarks, and ensuring they are available to teachers. Professional development programs in the use of these resources are likewise needed, as is the investigation of teaching and learning in integrated sciences such as the Ocean Sciences. COSEE should take the lead in infusing Ocean Sciences into high school curricula as a reality-based form of the integrated learning so important in achieving lifelong learning. Before encouraging new educational contributions, however, COSEE must inventory the contributions of existing Ocean Sciences outreach programs, for example, those sponsored by NASA, the National Sea Grant Program and its state programs, other programs within NOAA such as the National Estuarine Research Reserves and the National Marine Sanctuaries, the National Oceanographic Partnership Program (NOPP), and the Office of the Oceanographer of the Navy. COSEE must also identify other existing funding sources for outreach programs, beginning with the NSF Directorate for Education and Human Resources (NSF/EHR) and the Directorate for Geosciences (NSF/GEO). COSEE's efforts must also reach outside the classroom to assist teachers in combating students' disengagement from science by providing connections to appropriate role models, mentors, researchers, and career information. COSEE should particularly foster linkages

between the Ocean Sciences and traditionally underrepresented and underserved groups in science by assisting educators in providing services to them through social service agencies, community-based organizations, and informal education institutions. The coordination of informal and formal educators, which COSEE could facilitate, provides one of the richest sources for connecting with these populations.

At the undergraduate level, as in K-12 education, there is a demand for high-quality educational materials that COSEE could promote by coordinating the collaboration of researchers and educators, as NASA has done so successfully. There is also a need for faculty professional development in the use of these materials, in the use of innovative pedagogical methods, and in the use of instructional technology. The workshop endorses the urgent recommendations in the report *Shaping the Future* and urges COSEE to cultivate the interest of the Ocean Sciences community in the funding programs available through the NSF Division of Undergraduate Education (NSF/DUE) and NSF/GEO to implement some of these recommendations. The transition to undergraduate education should be seamless; a better understanding of how students learn integrated sciences would improve it. Ethnographic research reports that too many undergraduate students lose interest in science because of poor teaching. Poor quality is one of the deleterious effects on teaching that result from the far lower faculty (and graduate student) rewards for teaching than for research. COSEE should collaborate with higher education organizations to enhance the value of teaching in higher education. Indeed, COSEE could serve as a national forum on this and other issues in undergraduate education in the Ocean Sciences, including curricular issues, courses for preservice teachers, core competencies, continuing-education linkages among faculties at two-year and four-year colleges and universities, and recruitment and retention of traditionally underrepresented and underserved groups.

The training of everyone who teaches Ocean Sciences must be improved, not only the undergraduate faculty previously mentioned, but preservice and inservice teachers as well. Appropriate incentives should be established for the collaboration between faculties of Education and Ocean Sciences so the preparation of preservice teachers ensures that they graduate with sound Ocean Sciences content knowledge and instructional strategies, including field and laboratory experience. These future teachers will be part of the two million new teachers needed nationally in this decade. Similar faculty teams should design teacher enhancement/professional development programs for inservice teachers that span several years as research-based, technical assistance pathways. Professional development opportunities should also be offered for school and district administrators as critical support for the COSEE teachers at the regional level. A few funded programs in support of these goals already exist in NSF/EHR.

Encouraging Ocean Sciences researchers to consider the educational value of their results, even when that value may be rated low by their research colleagues, and then providing them with access to educational collaborators is a major challenge. COSEE could provide the forum for scientists, educators, the media, policy makers, and community leaders to bring the excitement of discovery and the process of research in the Ocean Sciences to students and the public, which in turn could enhance public support for Ocean Sciences research on a national level. These collaborations would be strengthened if scientists understand the needs of educators and together they select appropriate data and transform them into useful products. The NASA NOVA Program is one model. During this process, educators learn both the content and context of scientific information, and the research results are more accurately infused into the curricula. The emphasis should be the production of exemplary material. Whatever the information technology used, there is a recognized need for facilitation in access to the technology, funding for the required capabilities, changes in technology, and coordination with digital libraries.

Ocean scientists and educators need an infrastructure to encourage and facilitate interactions among themselves, and with other groups, as a critical first step in attaining excellence in Ocean Sciences education. The workshop endorses the emphasis on such collaborations and partnerships in other national reports, such as NSF in a *Changing World*, the NSF strategic plan. COSEE should play a vital role in arranging these interactions. For example, in developing new educational resources based on research data, COSEE could identify critical topics and organize workshops for the collaboration of scientists and educators on these topics. COSEE should be expected both to organize collaborations with the media to advocate Ocean Sciences and to form linkages with

the media to supply resources for news events. Liaisons should be maintained with the large Ocean Sciences research programs, the Federal agencies that have educational outreach programs, congressional staff members and policy makers, and particularly with the cultural leaders of underrepresented groups.

Within the traditionally underrepresented groups in the Ocean Sciences, women have made great strides in the last twenty years and account for the majority of undergraduate majors and graduate students in many institutions. Nevertheless, COSEE should collaborate with established organizations to enhance the professional growth and advancement of women in the Ocean Sciences. The near absence of African Americans, Hispanics, Native Americans, and Pacific Islanders in the Ocean Sciences is in stark contrast to the relative success of women and must be corrected in order to bring fresh perspectives and new talents into the study of the Ocean Sciences. This goal is a national priority with separate programs already existing through NSF/GEO, the NSF Division of Ocean Sciences (NSF/OCE), and the Office of Naval Research (ONR). Even so, more effort and better coordination among current efforts are needed. These students could be introduced to aquatic systems early in their schooling and be able to enter programs that will keep them from disengaging from science. Informal learning experiences to expose these students to appropriate role models and ocean scientists could be incorporated into these programs. Students at all levels should be encouraged to share their accomplishments with the local community, particularly a local minority community, and a special COSEE Minority Ph.D. Program should address the lack of minority students in Ocean Sciences graduate education.

Internships are popular with all students because internships place students closer to the real world of the subject than is possible in the classroom. Several organizations offer existing Ocean Sciences internships, Sea Grant being but one. Internship opportunities in the COSEE program, however, should be broader. They could extend from middle school to graduate education, and be particularly targeted at community colleges and minority-serving institutions, where access to research experiences and laboratory equipment is limited. In addition, teachers, faculty at small colleges, government employees, and other Ocean Sciences personnel who wish to increase their understanding of the Ocean Sciences or improve their capabilities can benefit from internships. Not all internships should be research-based. Internships can also provide experience in a particular work environment, such as an aquarium, museum, science center, or governmental agency. Career information, in addition to internships, should be integrated into the entire educational program, across all sectors. Even so, the nature of the information or the manner of its delivery can be expected to vary with the level of education. Whether the issue is internships or other career information, COSEE should promote the needed incentives for faculty participation in these programs.

Evaluation of each of the educational initiatives undertaken by COSEE should be a high priority. This evaluation could provide COSEE with a unique opportunity. COSEE could formulate strategies to address problematic issues of evaluation across all science education, not just Ocean Sciences education. In this manner, it could then take a leading role in reviewing, developing, implementing, and refining high-quality, flexible, and testable evaluation tools by using the integration of Ocean Sciences research and education as a case study. The results of this case study could be used by the science education community at large. Thus, through COSEE, the NSF could lead and redefine evaluation standards of excellence for all research-education initiatives in the sciences.

Although the organizational structure of COSEE was not a topic for discussion at the beginning of the workshop, a possible organizational structure had evolved by the conclusion of the workshop. The consensus was that COSEE should consist, at least in part, of Regional Centers, distributed across the U.S. and formed by consortia representing as many educational sectors of the Ocean Sciences as possible. Several advantages for ease of public access favor the location of Regional Centers at informal education sites and in sites among large populations of traditionally underrepresented groups. By being regional, these "Ocean Sciences Learning Communities" could more easily leverage resources available at this operational level. Additional benefits were noted for having a small, central office in Washington, D.C., that could maintain liaisons with NSF and other Federal agencies and provide national coordination for the Regional Centers. The advisory boards for COSEE, whether regional or national, should represent as many stakeholders as possible. Above all, COSEE must be a unifier of the Ocean Sciences education and research communities. It can provide external credibility to local

educational programs in all education sectors. It must strive to ensure a seamless continuation of lifelong learning from preschool informal education, through kindergarten to graduate school, and throughout adult informal education. Its efforts must include creating a "sense of ownership" to foster change in all the sectors of Ocean Sciences education from its beginning so that it will be deemed relevant by all sectors, thereby alleviating the segmentation that has impaired the effectiveness of Ocean Sciences education during the last decade of the 20th century.

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Introduction

Background

During the last decade of the 20th century, science education in the United States underwent the first changes in a major reform, following recommendations in national reports such as The Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993), National Science Education Standards (NSES) (National Research Council, 1996a), and Shaping the Future (National Science Foundation, 1996). These changes are continuing and are, by now, familiar to educators from kindergarten to graduate school, at least by name: inquiry-based learning rather than passive learning, integration of scientific research and education, understanding interconnecting themes rather than isolated content, learning with new technology, and other similar advances.

The Ocean Sciences would seem to have been a natural choice to lead this reform. After all, whether referred to in the plural as Ocean Sciences and "multidisciplinary" or in the singular as Ocean Science and "interdisciplinary," the science of the ocean is very broad, touching on all of the traditional scientific disciplines. This characteristic fits the statement about teaching science that "Science should be considered as intrinsically multi-disciplinary" (National Research Council, 1997). The Ocean Sciences can thus overcome the disadvantage attributed to the disciplinary sciences that "...their divisions do not necessarily match the way the world works, and they can make communication difficult" (American Association for the Advancement of Science, 1990a, p. 9). It is the Ocean Sciences, rather than science in general, that could have been the subject for the educational guideline in the NSES that "Curricula often will integrate topics from different subject-matter areas..." (National Research Council, 1996a, p. 23).

The intrinsic human interest in the ocean that is expressed in various creative human activities, from art to literature to navigation, should readily enable a teacher to implement the directive that "Science should be integrated with other areas of the curriculum" (Natural Science Resource Center, 1997, p. 68). Ocean Sciences research into the underwater realm of popular mystery, as well as the scientific unknown, should provide entry for students at all levels into compelling inquiry-based education, as the JASON Project (See Appendix 8 for description) has demonstrated. In addition, "The exciting thing about the ocean is that its science is virtually all [*italics in the original*] relevant to societal needs-quality of life, economic development, national security, education...." (Watkins, 2000, p. 214). Yet, in spite of all the advantages for leadership that one can identify for the Ocean Sciences, they have not been in the forefront of science education reform, in any education sector: informal, K-12, undergraduate, or graduate. Indeed, "Oceanography as a field has missed out on the chance to lead the burgeoning interest in interdisciplinary education even though oceanography is inherently interdisciplinary" (Nowell, 2000, p. 198). Opportunities were lost.

The interdisciplinary character of the Ocean Sciences has been more of a weakness than the strength it should have been in education. People teaching Ocean Sciences have had no common forum for the exchange of experience, ideas, and educational materials. Most Ocean Sciences teachers in K-12, unlike teachers of biology and physics, did not major in the science they teach and thus lack the biologist's or physicist's professional connections to, and understanding of, the science taught. In fact, the K-12 teachers, and informal educators, may choose to join the National Marine Educators Association (NMEA), whereas Ocean Sciences faculty in higher education are more likely to join the National Association of Geoscience Teachers (NAGT). Worse, while a marine geologist or geophysicist may publish, read, or secure teaching resources from the Journal of Geoscience Education, the chemical oceanographer will turn to the Journal of Chemical Education. Until very recently the biological oceanographer has not had a research reason to attend a meeting, let alone an educational session on integrating research and education, of the American Geophysical Union (AGU), nor the marine geophysicist a meeting of biological oceanographers at the American Society of Limnology and Oceanography (ASLO). The interdisciplinary strength of the Ocean Sciences in research has not carried over into education.

Further segmentation of the Ocean Sciences is demonstrated by the established network of informal education institutions, such as aquariums, museums, science centers, and marine laboratories that are so important to Ocean Sciences education. The educational efforts of these institutions represent the primary contact of Ocean Sciences with the public, but the efforts are noticed little, if at all, by researchers, who are removed from these efforts. In addition, any research scientist who wishes to begin sharing his or her research results with the public or students has no obvious organization or office to approach for guidance or assistance in this unfamiliar task, which itself will likely not be encouraged or accorded high value by research colleagues. Moreover, the location of some of the major Ocean Sciences research institutes away from university campuses has distanced their researchers from changing pedagogical concepts in the classroom. The location of ocean scientists has another drawback. For unlike the wide geographic distribution of researchers in most other scientific disciplines, the location of most Ocean Sciences researchers in coastal states renders them largely inaccessible to teachers in non-coastal states, which represent approximately forty percent of the U.S.

The Ocean Sciences lack a coordinated effort in education. Even when well-planned attempts have been made at coordinating Ocean Sciences activities, as through the admirable National Oceanographic Partnership Program (NOPP), the results have not covered all the sectors of Ocean Sciences education. (It should be noted that there indeed are individuals in all Ocean Sciences education sectors who are bringing change to their learning environments, but to paraphrase a report from the National Research Council (1996b, p. 6), "[Ocean Sciences] education will not change in a permanent way through the efforts of 'Lone Rangers'.")

Some of the deleterious results of the present condition in Ocean Sciences education are: (1) the results of Ocean Sciences research are not readily available for use in informal or formal education, either to engage the innate human interest in the sea for the study of science or the environment or as a context for the study of basic scientific principles; (2) the imagination of precollege students is not captured to engage them in a lifetime of experiential science learning; (3) arresting images of the effects of ocean processes on the climate, coastal land use, or other aspects of the quality of life are not routinely made available for use in instructing students or the public on rational decision-making about the ocean environment; (4) the Ocean Sciences do not appear as case studies in such education guidebooks as *The Liberal Art of Science: Agenda for Action* (American Association for the Advancement of Science, 1990b) or *Science Teaching Reconsidered: A Handbook* (National Research Council, 1997); (5) the Ocean Sciences are not used in examples of lessons or teachers in the NSES, even though forty percent of the U.S. population lives in the coastal zone; (6) the naturally integrated Ocean Sciences are neither proposing new integrative concepts for teaching science nor investigating how students learn integrated sciences, and (7) of all the sciences, the Ocean Sciences have exerted the least effort to improve education through the support of the NSF Division of Undergraduate Education (NSF/DUE).

Perhaps the greatest opportunity lost by the Ocean Sciences has been to use the results of Ocean Sciences research to develop new concepts of science content for teaching science. Consider this: even though the ocean was already considered a natural system in the classic textbook, *The Oceans*, in 1942, and even though in the 1970s the theory of plate tectonics, as developed from studies of geomagnetism in the ocean basin, revolutionized our thinking of the Earth as a whole system, and even though the exciting and enlightening research in Ocean Sciences since then could have led to a systems-based paradigm for teaching Earth science, the opportunity was missed. Instead, in the early 1990s, a committee of the National Aeronautics and Space Administration (NASA), including some ocean scientists and using the results of space research, conceived of "Earth System Science" (ESS) as an approach to the interdisciplinary study of the natural science and human dimension of the Earth.

In Earth System Science the Earth is studied as a system undergoing global change due to both Earth-generated and human-generated processes and for which much of the research data is derived from the remote sensing of parameters of the present-day environment. The teaching of Earth System Science has increased in undergraduate science departments in the nation over the past ten years and is now being introduced into secondary education. It is a systems framework to teach Earth science, including the atmosphere, the solid Earth, and the oceans.

The number of baccalaureate degree programs in Earth System Science is increasing. Recommendations that "The future for oceanography [baccalaureate programs] may lie in much stronger linkages to other geosciences..." (Nowell, 2000, p. 199) may be interpreted as a call for the elimination of oceanography programs. The absence of undergraduate degree programs would diminish the strength of Ocean Sciences education. "The undergraduate level plays a pivotal role. It is the conduit through which research can reach the Nation's schools" (National Science Foundation, 1995, p. 29). The Ocean Sciences missed the opportunity to develop a systems-based study of the Earth because there was no coordination of Ocean Sciences education. What other educational opportunities lie concealed in the fascinating, integrative results of Ocean Sciences research? What might their discovery enable students and the public to understand better about the ocean? The better society understands the ocean, the better off the nation is. As the Report on the Interagency Partnership Initiative states:

"Whether from the perspective of national security or quality of life one can argue that the US' advanced understanding of the oceans has been central to our stature as a world leader throughout most of this century" (Consortium for Oceanographic Research and Education, 1996, p. ii).

Research in the Ocean Sciences provides many opportunities to bring the excitement of discovery and the process of scientific research to students and the general public. Today is a time of renewed interest in the sustainability of our "water planet" and a time when humankind is faced with vital decisions about the use of our marine and coastal environments. Yet, ocean scientists have failed to integrate their research activities successfully into the education process, and an opportunity has been missed to engage students and the general public in the Ocean Sciences. The Ocean Sciences community continues to miss opportunities available for funding educational projects. Numerous programs exist that could fund some of the recommendations in this report, such as the programs in the NSF Directorate for Geosciences (NSF/GEO), Directorate for Education and Human Resources (NSF/EHR), and the NSF Crosscutting Programs, but the Ocean Sciences community does not submit enough excellent proposals to these programs to improve the quality of Ocean Sciences education.

All these missed opportunities can be summarized thusly: the Ocean Sciences do not have a nationally coordinated education program to enable them to meet the goals of achieving education excellence in all sectors and promoting the integration and dissemination of new knowledge for the benefit of society. Meeting these goals is crucial to the health of the Ocean Sciences and to the well-being of society. A workshop was conducted on May 23-26, 2000, by The University of Southern Mississippi's Institute of Marine Sciences at the USM-Gulf Park Campus in Long Beach, Mississippi, to recommend strategies by which the NSF could develop a nationally coordinated effort to meet these goals.

Workshop Goal and Charge

The charge to the workshop was:

"to create a document that recommends strategies for the National Science Foundation and other Federal agencies to use in a nationally coordinated effort to improve and promote Ocean Sciences education in response to the opportunities identified by this workshop."

The objectives of the workshop were:

- to determine the Ocean Sciences educational opportunities in three of the four sectors of Ocean Sciences education: (Informal education, K-12 education, and Undergraduate education),
- to prioritize these opportunities within each sector,
- to explore opportunities common to more than one sector in order to integrate strategies, and
- to recommend strategies by which these opportunities could be addressed.

(Graduate education was not considered specifically because NSF already provides significant support through science grants for graduate students to participate in research. Nevertheless, some recommendations responding to the national call for broader graduate education are offered in [Appendix 5](#).)

Workshop Structure

On March 3, 2000, the Co-Chairs and the Steering Committee met with staff from the National Science Foundation Division of Ocean Sciences at the National Science Foundation in Arlington, VA. Background information was provided by NSF representatives from the Division of Ocean Sciences; the Division of Undergraduate Education; the Division of Elementary, Secondary, and Informal Education; and the Directorate of Geosciences. The main objectives of the meeting were to determine the audiences from which the participants of the workshop would be invited ([Appendix 1](#)) and to formulate the guiding questions for the workshop (listed below).

The workshop began on the evening of May 22 with a reception and dinner at the Gulf Park Campus of The University of Southern Mississippi in Long Beach, MS. (The agenda is in [Appendix 2](#).) Seventy-three participants, and some invited observers, attended. The participants represented informal, K-12, and undergraduate Ocean Sciences education and Ocean Sciences research. (A list of participants is in [Appendix 3](#).)

On the morning of May 23, Dr. G. Michael Purdy, Director of the Division of Ocean Sciences, introduced the keynote speaker, Dr. Margaret S. Leinen, Assistant Director of the NSF, Directorate for Geosciences. Dr. Leinen stressed the need for the workshop to provide the leadership that would assist NSF in developing Ocean Sciences education excellence. She also made clear the challenges for Ocean Sciences education, including the general lack of understanding of science by non-scientists, the difficulty of teaching such a highly interdisciplinary science, and the existence of a very large portion of the nation that is not near, and hence lacks a practical interest in, the ocean. She stressed the challenge to increase diversity in the Ocean Sciences—a major challenge because there are fewer members of traditionally underrepresented groups in the Ocean Sciences than in any other science or engineering field. However, Dr. Leinen also pointed out opportunities to meet these challenges, such as by developing partnerships and using instructional technology with pedagogical creativity.

After the charge to the panels, the participants met in seven panels of the Ocean Sciences education sectors to determine the needs and priorities of Ocean Sciences education for these stakeholders. The panels were: Informal Ocean Sciences Education, K-8 Ocean Sciences Education, Grades 9-12 Ocean Sciences Education, Undergraduate Ocean Sciences Education, Teacher Preparation and Teacher Enhancement/Professional Development, Ocean Sciences Research and Information Technology, and Education of Traditionally Underrepresented Groups. The Steering Committee facilitated the panels' discussions and reported the panels' findings to the entire group of workshop participants at the end of the day. The Co-Chairs and the Steering Committee then discussed the panel reports to identify "Common Threads" that were woven throughout conversations among all the panels.

On May 24, Dr. Dorothy L. Stout, Program Director, NSF Division of Undergraduate Education, informed the workshop of the Division's various funding programs for improving undergraduate education, many of which are prospective sources for funding recommendations in this report. Then a Likert scale evaluation was administered to ascertain participants' opinions relative to the effectiveness of the workshop, and to obtain information in a manner timely enough to facilitate improving the workshop "mid-course." On a scale of 1, 2, or 3—with 3 being most positive—an average of 85% of all comments were most favorable, i.e., 3s. Of the remaining comments, 14% were at the mid-point, with an average of 1% below the midpoint. The items most responsible for the lower ratings were related to: (1) Time—participants frequently felt rushed, and wished to have additional time to discuss the issues at hand; and (2) Objectives—within the item relating to clarity of objectives, 24% of the respondents indicated a mid-point score, with 2% rating clarity of objectives at the lowest level (note: this 2% represents one response.) After

this formative instrument was tallied, workshop facilitators rescheduled portions of the program to accommodate the need for additional discussion time, and introduced each "break out" session with a restatement of the program objectives.

The participants were divided into seven "Common Thread" panels on the basis of threads identified in the panels' reports of the day before: Collaborations, Linkages, and Liaisons; Ocean Sciences Education Portal; Evaluation/Validation; Training and Professional Development; Curriculum Development and Educational Materials; Careers; and Internships. The Steering Committee facilitated these panels and at noon reported to the entire group of workshop participants. The participants then returned to their original panels and used the information from the "Common Thread" panels to propose strategies that COSEE could use in addressing the opportunities provided by the earlier-determined needs.

After the Steering Committee presented final oral reports of their panels' work to the entire group of workshop participants the next morning, May 26, the workshop was adjourned. The Steering Committee then began writing the reports of their panels' deliberations, which continued until the afternoon of May 27. These reports were drafted by the Co-Chairs into the workshop report, which was reviewed, first, by the Steering Committee, and then by all the participants.

Guiding Questions for the Workshop Discussions

- Why does the general public need to understand and appreciate the oceans?
- Why is it important to involve K-12 students in the excitement of science discovery in the oceans through authentic or hands-on learning that is tied to the National Science Education Standards and the Benchmarks?
- What is the relevance of collaborations between scientists and educators (formal and informal)?
- Why do the "pipelines" need to connect Ocean Sciences with traditionally underrepresented and underserved communities?
- Why should advancements in Ocean Sciences technologies be brought to the attention of the general public?
- What is the value of identifying exemplary curricular materials and making them available through COSEE?
- Why do precollege students need to be exposed to career fields in the Ocean Sciences?
- Why is it important to communicate to students and the public the interpretations of research data and the relevance of those data to our lives?
- Why is it important to have continued fiscal support in connecting people to one another at a physical facility, as well as providing virtual connections for them?
- Why are internship opportunities needed for students (secondary, undergraduate, graduate, and postdoctoral)?
- Why are education and scientific research opportunities and high-quality professional development programs in the Ocean Sciences needed for precollege teachers (preservice and inservice)?
- Other identified needs

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Guidelines for Reading the Recommendations

The workshop recommendations are presented in two sections. The first section, "Recommendations by Educational Sector," are the recommendations for each sector of Ocean Sciences education: Informal, K-8, Grades 9-12, Undergraduate, Teacher Preparation and Teacher Enhancement/Professional Development (including undergraduate faculty), and Ocean Sciences Research and Information Technology. The recommendations consist of strategies for responding to the educational opportunities identified. The second section of recommendations, "Recommendations by Educational Threads," are recommendations that cross all sectors. A certain amount of redundancy is included for continuity. A Glossary ([Appendix 8](#)) explains abbreviations and certain other terms.

Recommendations by Educational Sector

The recommendations stem from the consensus of the workshop participants that a Center for Ocean Sciences Education Excellence (COSEE) should be established. Although the recommendations are strategies for COSEE to consider, the organizational structure of COSEE was not discussed in the full workshop until the final session. A summary of that discussion is presented in [Appendix 4](#).

Informal Ocean Sciences Education

Informal Education is the education of the public, whether in institutions such as aquariums and museums, through the news media, or at other public gatherings. The educational advantages held by informal science education institutions are derived from their ability to reach larger and more diverse audiences than any other category of educational institutions. (More than two-thirds of all U.S. residents visit a museum, aquarium, or zoo each year). These sites can attract both K-12 students, who spend more time outside of school than they do inside of school, and the aging population of the U.S., which has a growing interest in lifelong learning, the environment, and experiential learning.

Opportunity: To enhance the use of informal science institutions as a way to reach a larger and broader audience in more receptive ways than is possible with any category of formal education institutions.

Strategy: COSEE should endorse the power of the delivery network of the informal science institutions, enhance collaborations with researchers and formal education institutions at all levels, and promote adequate funding for these collaborative efforts. In grasping this opportunity, COSEE should explore the resources available for informal education in the NSF Division of Elementary, Secondary, and Informal Education (NSF/ESIE). The informal science institution network is a critically important element in achieving COSEE's goal of enhancing Ocean Sciences literacy of the public, but it is only one element in what should be an integrated, coherent educational system.

Opportunity: To exploit the high public trust in informal science education organizations and their accessible, non-threatening, safe, neutral qualities to pursue COSEE's goal of enhancing the Ocean Sciences literacy of the public.

Strategy: COSEE could supplement and assist in developing forums at informal Ocean Sciences education centers on topical issues in the news, bringing together researchers, educators, the media, and decision-makers to explore the issues and to identify and evaluate alternative ways of dealing with them.

Opportunity: To provide Ocean Sciences results and issues to the public on a timely basis in ways that are accurate, balanced, engaging, and educational.

Strategy: COSEE should: (1) Offer scientific expertise and content to assist informal science education organizations in the creation of Rapid Response exhibits that are accurate, engaging and educational and that can be distributed to a variety of venues (in addition to museums, aquariums and zoos) that attract large numbers of people, for example, malls, airports, train stations, and county and state fairs. These exhibits should be created through collaborations of leading researchers, educators, and exhibit designers. (2) Develop radio and TV spots through collaborations. (3) Educate ocean scientists to "speak out" through media technology to audiences in a variety of venues on a particular issue or discovery that is in the news, and then facilitate connections between ocean scientists and the news media.

Opportunity: To share a rich and expanding array of Ocean Sciences educational opportunities with increasingly diverse and expanding communities around the nation.

Strategy: COSEE should promote the creation and development of a network of diverse Ocean Sciences educational institutions to ensure that all opportunities are being exploited and needs met through cooperation and collaboration among institutions and through the concentration by an institution on those audiences it serves best. COSEE should also build long-term relationships with different communities through community-based organizations, faith-based organizations, and other groups, as appropriate.

Opportunity: To raise the awareness and appreciation of the richness and diversity of knowledge and personnel in the formal and informal Ocean Sciences education sectors and the Ocean Sciences research sector.

Strategy: COSEE should: (1) Launch a comprehensive and coherent public relations/marketing strategy, using the informal science network as a major distribution system because it attracts so many people each year. (2) Promote traditional and non-traditional careers in the marine sciences and demonstrate how important a knowledge of the Ocean Sciences can be in many fields, from law to medicine. (3) Bring Ocean Sciences educators together on a topical basis to develop and deliver new, important, timely programs in the Ocean Sciences.

K-8 Ocean Sciences Education

In grades K-8 children are filled with a love of learning. They overflow with questions in search of answers. Science is the most successful system ever devised by humans for answering questions about the world around us. It can engage these students and bring the real world into their lives. The excitement of the ocean and Ocean Sciences can be brought into their classrooms and start them along the path toward understanding that world.

Opportunity: To involve students in the excitement of Ocean Sciences learning and discovery.

Strategy: The depth, breadth, and richness of topics in Ocean Sciences allow teachers to cover learning objectives by addressing many student learning styles. The discipline itself affords students the opportunity to construct their own learning experiences, while also having the option of replicating the experiences of others. Providing hands-on experiences addresses all learning styles. Ocean Sciences is real, interesting, engaging, integrative, and relative, thus holding students' attention and enabling them to benefit from authentic learning experiences. The basic value of the Ocean Sciences is that the ocean is vital and students will later be involved

with it in some manner, directly as a professional related to the field or indirectly as a decision-making citizen.

It is imperative to consider the Ocean Sciences as an entity that must be multidisciplinary, hands-on, and relevant, but also tied to the National Science Education Standards and the Benchmarks. COSEE should promote the correlation of materials and programs with the NSES and Benchmarks to drive the curriculum, thereby determining the scope and sequence. COSEE could align itself with efforts underway by the American Association for the Advancement of Science (AAAS) to develop an Atlas of Science Literacy that shows the knowledge and skills students need in order to achieve particular science literacy goals. COSEE could also recognize the deficiency in textbooks reported by AAAS. The focus should be on key concepts and their connection to each state's standards. Using this approach, COSEE can help integrate the curriculum, make science relevant to daily life, and provide authentic and hands-on learning experiences. Thus, COSEE can help connect all people to the ocean in order for them to develop a sense of stewardship. Attaining this goal can cross into informal education. There are many existing K-8 (and K-12) camp style programs, such as SEACAMP, the Catalina Island Marine Institute (CIMI), and SEA (the Sea Education Association). COSEE could work with these informal educators to integrate the standards into their existing curricula and tap into yet another vast network of students and teachers.

In particular, COSEE should address the opportunity to enhance K-8 education by encouraging broad programs of staff development. These programs could seek funding for teachers to attend workshops for teacher-to-teacher recruitment; for teacher internships with other teachers, educational institutions, or researchers; and for promoting summer institutes for educators to learn about current Ocean Sciences topics. A special benefit that COSEE could provide would be the development of closer connections between teachers (and their students) and ocean scientists. Connections should be arranged, on the one hand, to engage scientists for classroom visits, activities, projects, and career information, and on the other hand, to create and maintain links between teachers and research ships and research facilities for opportunities to participate in the field or laboratories. Connections should also be encouraged to provide opportunities for students to link with research vessels via electronic field trips through Web-based links or broadcast and video, to link by e-mail with researchers in the form of "Ask an Oceanographer," and to link with scientists for career information. (Before undertaking an "Ask an Oceanographer" program, however, COSEE should coordinate with The BRIDGE and its "Ask An Oceanographer" site and the Office of Naval Research (ONR) and its "Ask the CyberScientist" site.) COSEE should promote summer, after-school, and informal programs (possibly involving the expansion of NSF GK-12 programs) and internships with opportunities for students to shadow Ocean Sciences professionals. To prepare these scientists for interaction with the students, COSEE could provide tips for making presentations to K-8 students, assist in the creation or identification of kits and materials to be taken to classroom presentations or other outreach opportunities, and encourage scientists to stress the diversity of careers (both academic and non-academic).

Opportunity: To identify exemplary educational materials and ensure they are available, whether from COSEE or through links from COSEE to DLESE or other digital libraries.

Strategy: Teachers need to know what Ocean Sciences materials and resources are available and how to obtain them. COSEE can provide this information by inventorying the contributions of existing Ocean Sciences outreach programs, for example, those sponsored by the National Oceanographic Partnership Program (NOPP), the Office of the Oceanographer of the Navy, the National Oceanographic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA). COSEE should also determine the usefulness and completeness of these materials. It could also determine any alignment with the National Science Education Standards and the Benchmarks, provide guidelines for textbook adoption, serve as a voice for teachers to reach publishers, and, as a resource center, preview pilot materials, furnish guidelines for use of curricula, promote professional development, and provide essential tools to meet the NSES and Benchmarks.

COSEE could provide "one-stop shopping" for teacher outreach opportunities, identify sources of expertise for educators, including supplementary background materials (information search pathways), and identify funding

sources for teacher training, development, and resources. With respect to funding sources, it should encourage proposals to the NSF Directorate for Education and Human Resources (NSF/EHR) and the Directorate for Geosciences (NSF/GEO). COSEE should create a climate for articulation among ocean scientists and educators. In this climate educators could be encouraged to interpret scientific information for general and K-8 audiences and to be involved in the initial phases of grant proposals. COSEE should facilitate collaborations both to produce traveling exhibits (to museums, malls, state fairs) and to produce exemplary educational materials. As a linking site, COSEE could provide Web "hot links" to other Ocean Sciences sites, education sites, and professional organization sites, and provide educators with links to arts, literature, history, and other areas that can supplement or be integrated into science curricula, thereby promoting the integration of science within the K-8 curricula. COSEE could also provide linkages to model schools that use an interdisciplinary approach with the oceans as a theme. It could also provide demonstrations of simple hands-on activities that can be completed at home or in the classroom; use existing platforms for Ocean Sciences education, such as Public Broadcasting System programs; and provide guidance to existing video materials. COSEE should partner with publishers and others groups at national educators' conferences to promote COSEE efforts.

Opportunity: To improve the "pipelines" that connect underrepresented and underserved groups with Ocean Sciences education.

Strategy: Underrepresented and underserved groups in science can be connected to the Ocean Sciences if COSEE will join educators in an effort to reach them by providing services for these students and their families through social services agencies, libraries, museums, nature centers, aquariums, and specialized programs. Another method for connecting is to disseminate hands-on kits for parents and guardians to use and learn from, along with their children. COSEE could assist teachers by promoting awareness about PBS, TV programs and specials, series like Bill Nye (The Science Guy), the Magic School Bus, and Kratts' Creatures, as well as educational videocassettes that portray realistic, quality content and graphic representations. The combined experience of informal and formal educators is one of the richest sources for connecting with these populations.

COSEE should establish regional linkages between formal and information education organizations, policy makers, and leaders of underrepresented groups. It should promote a National Ocean Week-underwritten by major corporations or foundations. The YMCA, YWCA, 4-H Club, local community and park recreation centers, Boys' and Girls' clubs, and scouting can be targeted for participation in National Ocean Week and beyond. (Note: a National Ocean Day already exists and took place on June 8, 2000, but the timing at the end of the school year prohibited many students from participating.) Radio, public TV, and other distance education media can be used to reach underserved communities. It is important to include (on the Web page) segments and streamed video clips of minorities studying, teaching, and conducting research in the Ocean Sciences in order to attract the attention of this population.

Opportunity: To expose K-8 students to the wide variety of careers available in the Ocean Sciences.

Strategy: It is essential to build an awareness of the wonderful planet on which we live, the world around us and to refute profession and career stereotypes, including gender stereotypes, in the process. Preparation that involves this exposure helps to promote decision-making and interest. COSEE should highlight careers via commercials and public service announcements. Information should include virtual experience and real-life experience for exposure to careers and Ocean Sciences disciplines. Scientists could be videotaped within the context of their workplace and research; this activity should also be related to other careers. COSEE should stimulate an interest for future generations, parent- or guardian-to-child, to become directly involved in the Ocean Sciences. There is a need to have an informed citizenry familiar with all areas directly related to the Ocean Sciences.

Grades 9-12 Ocean Sciences Education

Two crucial issues specifically affect today's students in grades 9 to 12 and result in their disengagement from science: (1) By grade 9, students are often completely disinterested in or are afraid of science. Can their interest be triggered and their innate curiosity rekindled by realizing that the oceans play a prominent role in their life and the life of the planet? (2) The population of students in grades 9 to 12 is especially at risk due to societal pressures and cultural and social barriers that deter them from pursuing scientific interests. As noted by Tiffany McWane, a junior at the School Without Walls in Washington, D.C., and a participant in the COSEE workshop, "Even when scientifically-engaged earlier in their lives, it becomes difficult for students to keep their love for science alive." Could the Ocean Sciences community play a role in reducing the loss of students interested in science?

Opportunity: To enrich personal experiences through collaborations that can affect students in all schools, in non-coastal as well as coastal states, in technologically or geographically isolated communities as well as urban magnet schools, and for underrepresented minorities and disadvantaged, high-risk students as well as mainstream students.

Strategy: COSEE should be able to direct educators to programs for students in grades 9 to 12 that are funded at the national and regional levels by the NSF Directorate for Education and Human Resources (NSF/EHR), Sea Grant, the Office of the Oceanographer of the Navy, the National Oceanographic Partnership Program (NOPP), the National Aeronautics and Space Administration (NASA), and other Federal agencies, state departments of education, and non-governmental organizations. COSEE would identify, assess, and inventory these programs. COSEE could specifically target and recruit underrepresented, high-risk students in grades 9 to 12 for internships in Ocean Sciences. COSEE should take the lead in long-term experiences (i.e., internships over several years or summers) and in tracking changes in the student development through these experiences. COSEE should identify and select critical Ocean Sciences themes for collaborative efforts between scientists and students, teachers and students, or media and scientists. For example, during the last few years of El Niño and La Niña, media coverage has allowed scientific understanding of the phenomena to penetrate the comprehension of the general public and students in a pervasive way.

COSEE should help develop, produce, test, and offer high-quality, "endorsed," educational materials, research experiences, courses, and programs, such as adapting the Chautauqua course format (See Glossary, Appendix 8, for definition.) for students in grades 9 to 12 and developing a hosting program that links parents or guardians and students from coastal states and non-coastal states. In the spirit of "Language Exchange Programs," to be immersed in a culture is to learn a culture.

Personal experiences for learners of all ages, and especially for students in grades 9 to 12, require that COSEE take into account the financial and poverty issues that render many students in the U.S. non-mobile. COSEE should plan to "take the oceans to the community rather than bring all communities to the oceans." Through the Internet, a virtual ocean, lake, or river can be brought into the classrooms and homes. The most disadvantaged students, however, are likely not to have the technology to access these remote experiences. Knowledge about the Ocean Sciences might be brought to the "forgotten schools" in the U.S. by means of traveling exhibits (real and virtual), speaker tours (scientists, educators and maritime professionals), and mobile van units with educational materials. Collaboration with informal educators will once again prove to be invaluable for COSEE, for these type of programs already exist with many informal educators. Their advice and assistance will save COSEE time and funds.

COSEE should provide invaluable opportunities to link mentors and learners of all ages and diversity. This role is particularly important in the life of students and especially important at the 9-12 grade level, when students are

envisioning what their professional future might hold. They need exposure and access to information on careers.

Opportunity: To integrate natural sciences, social sciences, arts, languages, and humanities through the interdisciplinary aspect of Ocean Sciences, as an approach to science literacy.

Strategy: It is essential for students in grades 9 to 12 to be able to make connections between various subjects studied in the classroom and to develop skills in problem-based learning that they can use in the world of work. Ocean Sciences can serve as an unparalleled vehicle both to improve problem-based learning and to incorporate core subjects such as social studies, arts, and languages in order to provide integrated learning experiences. If COSEE were to take a leading role in promoting and supporting a novel teaching-learning approach by infusing Ocean Sciences in high school as a reality-based example of integrated learning, universities might have greater confidence in recognizing Ocean Sciences as a perfect tool to teach interdisciplinary science rather than, as often happens, too challenging a subject to teach because of its interdisciplinary aspect.

Undergraduate Ocean Sciences Education

Many two-year and four-year colleges and universities offer a general education course in Ocean Sciences. Many of these institutions, however, lack access to research technology and are thereby limited in their offerings. Some colleges and universities offer a baccalaureate degree program in Ocean Sciences. These programs are attractive for students who do not wish to limit themselves to one of the basic sciences. They can study the biology, chemistry, geology, and physics of the ocean. Even so, just as students in grades 9-12 can be deterred from pursuing scientific interests, so too can college and university freshmen. But for freshmen, a common, but by no means the sole, reason for "dropping out" of science is poor teaching (Seymour and Hewitt, 1997). COSEE should encourage effective and innovative teaching in the Ocean Sciences, to make courses in these sciences especially attractive to a diverse clientele.

Opportunity: To facilitate the development and distribution of marine educational resources, both digital and experiential, that can be used to enhance undergraduate education in the Ocean Sciences.

Strategy: COSEE should provide easy access to the high-quality instructional materials that are in great demand for undergraduate Ocean Sciences education. Many faculty members teaching oceanography at the introductory level have not been formally trained in the Ocean Sciences or in college teaching. This situation is especially true at the community colleges, which enroll almost half the undergraduate enrollment in the U.S. and which serve underrepresented groups and future teachers in large numbers. These faculty members can be assisted by having research results of the Ocean Sciences community available in their undergraduate classroom and laboratory to capture the interests of students early in their academic years. In many cases, digital and other resources already exist; particularly through the various programs of NASA, however, widespread knowledge of these resources or experience in incorporating them into courses is lacking. Also lacking is a critical mass of essential equipment such as portable laptop computers and projectors. Many departments have one (or only a few) of each, which makes usage of them during teaching difficult. Therefore, making high-quality resources for these computers accessible through a widely recognized portal is critical to their widespread use. In other cases, research materials need to be transformed into efficient learning instruments and reviewed for educational quality, after which they can be linked to digital libraries. Gaps in the content and quality of existing materials need to be identified. COSEE can play a proactive role in soliciting projects to fill these gaps. Once developed, learning resources could be accessed through COSEE either in person or through links to stable, long-term digital libraries such as the Digital Library for Earth System Education (DLESE).

Educational resources available through COSEE should, however, extend beyond educational materials to include linking people to people. COSEE should assist in identifying exciting opportunities in field-based and laboratory-based activities for experiential learning or laboratory research for undergraduate faculty and students. These opportunities can be made available through COSEE's linkages to the research community and sites of informal education or through collaborations with other undergraduate institutions, on a national or regional basis. Other resources may include opportunities for undergraduate students to attend professional meetings and workshops, to participate in internships, and to gain research experiences aboard oceanographic vessels. Indeed, COSEE should serve as an important referral service to a wide variety of resources and opportunities, all of which can have a positive impact on the quality of undergraduate education through enhancements in content knowledge, educational materials, instructional methods, and theories in student learning.

Opportunity: To provide opportunities for professional development to enhance faculty knowledge of the interdisciplinary nature of the Ocean Sciences, innovative pedagogical methods in science education, new uses of instructional technology, communication methods with the public, and mentoring skills.

Strategy: The dynamic nature and interdisciplinary foundation of Ocean Sciences require that faculty knowledge in the discipline be constantly renewed and enhanced. This training should extend beyond current faculty to include graduate students who will serve as future faculty. Training should take multiple paths to include subject knowledge as well as teaching methods and skills in student mentoring. The last two subjects are not included in traditional graduate training. In addition, postdoctoral scientists should be provided with opportunities in education, such as those offered through NSF's Postdoctoral Fellowship in Science, Math, Engineering, and Technology Education (PFSMETE) Program. Such opportunities are particularly important if COSEE serves as an advocate for the career benefit of such educational experiences, a benefit that is only now being recognized in some departments. COSEE should promote the availability of programs in the NSF Divisions of Undergraduate and Graduate Education (NSF/DUE, NSF/DGE) and the Directorate for Geosciences (NSF/GEO) to implement this strategy and the other strategies presented here.

Opportunity: To establish linkages between students and faculty at undergraduate institutions and the Ocean Sciences research community, K-12 education, informal education, underserved populations, private industry, state and federal laboratories, the national and regional media, and the general public.

Strategy: Although many projects throughout the nation are devoted to Ocean Sciences education, the undergraduate Ocean Sciences community is serving an increasingly diverse audience, such as science majors, environmental studies students, general education students, and preservice and inservice K-12 science teachers. As a result of this growing community, linkages should be established between existing programs in Ocean Sciences education and the educational sectors. For example, linkages could be explored between the Consortium for Oceanographic Research and Education (CORE), the Marine Advanced Technology Education (MATE) Center, and the Ocean Sciences Education Teacher Resource Center (The BRIDGE), on the one hand, and the educational sectors, on the other hand, including K-12 schools, graduate universities, community colleges, four-year colleges and universities, informal education sites, and cultural groups of underrepresented populations, located in both coastal and non-coastal sites. These linkages should foster collaboration in Ocean Sciences education, including making available internship and career information for students and faculty, as well as opportunities to improve outreach to the media and the public.

Opportunity: To assist in establishing guidelines to strengthen and reform curricula in the Ocean Sciences, including core competencies and methods of assessment.

Strategy: Introductory courses in oceanography serve a very broad group of students including non-majors fulfilling a science requirement, undergraduate majors, and preservice science teachers. These courses are offered in a number of formats, including lecture, laboratory, field-based or problem-based learning, non-linear modular approaches, and most recently, online formats. In addition, the goals for these courses are often different, reflecting the different audiences they serve. At some institutions these courses serve as a gateway to the major, whereas in others the course may fulfill the final general education requirement for a graduating senior. In addition to providing educational resources to these diverse formats, COSEE should serve as a national forum for discussions on appropriate core competencies for courses based on their target audience. In particular, COSEE should facilitate discussions on core competencies that should be mastered prior to entering more advanced course work in the major. COSEE should also facilitate discussions concerning the adoption of valuable assessment strategies to improve curricula. For example, guidelines could be adopted from successful course models for recruiting and retaining members of underrepresented groups in the Ocean Sciences or for meeting the needs of preservice science teachers. In the undergraduate major, discussions could be held on the meaning of an undergraduate degree in the Ocean Sciences and on ways to ensure the degree provides a direct pathway to careers at the baccalaureate level or to graduate work. Some graduate research institutions do not understand the requirements of the undergraduate degree, with a resulting confusion that may inhibit the most promising students from pursuing graduate studies, even though they had found a special interest in the Ocean Sciences early in their academic life. One argument holds that Ocean Sciences will never be viewed as an equal to traditional scientific disciplines until it gains the visibility of a widely established undergraduate degree program. The low level of current visibility may be one reason that the Ocean Sciences play a marginal role in the K-12 national and state science education standards. COSEE should consider advocating an Ocean Sciences Advanced Test for the Graduate Record Examination (GRE) so that undergraduate Ocean Sciences majors are not forced to take the biology, chemistry, geology, mathematics, or physics test.

The Ocean Sciences serve as an excellent vehicle to enhance the knowledge of science content and process for preservice teachers, especially at the elementary and middle-school levels. In this connection, there is a debate whether preservice science teachers should be taught in existing courses for majors or in courses designed to meet their special needs. COSEE could provide a forum for these discussions and for discussions on developing assessment tools for student learning or degree outcomes, both of which are receiving growing attention on a national scale.

Opportunity: To advocate equal recognition of education and research activities as a national goal, including contributions of members of the research community to educational initiatives.

Strategy: In some institutions, particularly research universities, projects in education are not valued as highly as research projects. This situation acts as a barrier to the participation of many junior faculty in education and public outreach. It also inhibits the contributions of scientists at research institutions. COSEE could serve a powerful role of advocacy to ensure that educational efforts are properly rewarded as valuable contributions to the field of Ocean Sciences specifically and to undergraduate education in general (See [Appendix 5](#)).

Opportunity: To provide a resource center for career opportunities for undergraduate students, especially those from underrepresented and underserved populations.

Strategy: The Ocean Sciences community does not currently reflect the diversity of our nation's population. Many groups are underrepresented and underserved. The Ocean Sciences are not the major that comes to the minds of many of these students, especially those who may represent the first member of the family to attend an institution of higher education. As a result, the undergraduate institutions in the Ocean Sciences must make a special, and sustained, effort to engage the interest of this population. COSEE should provide information and linkages to

successful programs for addressing this education challenge, such as the Native Americans in Marine Science program at Oregon State University, and the Minorities in Marine Science Undergraduate Program (MIMSUP) at Western Washington University, as well as access to a listing of underrepresented peoples currently employed in the Ocean Sciences who can serve as mentors to these students. Moreover, COSEE should provide a focus for discussions on innovative programs around the nation that are addressing this critical need, for example, the American Society of Limnology and Oceanography (ASLO) program.

Teacher Preparation and Teacher Enhancement/Professional Development

The central question is "How do we create opportunities for educators at all levels to involve others more effectively in the excitement of ocean discoveries?" This question clearly cuts across many disciplines and organizational structures, including two- and four-year institutions of higher education and their associated faculties within Schools of Education and Schools of Science, public school administrators, informal science educators, and scientists and professional organizations such as the National Science Teachers Association (NSTA). Several programs in the NSF Directorate for Education and Human Resources (NSF/EHR) are applicable to these opportunities. Because many recommendations for teacher preparation and teacher enhancement/professional development overlap their respective divisions of "preservice" and "inservice," the term "educator" includes those involved in all sectors of education, including K-12, undergraduate, graduate, informal education initiatives, and scientists involved in education efforts.

Opportunity: To provide unique opportunities for faculties within Schools of Education and Schools of Science to enhance their understanding of how to teach Ocean Sciences topics more effectively.

Strategy: First, the basic Ocean Sciences content necessary to determine a level of proficiency in understanding the ocean system needs to be identified, i.e., what is it that an educator needs to know to have a basic understanding of the interconnected ocean system in order to teach it effectively to others? Answering this question will require extensive conversations among key stakeholders, in particular faculties within the higher education system, so that students exit colleges and universities with a sound Ocean Sciences content knowledge. Once the "basic Ocean Sciences content" question has been answered, Chatauqua courses (See definition, [Appendix 8.](#)) should be offered to higher education faculty within Schools of Education and Schools of Science to demonstrate not only effective approaches and methods of teaching Ocean Sciences, but also ways of teaching basic science concepts in biology, chemistry, geosciences, physics, and mathematics using the Ocean Sciences as the vehicle. COSEE can place this development on a firm foundation by encouraging research to discover how students learn integrated sciences such as the Ocean Sciences. Cooperation with the National Association for Research in Science Teaching (NARST) and its commitment to the improvement of science teaching and learning through research should be explored.

Opportunity: To enhance collaborations among all groups involved in teacher preparation and teacher enhancement/professional development.

Strategy: Because the Ocean Sciences are interdisciplinary, appropriate incentives need to be in place to encourage collaborations among faculties within Schools of Education and Schools of Science, with a special emphasis placed on involving research faculty. COSEE could countenance the NSF Division of Ocean Sciences (NSF/OCE) to encourage these collaborations by requiring that all proposals submitted to NSF/OCE contain education components tied directly to the proposed research. In addition, appropriate education proposals submitted to NSF/OCE and the NSF Division of Undergraduate Education (NSF/DUE) might include partnering with scientists involved in current Ocean Sciences research. Interdisciplinary approaches would be encouraged for

both groups. Liaisons well-versed in both education and research could be available, as needed, to help "bridge the gap" between the educators and scientists to develop competitive proposals. COSEE might advocate that research institutions designate a department liaison to provide outreach and education in the K-12 community and to serve as a point of contact for the education community seeking guidance and support in the Ocean Sciences. COSEE should also promote greater "crossing over" of professional organizations of educators and scientists as a means of "bridging the gap" and increasing the awareness of COSEE and the fundamental role it can play in connecting educators and scientists in ocean research.

Opportunity: To design more effective teacher preparation and teacher enhancement and professional development programs.

Strategy: Teacher enhancement and professional development programs promoted by COSEE should be long-term, spanning several years, and modeled after research-based best practices so that clear, research-based technical assistance pathways are offered as opposed to a series of one-shot workshops. These pathways should continue to support participants by providing them resources and other types of support long after their initial participation in the program. An interdisciplinary, team-based approach (pairing scientists with educators as instructors) is a highly-effective means of designing teacher enhancement/professional development programs. Exemplary informal education programs should be incorporated into the overall design of professional development "pathways."

Training needs to be offered to all educators to demonstrate effective methods of connecting Ocean Sciences to other subject areas, including mathematics, literature, social studies, and history. Problem-based learning approaches should be encouraged. Additionally, educators must have access to field experiences and a solid understanding in how to translate these experiences effectively into engaging, interdisciplinary pedagogical approaches that will enable them better to prepare students to make intelligent, rational decision about issues affecting the world ocean. Courses and training need to be offered to show educators how they can effectively integrate cutting-edge technology and data relative to Ocean Sciences exploration into classrooms in all education sectors. Every effort should be made to strive for a seamless integration between content and technology.

Teacher enhancement/professional development opportunities, including formal course work and informal science program offerings should, as appropriate, be tied to Ocean Sciences concepts or applications that are specific to a geographic region, thereby enabling educators more effectively to demonstrate real-world connections (relevancy) in science teaching and learning. This process would also provide a means of leveraging formal and informal education and scientific resources within the region. Teacher education and teacher enhancement/professional development offerings must include career components so that educators can pique students' interest in pursuing Ocean Sciences careers by providing them with access to high quality, up-to-date information on these careers so as to ensure a "critical mass" of future researchers for Ocean Sciences disciplines.

Finally, there is a critical need nationally for the development of a more effective evaluation instrument for teacher enhancement/professional development programs. Historically, these programs, if evaluated at all, have based evaluations solely on student achievement and have failed to take into account such factors as changes in teaching behavior, use of exemplary standards-based materials, standards-based assessment, educators' roles as leaders in their field, student attitudes toward the subject area, partnerships, policy development, and resources leveraged to support the project.

Opportunity: To increase opportunities for participation in ocean science courses.

Strategy: Research indicates that approximately one-half of all undergraduates-including one-half of African-Americans, one-half of Hispanics, and one-half of Native American students-in this country are enrolled in

community colleges. Developing courses in the Ocean Sciences that could be offered at these institutions would ensure that the majority of undergraduates, and in particular, a majority of students from groups traditionally underrepresented in science, would have access to ocean science courses. Additionally, successful recruitment strategies need to be explored for involving both educators and scientists from traditionally underrepresented groups in Ocean Sciences education and research.

Linkages between community colleges/technical colleges and four-year higher education institutions need to be encouraged to facilitate opportunities for educators to enroll in Ocean Sciences-related courses for continuing education or graduate credit.

Opportunity: To provide access to high-quality Ocean Sciences curricular materials.

Strategy: COSEE should facilitate the development of criteria to determine what is, in fact, considered to be an exemplary curriculum and curricular materials. In addition, a peer review process for curriculum materials should be established, including both educators and scientists, to review these materials. The materials should be standards based (correlated to the American Association for the Advancement of Science Benchmarks and the National Science Education Standards (NSES)); the professional development programs need to support these materials. The materials should ensure a sound foundation for understanding Ocean Sciences concepts at the completion of the experience. COSEE could play a role in serving as a portal for effective professional development models and the dissemination of exemplary curricula and curricular materials, thus ensuring quality control ("COSEE-approved") and accessibility for all. Models developed by NASA for Earth Science education could be examples.

An information database, tied into the Digital Library for Earth System Education (DLESE), along with an effective dissemination network, needs to be in place so that educators and scientists within a region can easily locate each other and have access to resources and opportunities unique to each, thereby encouraging partnerships and collaborations between the two groups. Liaisons can assist both groups with "teasing out" the appropriate education component of the research, and they can provide assistance to educators submitting education proposals on effectively incorporating Ocean Sciences research-based experiences into the proposed project.

Opportunity: To identify Ocean Sciences lead educators and provide them with leadership opportunities.

Strategy: Effective means of identifying "leadership teachers and emerging leadership teachers" for COSEE program participation need to be explored, with a specific emphasis placed on elementary and middle school teachers. Professional development opportunities should likewise be created for school- and district-level administrators so that these lead educators would have the necessary and very critical support to build capacity at the regional and local levels. In addition to teacher enhancement and professional development opportunities, leadership development opportunities need to be offered (facilitation skills, presentation skills, grant-writing skills, and team-building skills, to name a few) to ensure the highest quality in the delivery of the professional development programs related to the Ocean Sciences.

Ocean Sciences Research and Information Technology

With the rapid changes in, and increasing capabilities of, technologies that allow not only wider distribution of information but also more exciting presentation of that information, educators are poised to integrate Ocean Sciences into the lifelong learning experiences of every citizen. This will happen only through the establishment of partnerships and cooperative ventures between scientists, formal and informal educators, the media, policy

makers, and community leaders. However, true partnerships and collaborations are difficult to achieve between disparate groups without a concerted effort to promote them. COSEE should provide the forum for the types of activities that are necessary in order to bring this integration to fruition.

Ocean Sciences Research

Opportunity To translate Ocean Sciences data and information into products usable by educators.

Strategy: The highest priority in incorporating the Ocean Sciences into the education process, whether in a classroom setting or in an informal setting, is the translation of Ocean Sciences data and information into products usable by educators. NASA's presentation of Ocean Sciences data on El Niño for educational use is a shining example. Scientific researchers typically need assistance in producing educational materials, and science educators are faced with huge data sets that are hard to interpret and understand. The best way to overcome this dilemma is to provide mechanisms to develop stronger partnerships between scientists and educators so that (1) scientists can learn and understand the needs of educators; (2) they can jointly select appropriate data and translate them into usable products; (3) educators can learn and understand the scientific content and implications; and (4) the results and materials can be infused into the educational process.

COSEE's role should be to provide opportunities to initiate and nurture partnerships and collaborations between scientists and educators. This role requires a more aggressive approach than simply providing a portal for contact information, and opportunities must be provided to bring educators and scientists together to interact on common issues. COSEE might identify critical Ocean Sciences themes of interest, and then sponsor topic-specific workshops for scientists and educators to discuss the available information, the goals of including that topic in education resources, and the possible content of those materials. Such interactions could result in collaborations and the development of joint proposals from more than one Ocean Sciences education sector. COSEE's encouragement of research on how students learn integrated science could provide added strength to such proposals. Furthermore, inasmuch as one of the functions of the Digital Library for Earth System Education (DLESE) is to provide communication networks that facilitate collaborations across all interests of Earth system education, COSEE should collaborate with DLESE for the greater effectiveness and efficiency of both organizations. COSEE could also benefit from discussion with NASA of its highly successful translation of research results into educational resources.

An important part of learning and understanding the issues in the different working environments of the scientists and the educators is the opportunity to experience them. COSEE could maintain a database of field and laboratory opportunities for formal and informal educators, including science faculty in two-year and four-year colleges and universities, to work with scientists doing Ocean Sciences research. Other COSEE-sponsored internships could also be offered to encourage participation by underrepresented groups. Conversely, COSEE could initiate a "Scientist in the Classroom" program in which it helps educators find a scientist in their area willing to visit the classroom and participate in the teaching process.

A major barrier to the successful development of scientist-educator partnerships, however, is the value system that is currently in place in many research institutions and universities. Promotions, tenure, and other career-track decisions are commonly made on the basis of contributions to research with little value placed on efforts to improve education of students or the general public. A cultural shift is required in academia toward greater acknowledgment of contributions to education in order to encourage scientists to invest more time in education. COSEE should encourage the NSF to develop more programs to address this issue, like the Faculty Early Career Development Program (CAREER), Graduate Teaching Fellows in K-12 Education (GK-12), and Integrative Graduate Education and Research Traineeship Program (IGERT) (See [Appendix 5](#)).

Opportunity: To provide exemplary education materials at all levels.

Strategy: A large amount of Ocean Sciences education materials of varying content and quality is now available for educators. However, the busy educator needs a place to go where he or she can find materials or links to materials that are certified to be of high quality, are current, and address the National Science Education Standards (NSES), state standards, and the Benchmarks. An important role for COSEE should be to identify exemplary educational materials and gaps, and develop new materials and programs, using current Ocean Sciences data.

The first issue that COSEE would face is defining "exemplary" in the context of Ocean Sciences education. Some of the criteria might be that the material has gone through a rigorous review, assessment, and evaluation process, is appropriate for the entire society, and incorporates career information. COSEE-encouraged research on how people learn integrated sciences could provide insight, as could cooperation with the American Association for the Advancement of Science (AAAS) and the application of its criteria for Middle Grades Science Textbooks Evaluation (See Appendix 8) and with DLESE and the application of its evaluation criteria. Based on a review of available materials, COSEE could give a "COSEE Stamp of Approval" to some and provide either a link to the Web location of those materials or information on their availability in hard copy. COSEE could then organize development of products to fill gaps and provide current topics in the Ocean Sciences. COSEE must also determine its responsibility for endorsed exemplary material when the research results on which the material is based are superseded by different results. It will be essential for COSEE to reach a mutual understanding with clearing houses on the review by COSEE of Ocean Sciences information repositied in their collections.

Opportunity: To develop effective models for evaluation of Ocean Sciences educational materials and programs.

Strategy: Evaluation and validation are essential parts of the development of Ocean Sciences educational materials and programs. However, scientists are completely unfamiliar with these requirements, and hence cannot institute effective assessment procedures in the development of programs. In addition, the new instructional technologies currently being used are likely to require different evaluation tools. COSEE needs to provide services to assist scientist-educator partnerships in assessing their needs in terms of evaluation. The roles that COSEE could play include: (1) conducting needs assessments for scientists, educators, and evaluators; (2) determining effective evaluation tools for new instructional technologies; and (3) holding sessions to train the Ocean Sciences community to use the tools.

Information Technology

Opportunity: To use information instructional technologies effectively in Ocean Sciences education.

Strategy: Information technology is a rapidly advancing field that will play an increasingly important role in lifelong educational activities. NASA has been a leader in this field. In fact, according to CNN, Ocean Sciences information on the 1997-1998 El Niño supplied by ocean scientists through NASA reached two billion people. Changes are occurring in TV, video media, and the Internet so rapidly that five to ten years from now every home in the nation may well have integrated technologies that will change the way the nation learns. It is very important, however, for educators, as they look toward this scenario, to remember there are still many parts of the country that lack access to the Web. Hence, over the next several years, the capabilities of our nation's schools will vary considerably, and yet our educational tools must continue to meet the needs of everyone.

Effective utilization of informational technologies requires access, and many underserved communities do not have

the infrastructure, hardware, or software to access the Internet. COSEE should lead efforts to articulate the importance of access and to identify funding for the required capabilities. As local areas are able to upgrade, COSEE should also provide updates on the future directions of connectivity. As access to a range of instructional technologies becomes more widely available, integrating different technologies to enhance the effectiveness of delivery will become an important issue. A range of studies has been conducted on the effectiveness of different technologies for different communities and cultures, and it will be important for COSEE to keep those individuals designing Ocean Sciences educational materials aware of the progress being made in this research. In addition, scientists and educators will need training to better use broadcast, multimedia, Geographic Information Systems (GIS), visualization, and data-manipulation techniques in the educational process.

One of the major vehicles for COSEE educational materials is likely to be video. COSEE should assist in the development of regional partnerships between educators, scientists, and production companies to develop video materials, and to encourage the use of other broadcast media, such as TV, in presenting Ocean Sciences. COSEE should also be alert to the significance on the development of educational materials of the switch to HDTV.

Changes in technology occur rapidly. It will be important that COSEE keep abreast of those changes and work toward making the changes appear seamless. This process will require COSEE to monitor advances in technology, and maintain and upgrade services appropriately. In addition, COSEE should identify professional Information Technology societies, and arrange for connections to them by ocean scientists and educators.

The innate human fascination with the ocean, coupled with the interdisciplinary nature of the Ocean Sciences and accessibility of ocean data, creates an excellent opportunity for incorporating technology into the learning experience. COSEE should encourage the sharing of experiences using different technologies, providing a foundation for an open discussion on how technology and science education relate to 1) Curriculum Reform - What intellectual skills do students need, and how can technology be used to foster them? 2) Professional Development - What training do teachers need to effectively incorporate technology into their classrooms? 3) Assessment - What methods exist, or need to be developed, to evaluate technology as an effective learning tool? 4) Equity - What can be done to better ensure that all children can realize the potential benefits of educational technology?

Opportunity: To use the Internet as a collaborative tool.

Strategy: The Internet is revolutionizing the way in which we send and receive information, learn, and actively participate in scientific research. It provides an information resource, an educational tool, a means of distributing scientific data to the public, and a means of communicating between individuals in all walks of life. One of the main functions of COSEE, as the portal for Ocean Sciences education, should be to maintain a Web site that offers Internet services effectively. These services will require "good" Web site design and a user-friendly and high-level search capability. Given that other efforts are currently underway to provide digital information for educators, such as DLESE and The BRIDGE, it will be important that COSEE interface easily with these digital libraries. However, COSEE also needs to arrange a mechanism with these libraries to endorse those Ocean Sciences education materials that it finds of high quality. The "COSEE Stamp of Approval" discussed in the previous section could meet that need.

The COSEE portal should provide access to several destinations of opportunities and resources. One educational resource should be Ocean Sciences data sets for educational use, such as environmental monitoring data and sample scientific data sets for student manipulation. COSEE should ensure that Ocean Sciences data are a part of DLESE and other digital libraries. As the portal for Ocean Sciences education, COSEE should also provide "one-stop" access through links to societies, professional organizations, and research projects. With an "Ask an Oceanographer" program, COSEE could provide opportunities for interactions between scientists and the general public to promote a sense of participation. However, in preparation for such a program, COSEE would be well advised to coordinate with The BRIDGE and its "Ask An Oceanographer" site and the Office of Naval Research

(ONR) and its "Ask the CyberScientist" site.

Opportunity: To evaluate the use of technologies for Ocean Sciences education.

Strategy: As with content evaluation for Ocean Sciences educational materials, it is important that the effectiveness of different instructional technologies be evaluated. COSEE should encourage the involvement of education researchers in continuous evaluation of the implementation of new instructional technologies.

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Recommendations by Educational Threads

A Portal for Ocean Sciences Education and Professional Development

There is a demand for a portal to ideas, information, and resources that connect and celebrate Ocean Sciences teaching, learning, and scientific discovery at all levels. The COSEE portal needs to have high visibility and be perceived as "the place to go first" for Ocean Sciences educational resources and services. In this sense, COSEE will bear resemblance to educational efforts of organizations in other geosciences, for example, the University Corporation for Atmospheric Research (UCAR), which is "the place to go first" for education materials and services in Atmospheric Sciences, the Incorporated Research Institutions for Seismology (IRIS) in Seismology, and the Earth System Science Education (ESSE) Program of the Universities Space Research Association (USRA) in Earth System Science.

Once inside the portal, either "virtually" by computer or in person at a regional COSEE center, the user should expect to find several resource destinations, one of which should be "Educational Materials." An elementary role for the portal would be as an entry, by means of links, to the clearing houses for Ocean Sciences educational materials that already exist, such as The BRIDGE, the Educational Resources Information Center (ERIC), and the NASA Earth Science Enterprise (NASA/ESE). These educational materials include books, films, videos, curricula, hands-on activities, and Web-based programs. Because so many people are unaware of the full constellation of the clearing houses that exist, or what they do, an inventory of these sources is essential. COSEE should not duplicate other efforts but provide an added value.

COSEE should also ensure that these materials are made accessible to more users, and to more diverse users. To accomplish this goal COSEE should explore close collaboration with the Digital Library for Earth System Education (DLESE), even to becoming a federated partner of DLESE. DLESE is to be operated as a distributed network across the Earth Sciences and will thus include the Ocean Sciences. DLESE is already developing the systems by which materials can be organized for easy discovery and the systems for transparent access to these materials. COSEE should work with DLESE to ensure that these metadata systems of discovery and access are appropriate for Ocean Sciences educational materials and other educational resources. If COSEE organizes the Ocean Sciences educational resources so they can be accessed through DLESE, both programs will benefit. COSEE should be a major participant in the efforts across the Earth sciences to share resources for mutual benefits and to ensure that all parties can communicate effectively. In addition, DLESE will bring Ocean Sciences materials to the attention of a larger audience. COSEE could join UCAR, IRIS, ESSE, and other organizations as federated partners of DLESE in order to share digital resources and technology and to be an integral part of the National Digital Library for Science, Mathematics, Engineering, and Technology Education.

COSEE should examine the system for reviewing educational materials that is being developed by DLESE and consider it for adoption to ensure consistency. COSEE should participate in the deliberations by DLESE in developing review criteria to ensure that they are appropriate for Ocean Sciences material. Both COSEE and DLESE could then publicize these criteria. Partnership with DLESE could also lead to a three-part collaboration. COSEE could be expected to identify the needs in Ocean Sciences education for Ocean Sciences data sets. COSEE and DLESE could, together, develop the instructional technology and pedagogy for their use in the classroom. And DLESE could be expected to provide the discovery systems and services for users.

COSEE should also facilitate the creation of new educational materials for discovery by using the DLESE technology through either the COSEE or the DLESE portal. Both digital and non-digital educational materials could be distributed by COSEE or by the creators of the materials. The DLESE information networks should be able to direct users to the materials, whether digital or non-digital. COSEE would be expected to increase the quantity, diversity, and quality of educational materials, while categorizing them, acting to fill important gaps, and awarding a COSEE approval to the best of them. COSEE should also likely in partnership with DLESE-ensure that

promising pedagogical practices in the use of these and other materials are developed and made available. For educational materials, COSEE should be responsible for providing needed and reviewed materials to the DLESE discovery system.

Another destination through the COSEE portal should be "Curricula." These curricula would bring the excitement of Ocean Sciences research into the classroom. By developing these curricula in collaboration with the information technology developments of DLESE, COSEE can make sure the curricula can be discovered through the DLESE system.

COSEE should also be a portal to a much-needed research-based technical assistance professional development pathway for faculty, future faculty, preservice and inservice teachers, informal educators and administrators. These programs would be rigorous offerings in content, technology, grant proposal-writing, leadership skills, Ocean Sciences research experiences, appropriate pedagogical approaches, and preparation of Chatauqua courses (See [Appendix 8](#) for definition). COSEE should ensure that proposals are written to support participants in the pathway. COSEE Lead Educators could be the end product of the pathways. Other professional development opportunities offered outside of the formal COSEE pathway should be identified and assistance provided by COSEE to help re-design and enhance Ocean Sciences content and pedagogy in these programs, as appropriate. For example, scientists, who are not traditionally trained to share their discoveries with the general public, could learn methods of better translating and presenting their research results. "Master Ocean Sciences Educators" could be identified, who would be willing to serve as mentors to preservice teachers.

COSEE should be a "meeting place" for all those who share an interest in, and a passion for, the aquatic environment, both saltwater and freshwater-researchers, educators in all sectors, media, and decision-makers. COSEE could help reduce the isolation of Ocean Sciences educators in all education sectors, just as the National Science Teachers Association (NSTA) program "Building a Presence for Science" aims to end the isolation of the classroom science teacher. In aiding this communication, COSEE should explore with DLESE the use of the DLESE communication networks. COSEE should be a focal point for communication, cooperation, and collaboration across diverse communities of Ocean Sciences educators and researchers. A wealth of information related to Ocean Sciences could be imported into, and exported through, the COSEE portal, including a skills bank, information on other national programs, materials, professional development, and research opportunities for teachers and students. COSEE would also be expected, by working in partnership, to enhance the effectiveness for Ocean Sciences education of existing collaborative programs and digital libraries, such as the Consortium for Oceanographic Research and Education (CORE), The BRIDGE, DLESE, ERIC, the Eisenhower National Clearinghouse (ENC), and the Marine Advanced Technology Education (MATE) Center.

The enhancement could come from developing and implementing a national strategy focused on diversity, interdisciplinary programs, advocacy, and technology. One strategy could be to create several Chatauqua courses (See [Appendix 8](#) for definition) during the academic year that focus on recent advances in the Ocean Sciences and that include among the participants Ocean Sciences educators from all sectors. These courses should be offered in different sections of the country, with the results of each being shared with all. Diversity among participants ought to be high. The impacts of the program should be assessed and tracked. One important metric of success would be the number of new collaborations for Ocean Sciences education that are fostered.

The COSEE portal should be the highly visible News Source for the Ocean Sciences, particularly to the news media. It should encourage and support spokespersons. A good model for implementing this task is the NASA example. The COSEE portal could recognize Ocean Sciences heroes and heroines. For example, the submersible Alvin pilots who explore the sea floor could become heroes like the astronauts have become for exploring space. COSEE should be expected to provide the book, film, TV, and radio industries with links to scientists who can serve as scientific advisors for maritime-inspired movies, books and TV series (for example, "Perfect Storm," "20,000 Leagues Under the Sea," and "Titanic"). The impact of TV on students is tremendous, but very few students actually watch Public Broadcasting System (PBS) channels, while millions of them watch mini-series, sitcoms and cartoons

that could carry accurate and engaging information about the ocean. Even so, PBS programs should not be ignored. In addition, COSEE could consider arranging for a few seconds of ocean-related information on a daily basis on National Public Radio, a spot that should reach millions of listeners and, little by little, allow the content to permeate the public mind. COSEE could also coordinate an "Ocean Sciences Rapid Response Team" that would prepare informative educational materials and examples of the scientific data for educators and for the news media when an ocean event with a societal effect occurred. This process would allow educators and the media to turn current events into learning situations fully supported by the appropriate materials.

Other methods of bringing the ocean to the attention of the public include: (1) public service announcements on commercial TV; posters; and PBS one-minute spots, called "interstitial," during prime time viewing; (2) national events with high visibility such as "Ask an Oceanographer" and National Ocean Day, the former event being similar to existing events and the latter event having been congressionally mandated; and (3) exhibits at local museums, aquariums, and traveling exhibits. For National Ocean Day, COSEE should explore facilitating the collaboration of students, teachers, Ocean Sciences faculty, and personnel in government agencies, businesses, and non-governmental organizations that have ocean-related interests in one specific, common activity across the nation, like the tree planting on National Arbor Day.

Finally, COSEE must decide where the resources in each of the portal resource destinations will be reposted. That is, if the material is digital, will COSEE use its funds and personnel to maintain the collection in order to preserve it? Or will the creator of each piece of material or that person's institution be responsible for maintaining the availability of the material, even though Web sites can change or vanish? Although COSEE may become a partner of DLESE, DLESE is not expected to maintain a collection. It will supply the discovery system for users to find the material at remote sites. COSEE should explore the question of repository with such organizations as The BRIDGE, UCAR, IRIS, and ESSE that have experience with the issue.

Educational Materials and Curriculum Development

High-quality educational materials that are accurate, balanced, objective, and tailored to the needs of different audiences are needed for Ocean Sciences education in all sectors, as is expert guidance in the development of Ocean Sciences curricula. COSEE can provide this support through four strategies: (1) establishing broad goals and guidelines for providing these services; (2) providing linkages among educational systems, institutions in informal education, and the general public to foster collaboration in development and implementation of these materials; (3) marketing COSEE as a national and regional portal to high-quality educational materials and ideas on Ocean Sciences curricula; and (4) providing innovative learning experiences in the Ocean Sciences and timely information on major oceanographic events that affect society.

COSEE should first establish goals and guidelines for a large resource of educational materials. Materials that are recognized by COSEE will receive national recognition for their quality in terms of content, pedagogy, and innovation. The definition of broad goals would assist COSEE in assembling a library of existing materials, such as those accessible on The BRIDGE. Guidelines would be helpful in developing future materials that take advantage of the results from Ocean Sciences researchers. COSEE should avoid duplicating existing resources or diminishing the importance of previous work, but instead identify successful materials, models, and dissemination structures, which can be leveraged to bring ocean research to the classroom and general public. Gaps in existing materials in Ocean Sciences education, in terms of quality or subject matter, should be identified, especially as new developments in research provide opportunities in education and vice versa. Procedures must also be established to address the fate of educational materials that are based on research results that have been superseded.

Effective partnerships need to be established between researchers and educators in order to translate research results into active learning instruments. Students and teachers provide an underutilized human resource that can assist the research community through sampling and monitoring programs (for example, the Global Learning and

Observations to Benefit the Environment (GLOBE) Program). Materials available through the COSEE portal should attempt to follow the National Science Education Standards (NSES) and the Benchmarks, and on a regional basis, the state standards. COSEE should be a strong advocate for encouraging an interdisciplinary approach to science education and in applying ocean phenomena to illustrate fundamental principles in the basic sciences. By encouraging research on how students learn integrated sciences such as the Ocean Sciences, COSEE may be able, perhaps through coordination with the National Association for Research in Science Teaching (NARST), to enhance the pedagogical significance of the educational materials.

Guidelines should be established for reviewing educational materials and recruiting qualified reviewers from all segments of the community that COSEE will serve. Strategies to handle the potentially large volume of material may follow a structure adopted by DLESE, which includes both reviewed and non-reviewed sections. In fact, COSEE should work in close coordination with DLESE, The BRIDGE, NASA Earth science education, and other digital libraries and clearing houses to develop guidelines for review and evaluation. The educational resources that can be accessed through the COSEE portal must also include instruments for assessment. In addition, COSEE needs to include opportunities for non-coastal communities and cities to learn about coastal systems and the importance of the global ocean in order to develop a national presence for the Ocean Sciences. Models of curricular development should take advantage of regional resources, including the cultural history of underrepresented populations in the Ocean Sciences. Programs, such as the National Institutes of Health Minority Access to Research Careers (MARC) Honors Undergraduate Program, should be adapted to the Ocean Sciences in order to attract and support students from these groups.

COSEE should likewise serve as a destination for information on curricular development across the disciplines in Ocean Sciences. This resource should include links to educational materials, field experiences in hands-on learning, and class activities, some of which would be accessible from DLESE, all of which would be categorized according to subject and grade level. Linkages among groups can provide information across boundaries in education systems, establish ties to cultural groups to enhance diversity, and develop lasting connections with the research community, other governmental agencies, and the media. Cooperative agreements and educational exchanges should be facilitated by COSEE, including the establishment of a network of scientists to participate in an "Ocean Scientist in the Classroom" program and announcements of opportunities for students to visit research laboratories or ships.

It will be very important for COSEE to establish an identity as the place to go for high-quality educational materials and discussions on curricula that bring the excitement of ocean research into the classroom. Avenues for promotion include notices to professional societies, cross-referencing on popular Web sites, and an aggressive outreach program to schools, colleges, universities, and sites of informal education. COSEE should gain the reputation of being the stable, long-term portal for information on Ocean Sciences education. It could establish a network of spokespersons for communicating with the media, and it could work to provide highly visible role models for underrepresented groups.

COSEE should take advantage of high-profile news events involving the oceans by forming a "Rapid Response Team" that can communicate the role of Ocean Sciences research. Ocean Sciences experts can be brought into the classroom or made available to the media, in many cases through the use of technology, to give accurate, first-hand information on the ocean process behind the news event. Partnerships should be formed with the oceanographic research community to develop learning experiences for "just-in-time learning" that reflect the excitement of contemporary Ocean Sciences. Research experiences for students and teachers at sea or within laboratories can be used to develop instructional materials and to influence curricula. Materials should be developed that highlight the importance of good citizenship in maintaining a healthy ocean system. All of these activities will serve to keep K-12 teachers, informal Ocean Sciences educators, and faculty in two-year and four-year colleges in touch with the recent results of Ocean Sciences research.

Collaborations, Linkages, and Liaisons

One of the most important needs of ocean scientists and educators is a mechanism that encourages and facilitates interactions of different types among members of the community. Collaborations involve substantial cooperative activity in intellectual pursuits, such as research endeavors or development of new programs. They require a commitment of a group of people to work together for an extended period of time to produce a product. Linkages involve sharing of information, and can be accomplished either virtually or in person. Liaisons can take two forms. The first is that of an intermediary between two groups who assists in communications or transitions between them. For example, a liaison could facilitate the transition of community college students into their first year at a four-year university. The second form is that of a liaison acting as an information channel between two groups whose interests are similar or who need to be brought together. All types of interactions are required throughout the lifelong educational process, and must involve not only ocean scientists and formal and informal educators, but also policy and decision makers, the media, and the general public, particularly underrepresented groups. Such interactions do not occur naturally, and require that strategies be set in place in order to promote and nurture them (Mattessich and Monsey, 1992; Dierking et al., 1997). COSEE should play a vital role in initiating these types of interactions; they are the critical first step toward scientists and educators working together for excellence in Ocean Sciences education.

Collaborations

An example of a particularly valuable type of collaboration is the development of new educational materials that include current scientific data. COSEE should identify topics of priority, perhaps by bringing together representatives of the different sectors of Ocean Sciences educators and researchers on a recurrent basis, and then facilitate collaboration by organizing regional and national workshops to allow cross-fertilization of ideas between scientists and educators. COSEE could encourage meaningful collaboration from the planning stage by advising NSF to include collaborations across Ocean Sciences education sectors in every step of the proposal process from program announcements to panel reviews to awards. Furthermore, COSEE could recommend the addition to every major new interdisciplinary and multi-institutional program in the NSF Division of Ocean Sciences (NSF/OCE) a collaborative component for education that includes an on-going evaluation. In addition, COSEE could act as a portal for contact information, both on a regional and national level, for scientists or educators seeking collaborators. COSEE could also assist by coordinating the development of a national proposal from small regional proposals for ideas that need to be implemented on a regional scale. COSEE might seek collaborative relationships with textbook publishers and develop on-line links to current research in the type of relationship currently being pioneered by a partnership between NASA and the National Science Teachers Association (NSTA).

Another way to promote collaborations is through topic-specific Summer Institutes, such as the National Oceanographic Partnership Program (NOPP)-sponsored Consortium of Oceanographic Activities for Students and Teachers (COAST) and the Marine Activities Resources and Education (MARE) Leadership Institutes offered in California, Texas, and New Jersey. These institutes would be designed to facilitate the acquisition of knowledge by educators and would bring in scientists (or others, such as education researchers) to discuss recent advances in a particular field. These types of focused experiences often result in the development of collaborations.

An area in which the Ocean Sciences have performed very poorly is that of bringing the excitement and wonder of the oceans to the attention of the general public. To correct this shortcoming, COSEE needs to be proactive in developing collaborations with the media. Apart from developing collaborations to produce TV, video, and radio shows, COSEE might develop collaborations for traveling exhibits, such as displays in museums, aquariums, and state fairs. Such venues reach large segments of the general public and can be highly effective publicity tools. COSEE could also offer training for scientists and educators in effective techniques for outreach so that they may

play a greater role in advocating the Ocean Sciences. COSEE could also advocate the creation of staff educator/facilitator positions in postsecondary Ocean Sciences academic units. This staff, rather than the faculty, would assume the burden of organizing and facilitating the interaction.

Linkages

Linkages provide many rich opportunities to share information and ideas, and COSEE should be the focus of this activity in the Ocean Sciences. Regional linkages are particularly critical, as this is the first level at which projects are undertaken. COSEE could assist in the development of linkages on the local and regional levels between K-16 educators, scientists, museums and aquariums, policy makers, industry, and leaders of underrepresented groups. COSEE could also connect teachers with scientists willing to make classroom visits, and participate in other activities and projects. These visits could convey the excitement of science by involving scientists from both genders and all ethnic groups as real people who are enthusiastic about what they do. A linkage can dispel stereotypes and develop an awareness of what scientists really do and how their work is vital and related to the real world. It can bring authenticity to learning situations by using common language. Teachers can put the scientist's experience into words that will make the learning experience come "alive" for students and provide a connection. Teachers can be spokespersons for scientists as they observe and participate in research. Researchers can gain new perspectives of their results by viewing their work through the eyes of a teacher. In addition, COSEE could maintain a database of research ships of opportunity, and field and laboratory-based experiences that are available for both scientists and educators.

COSEE should also be the resource site for the Ocean Sciences that provides a "one-stop" interface and link access to other Ocean Sciences sites, education sites, and professional organizations. In addition, COSEE could establish a program similar to the popular USGS "Ask a Geologist" program. "Ask an Oceanographer" would link scientists directly to students and the interested public in a personal way. Before undertaking this task, however, COSEE should coordinate with The BRIDGE and its "Ask An Oceanographer" site and the Office of Naval Research (ONR) and its "Ask the CyberScientist" site.

Linkages should also be maintained to the media. COSEE would act as the portal for a News Source for the media, both in terms of providing them with story lines and referring them to appropriate scientists and educators for comment on specific topics.

Liaisons

It is important that COSEE stay in contact through liaisons with large oceanographic research programs, as well as with Federal agencies, such as NASA, NOAA, and the USGS, that have educational outreach programs. In addition, COSEE should appoint liaisons to congressional staff members and policy makers. Of particular importance are COSEE's efforts to embrace underrepresented groups in its activities. Hence liaisons with cultural leaders of such groups are critical.

There should also be a liaison relation with the media that operates in two directions. COSEE should be extremely active in providing press releases to the media. The Ocean Sciences should be as visible as the weather forecasts on radio and TV. COSEE should also sponsor symposia at meetings of the American Association for the Advancement of Science, which are attended by large numbers of media representatives. In the reverse direction, COSEE should act as a referral service-fielding questions from the media about Ocean Sciences research and education issues, and directing the media to the appropriate experts.

Traditionally Underrepresented Groups in the Ocean Sciences

COSEE programs must address the diversity issue in all of its components. In addition to ethnic minorities and women, the needs of other underserved groups warrant attention. These groups include persons with disabilities, those who are economically disadvantaged, and those from underserved regions. It is important for COSEE to coordinate its program with those of the NSF Directorate for Education and Human Resources (NSF/EHR) and Directorate for Geosciences (NSF/GEO) and the Office of Naval Research (ONR). COSEE should also explore the coordination of its efforts with the outreach activities of organizations for underrepresented groups in science, such as the Association for Women in Science (AWIS), the Association for Women Geoscientists (AWG), the National Association for Black Geologists and Geophysicists (NABGG), and organizations mentioned in the following paragraphs.

African Americans, Native Americans, Pacific Islanders, and Hispanics are scarcely represented in the Ocean Sciences professions. The near absence of these groups must be corrected in order to take full advantage of the potential within the human resource pool. Individuals from these groups can provide fresh perspectives and bring new talents to solving the problems faced in the study of Ocean Sciences. Moreover, population centers of many of these minority groups are found in coastal regions.

Despite the very low numbers of minority scientists in the field, there has been enough progress over the last two decades for the formation of a small, but active cohort of African American, Hispanic, and Native American aquatic scientists with PhDs. These individuals now serve as role models to minority students. COSEE projects should identify these individuals and utilize their expertise in promoting careers in the Ocean Sciences.

Women have made great strides in the Ocean Sciences in the last 20 years and account for the majority of graduate students in many institutions. Even so, COSEE should foster the continued progress of women in the field. A major goal should be to promote the graduation of PhD's at a rate that reflects the population in general. Projects that promote gender equity at the higher levels of academia and the profession should also be encouraged.

K-12 Education

The progression of students toward careers in the Ocean Sciences can be thought of as forming a pipeline that begins in childhood and stretches into early adult life. Although students from all groups tend to "fall out" of the pipeline at various places along the way by being "turned off" to science, minority students "fall out" at a much higher rate than non-minorities. COSEE programs must identify these critical areas of transition and develop steps to correct the situation. Successful remedies for retaining minority students can also be used to help retain non-minorities. Minority and women students should have early exposures to aquatic systems in order for them to develop an affinity for these marine and freshwater environments. These exposures should be followed by curricular activities in schools and informal learning experiences that expose students to appropriate role models and Ocean Sciences practitioners. As students progress through middle and high school, they should have more in-depth opportunities, including internships and hands-on activities in the field and laboratory that could be modeled on existing federally funded programs for summer science research experience, such as the National Institutes of Health High School Opportunities. Web-based modules, tailored to the needs of minority and women students, should follow this inclusion. Minority and women role models, concepts of environmental justice, and relevant context should be included in the modules. The students should be informed of the need to take college preparation courses in mathematics and science if they want to prepare for careers in the Ocean Sciences.

Undergraduate Education

Although substantial numbers of minority students choose to study science in college, the numbers selecting Ocean

Sciences career paths is very small. For example, many minority students hope to become physicians, because it is a familiar career often encouraged by parents or guardians, but they do not reach that goal. These students must be made aware of Ocean Sciences as an alternative rewarding, and still demanding, career direction. COSEE programs should target minority students and their parents and guardians to help them consider Ocean Sciences careers and to support those students who have committed to this career path. COSEE should explore coordinating the efforts of the few undergraduate Ocean Sciences degree programs at minority institutions (for example, Hampton University and Savannah State University) to improve their graduation of students. An arrangement should be developed to link minority students to opportunities in Ocean Sciences. These opportunities could include internships, Research Experiences for Undergraduates (REU) programs, special targeted programs involving scientific societies, links to appropriate role models and to other students with shared interests, informal education activities, governmental agency programs, and programs with non-governmental organizations (NGOs). COSEE should focus its efforts on institutions with high concentrations of minority students, including tribal colleges, community colleges in minority communities, historically minority-serving institutions, and institutions with proven track records of success with other science minority programs.

COSEE should also encourage institutions to develop more opportunities for minority students to experience the various aspects of Ocean Sciences careers. These opportunities could include traditional REU type summer programs, special summer camps, cruises on research vessels, and internships at aquariums and various governmental agencies. Successful models exist for a variety of such programs, including the Native Americans in Marine Science program at Oregon State University and the Minorities in Marine Science Undergraduate Program (MIMSUP) at Western Washington University. These targeted programs should include significant numbers of students in the context of a supportive environment. Peer mentors and role models should be used to enhance these activities, and the activities should take advantage of partnerships with a variety of institutions, including majority universities, aquariums, NGOs, agencies, school systems, scientific societies, industry, and minority organizations (such as the American Indians in Science and Engineering, AISE, and the Society for the Advancement of Chicanos and Native Americans in Science, SACNAS). Various programs sponsored by the National Institutes of Health provide solid models for emulation at minority institutions. These include the Minority Access to Research Careers (MARC) Program, the Minority Biomedical Research Support (MBRS) Program, and the Minority International Research Training (MIRT) Grant.

Graduate Education

Over the past twenty years, several hundred minority students have earned B.S. degrees in the Ocean Sciences, marine biology, environmental science, natural resources, and related fields; however, very few of them have continued their education to earn Ph.D.s. A special COSEE program should address the failure of the pipeline at the transition to graduate school. Producing a cohort of minority Ph.D.s will profoundly influence the success rates at earlier stages along the pipeline. These individuals can open new doors of opportunity and serve as role models and mentors for subsequent generations of minority students.

To begin with, the special COSEE Minority Ph.D. Programs should be located at a very few (perhaps three) of the leading institutions in the Ocean Sciences and should be structured such that they will induce institutions to compete for them. These institutions would propose the development of comprehensive programs to attract, train, and matriculate minority students. The programs should work with small cohorts of students (perhaps six) at each institution. A COSEE coordinator could develop and direct the program at each school. Each program could include special aspects to help prepare incoming students to meet the challenges of rigorous course work and research. Programs could also include innovative steps to aid the students as they progress through their course work and research. The expected outcome is to produce a significant cohort of minority Ph.D.s who have demonstrated excellence in their classroom and research efforts. These individuals would be prepared to enter postdoctoral programs, academic positions, or other jobs that can utilize their talents. The programs should be structured to recycle some of the graduates back into COSEE leadership positions for a period of time so that they

can help mentor subsequent cohorts of students. In laying the groundwork for its Minority Ph.D. Programs, COSEE should explore the opportunities for funding in the NSF Minority Graduate Education (MGE) Program. COSEE could also learn from the study (*Making Strides*, American Association for the Advancement of Science and the Commission on Professionals in Science and Technology, 2000) on stimulating the creation of a structural approach to support graduate education and from the results of THE PH.D. PROJECT (See Glossary, [Appendix 8](#)) that attracts minorities to business doctoral programs and provides support during the program.

Minority Community

In addition to efforts directed at the educational pipeline, COSEE's activities should also include outreach to the minority community in general. Students in COSEE programs should be given opportunities to share their work with their local communities. Visits to classrooms, clubs, church and community groups would provide peer mentoring and role models for local youth. A COSEE sponsoring of National Ocean Day could help catalyze activities in minority communities. COSEE could also link Ocean Sciences professionals to minority communities to promote eco-citizenship and greater awareness of environmental justice, issues that relate to watershed and coastal concerns. The COSEE portal should provide links to ocean-related information usable to the minority community, and COSEE outreach workshops should link various entities within and outside the minority communities.

Ocean Sciences Internships

One of the most effective ways to develop interest, insight, and skills in the Ocean Sciences is through participation in an internship. Internships provide participants with real-world experiences to complement traditional academic training. An internship provides the most beneficial experience when it is designed to meet the needs of the student, and only secondarily to aid the institution. Most ocean scientists view their first internship or research experience as their portal to their profession. Although a few internship programs in the Ocean Sciences already exist, for example, the Georgia Sea Grant Marine Science Education Internship Program and the NSF Research Experiences for Undergraduates (REU) Program, the COSEE program should be more diverse than these.

Internships may vary in whom they serve and the types of experiences generated. Students as early as middle school could participate in COSEE internship programs at local aquariums, sea coast parks, or laboratories, as appropriate. Beginning in high school, and extending through all levels of higher education, internships can serve students seeking experiences to augment their traditional training. This opportunity is especially important for students at community colleges and minority-serving institutions, where there is limited access to research experiences and specialized equipment or situations. Internships are also useful for non-students. Precollege teachers benefit from exposure to research, as do professors at small institutions lacking adequate facilities. Governmental agency and private sector employees also gain from such experiences. In addition, researchers wishing to improve their teaching skills can learn much from an internship.

There are various types of internships. Research experiences, such as those provided by the NSF Research Experiences for Undergraduates (REU) settings, are invaluable to the students they serve. This is especially true for minority students who may not have access to such activity at their home institution. The research REU can teach them to become scientists. Other internships may focus on learning practical skills in the work setting. Internships at museums or aquariums teach students how to interpret Ocean Sciences for the public, as well as how to design and maintain displays. Internships with school systems, the private sector, NGOs and government agencies all offer insight into how those entities function. These internships may vary in length and time of year. Although most student internships occur during the summer, there are also part-time internships during the academic year.

The mentor should communicate effectively with the student and provide a well-organized experience. Minority students should not be placed in situations where they are isolated. It is best to have a critical mass of minority

students working at the same location, if not in the same laboratory. The project should be meaningful and result in a product that the student can present at meetings or publish in a proceedings. The experience is even more beneficial if the project can be continued at the student's home institution and if faculty members there become involved in the project at some level. The presence of graduate students or other peer mentors also improves the experience.

Students holding COSEE internships must be compensated at a level competitive with traditional summer employment. The internship should provide for transportation to and from the location, if is remote from the home institution, as well as room and board. Opportunities for social interaction and learning outside the main assignment are also important to the success of the experience.

There should be formative and summative evaluation of the experience to ensure that the internship is working well for all parties concerned. The students should be tracked to help measure the impact of the COSEE internship upon their professional development. Programs designed for minority students must be culturally sensitive and interact with minority institutions, appropriate role models, and community groups. Finally, mentors should be rewarded for their efforts, for example, in the form of additional compensation, by having the mentoring included in promotion and tenure decisions, or in the form of supplies for their laboratory, and they should receive special recognition in their institution.

Ocean Sciences Careers

COSEE should encourage the integration of career information into the entire educational process across all levels. The breadth of the career path with an Ocean Sciences degree should be emphasized. Not only are the students prepared for careers in the biology, chemistry, geology, or physics of the ocean-and the integration of these sciences-but they are also sufficiently grounded in the basic sciences to consider careers in marine policy and such non-marine professions as environmental journalism, veterinary medicine, conservation biology, and geophysics. Nevertheless, the nature of the career information or the manner of delivery can be expected to vary with the level of education.

For grades K-12, COSEE should specifically advocate preparation for scientists seeking to act as career counselors. This could be called "aids to communication." For example, COSEE could promote efforts to organize kits for use by educators (slides, demonstrations, chemicals, and other resources) and provide tips for presenting the information effectively to audiences at each grade level. COSEE could also assist in developing support for summer programs for middle-school and high-school levels using undergraduates as mentors. This effort could perhaps involve an expansion of the NSF GK-12 Fellows Program to include summer programs with diverse Ocean Sciences careers as a focus. Consideration could also be given to using internships as opportunities for students in different career paths, i.e., internships should not be limited to working only with scientists.

For undergraduate education, COSEE should provide a synthesis of career information, including links to job options, for integration into Ocean Sciences courses. This information should highlight non-academic career paths, including marine technology, non-college teaching, advocacy, and policy-related jobs. COSEE should also promote better connections for career information. It could acknowledge that informal education experts could serve as bridges to opportunities in diverse career paths. It could inform industry of the capabilities of Ocean Sciences students and encourage industry representation at professional meeting exhibits to indicate the diversity of opportunities. Virtual mentoring programs based on email communication could be encouraged. With respect to teaching careers, COSEE should encourage B.S. and B.A. programs to be a linkage to K-12 teaching. To strengthen this linkage, undergraduates at colleges and universities could serve as role models for K-12 students in nearby areas. To evaluate the effectiveness of Ocean Sciences undergraduate and graduate degrees, COSEE should conduct an assessment of placement, career satisfaction, and adequacy of preparation, using initial and follow-up surveys. To ensure success in these programs, COSEE must promote the development of needed

incentives for university faculty participation in them.

For graduate education and continuing education, COSEE should enhance communication about the body of knowledge and the means of study in the Ocean Sciences for people not familiar with the sciences. Short courses could be offered for non-marine scientists and other professionals to heighten their awareness and understanding of the field. These courses could draw people from industry, policy, management, law, and journalism who, as a result, would be better able to estimate the talents and expertise that an Ocean Sciences student had to offer. Either associated with these courses or separately, Ocean Sciences educational materials could be developed to make non-scientists aware of Ocean Sciences issues and how those issues could influence their careers. The information could be available in brochures, as well as at Web sites, for people who do not have access to the Internet. Finally, COSEE should promote the creation of new careers through linkages, thereby increasing interdisciplinary awareness.

Evaluation of Ocean Sciences Education Initiatives

Evaluation of innovative educational initiatives is a major concern to the Ocean Sciences community. As researchers "step out" of the traditional comfort zone of directing graduate research to reach the general public or Congress, they need to learn how to evaluate the effects of their efforts. Similarly, teachers and undergraduate faculties experimenting with novel teaching approaches, such as those based on the scientific process for problem-based learning, need new methods to evaluate how these techniques change and enhance their own learning and their students' learning. As a result of these new trends, evaluation is in constant flux and a leading area of research in the educational arena.

Evaluation is a complex, long-term process that should be integrated into any activity, program, or approach attempted in education. It is a multi-step, time-dependent process. Standard evaluation should include:

Front End Evaluation. Before any educational process is attempted, it is essential to understand thoroughly the needs of the audience who will be targeted and to match the process goals accordingly. For instance, although a program to raise the awareness of Ocean Sciences in African-American students might be a national priority, there is no point in designing such a program for teachers in a community of mostly white American, Native American, and Hispanic students. Once the audience has been identified, matching the goals of the process with the needs of that community and with the changes expected from the process is very important. Finally, to ensure the changes that will result are valid and of value to the community, one needs to know the status of the audience's knowledge or awareness before the initiation of the evaluation process.

Formative Evaluation. Constant feedback is required throughout the development and implementation of the educational process in order to correct problems generated by the implementation or the design of the original process.

Summative Evaluation. An overall demonstration of accomplishments is required at the end of the process. If the process generated positive results, they should lead to a model that can be shared. If negative results were generated, the opportunity to develop new thinking and learning should not be lost. As in the scientific process, one learns as much from mistakes as from successes.

Impact. The impact is the long-term follow-up and analysis of the process. It should be a vertical (longitudinal) study, carried out over several years after the process has ended.

COSEE should give particular attention to the following types of evaluation as it defines its educational missions:

Evaluation of the Learning Process. This process is a long-term approach that can only occur with

collaboration between education researchers and research educators.

Evaluation of Educational Programs. The evaluation of programs has to be goal-specific and driven throughout the evaluative steps. It will require collaboration between evaluators and program designers. This collaboration has to begin with the birth of the idea. In the best-case scenario, the evaluator will assist in defining the program's goals. The common, flawed scenario involves contacting the evaluator once the proposal is written and bringing the evaluator on board when the program starts.

Evaluation of Products. (Curriculum, modules, activities, lessons, Web sites, CD-ROMs, and similar products.) For production of effective and high-quality products, the design and implementation of educational products or materials should involve collaboration between scientists, technologists, teachers, and the audience. Testing of this product on a limited representative sample audience is essential before release of the product to a wide audience.

Evaluation of Tools and Technology. (Internet, Web, publishers, dissemination, communication.) Evaluating the effectiveness of dissemination tools also requires collaboration between scientists, technologists, and education researchers who understand the learning styles of their audiences. Again, newly developed material should only be distributed to very large audiences after thorough testing on a representative sample of the targeted population.

COSEE should formulate strategies to address problematic issues of evaluation across all science education. These strategies might include: how to educate scientists in the importance of evaluation, especially front end evaluation, and specifically with respect to initiatives for informal education and teaching underrepresented audiences. The strategies might also include how to educate educators at all levels about the need for authentic assessment that reflects learning and changes in attitudes, not just numbers reached in audience. There is the need for strategies on how to educate funding agencies in the need for longer-term funding for evaluation than traditionally awarded in grants and in the need for long-term analysis assessing impact through years, which is now nonexistent. Another example is how to educate the field of science education in the need for tools to evaluate the effectiveness of material in learning (especially with Web-based material).

Although the digital libraries are facing the same problems, COSEE should take a leading role in developing, implementing, and refining high-quality, flexible, and testable evaluation tools to serve its mission. The evaluation problem can be well addressed by COSEE using the integration of Ocean Sciences research and education as a case study. The findings of this focused effort could be shared with, and used by, the science education community at large. Through COSEE, and in collaboration with the digital libraries and the NSF Directorate for Education and Human Resources (NSF/EHR), the NSF could lead and redefine evaluation standards of excellence for all research-education initiatives in science.

To attain this ambitious goal in excellence, COSEE would need to: (1) build bridges between evaluators, science researchers and education researchers; (2) move the understanding of learning forward; (3) identify exemplary evaluation methods, tools, best practices, and models; (4) facilitate the dissemination of evaluation models and tools; (5) provide guidelines to assess long-term impact; (6) educate Ocean Sciences researchers in evaluation; (7) promote a science focus for evaluators who collaborate with science researchers; and (8) foster a better understanding of technology-driven, rapidly-evolving "new teaching methods."

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Some Pervasive Concerns

Even though recommending the establishment of COSEE with great enthusiasm, the workshop also records some pervasive concerns: COSEE must have a clearly defined focus because "if everything is a priority, nothing is a priority." The starting point for defining the focus is the prioritization of educational opportunities and strategies discussed in the first part of this report. If COSEE is to be the intended unifying force for Ocean Sciences education, it must apply its efforts to needs of all the education sectors from its beginning: informal, K-12, undergraduate, and, as applicable, graduate. COSEE must be deemed relevant to all sectors from the beginning or segmentation will continue. Education must be seamless lifelong learning across all sectors.

Another concern is the scale of the challenge in bringing teachers and researchers together. Many of the activities recommended, for example, having a scientist visit the classroom or a teacher participate on a research cruise, are possible only at a small scale, reaching few teachers and students. Indeed, one estimate is that there are 54,000,000 precollege students in the U.S. and 2,000,000 science teachers. If the entire 35,000 members of the American Geophysical Union, who are not all ocean scientists, were to visit these teachers in their classrooms each year, each scientist would have to visit more than two classes every week for the entire academic year. As a past president of the National Science Teachers Association (NSTA) has noted, new ways have to be devised for bringing scientists and teachers together.

COSEE not only needs focus and attention to the scale of the problems, it needs metrics for measuring success; and it needs a business plan. (For some examples of metrics, see [Appendix 6.](#)) Will COSEE compete with existing organizations in creating and delivering Ocean Sciences education programs? Will COSEE become just another grant category at NSF? Affirmative answers to these questions are not the intention of the workshop and would make for the loss of a great opportunity. Despite these concerns, the workshop recommends the establishment of COSEE with great enthusiasm and views COSEE as an unparalleled opportunity both to make Ocean Sciences an integral part of our educational system and to develop a citizenry that can make informed decisions about the future use and conservation of the Earth's ocean environment.

Workshop Evaluation

In preparation for the summative evaluation of the COSEE Workshop, a Likert Scale instrument was developed to solicit participant attitudinal evaluations of the workshop and its various components. This instrument was collected from the participants at the conclusion of the Workshop. A researcher at USM's Institute of Marine Sciences/J.L. Scott Marine Education Center and Aquarium compiled the responses into percentages within categories representing strength of agreement with evaluative statements. (See [Appendix Z](#) for data.)

On the morning of May 23, Dr. Margaret Leinen, Assistant Director of the National Science Foundation, delivered the Keynote Address to the participants and facilitators. Her address was deemed Very Valuable or Valuable by 89% of participants, Average Value by 9%, and of Limited Value by 2%. The audience included the 68 workshop participants, seven facilitators, Drs. Dean McManus and Sharon Walker, five National Science Foundation staff members and one staff member from the Office of Naval Research.

Following the Keynote Address, the 68 participants met in seven pre-selected Education Sector Panels to determine the needs and priorities of the Ocean Sciences education community. The panels are identified in the Workshop Structure section of this report. The Educational Sector Panels perceived their pre-selection of these identified stakeholder groups as being 98% Very Valuable or Valuable. Further, 98% of the participants perceived their time as being well spent in the COSEE Educational Sector Panels' discussions in terms of the effectiveness of those Panels.

The Educational Sector Panels identified major threads which were substantively overlapping and the participants were re-divided into these Common Thread Panels to identify opportunities and needs relative to the commonality of these presentations. Following these meetings, the Educational Sector Panels reconvened to exchange their thoughts based upon the opportunities and priorities identified by the Common Thread Panels. Seventy-four percent of the participants believed the final summaries of opportunities and priorities were Very Valuable or Valuable. Twelve percent of the participants believed these summaries were of Average Value. And, 14% of the participants perceived the identified opportunities and priorities of Limited or Very Little Value.

In a final round of "break-out" meetings, the Educational Sector Panels identified specific strategies to address their respective needs. These specific strategies were perceived as 72% Very Valuable or Valuable, 20% Average Value, and 8% of Limited or Very Little Value by the 68 participants. Additionally, the participants evaluated the specific actions identified by the Educational Sector Panels as 98% Very Valuable or Valuable and 2% of Average Value

Finally, on a holistic level, the 68 participants were asked to evaluate the overall format and/or structure of the COSEE Workshop as it related to accomplishing the stated goals. The COSEE Workshop infrastructure was perceived to be 93% Very Valuable or Valuable in achieving its goals while 7% of the respondents deemed the format to be of Average Value in achieving the COSEE Workshop goals.

Acknowledgments

We would like to thank the participants in the workshop for their lively and penetrating discussions. This report is a consensus of their comments. We are indebted to the support staff of the J.L. Scott Marine Education Center and Aquarium and the staff of the USM-IMS and Gulf Park Conference Center for their unflinching efforts and good-cheer in making the workshop a success. We are honored to have had Dr. Margaret S. Leinen, Assistant Director of the NSF, Directorate for Geosciences, as the keynote speaker. We extend our deep appreciation to Dr. G. Michael Purdy, Director of the Division of Ocean Sciences, and to Dr. Dorothy L. Stout, Program Director (GEO), Division of Undergraduate Education, for their contributions to the workshop. We have benefited from the advice and assistance of Dr. Elizabeth A. Day, Assistant Program Director, and the wise counseling of Mr. H. Lawrence Clark, Program Director, and Ms. Elizabeth L. Rom, Associate Program Director, Division of Ocean Sciences, in the planning and implementation of this project. Finally, we thank David Mogk and Cathryn Manduca of DLESE for their informative e-mail discussions about DLESE.

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Appendices

Appendix 1. Audiences From Which COSEE Participants Were Selected

Students

Undergraduates-general education, Ocean Sciences, preservice teachers
Graduates-education and/or science

Instructors

Teachers-Grades K-5, 6-8, 9-12
Postsecondary instructors-community college, college, university
Informal education instructors-informal education organizations, science media, non-profit organizations

Investigators

Scientific investigators-including research programs in OCE
Education investigators-including research programs in EHR
Currently funded programs for teachers
Investigators in instructional technology

Representatives of Heritage and Education Organizations for Ethnic and Racial Minorities

Representatives of Professional Organizations (National, State, Local)

Teaching associations
Scientific societies
Environmental organizations

Representatives of Government Agencies

Federal government
State government
Regional and local government

Representatives of Informal Education Organizations

Within-Audience Diversity

Discipline-science, policy-legislation, engineering
Location-coastal/open ocean, polar/non-polar
Human-urban/rural, ethnic-racial, disabilities, seniors, junior professionals/senior professionals, geographic location

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Appendix 2. Workshop Agenda

CENTER FOR OCEAN SCIENCES EXCELLENCE (COSEE)WORKSHOP AGENDA

May 23-May 26, 2000

The University of Southern Mississippi-Gulf Park
Long Beach, MS

Tuesday, 23 May

5:00-6:00 p.m.	Registration and Reception
6:00-8:00 p.m.	Dinner at Gulf Park
8:00-8:10 p.m.	USM Welcome-Dr. Donald R. Cotton, VP for Research and Dr. James O. Williams, VP for the University of Southern Mississippi-Gulf Park.
8:10-8:20 p.m.	Welcome and Introductions, Dr. Elizabeth Day and Ms. Lisa Rom (NSF/OCE).
8:20-8:30 p.m.	Purpose of COSEE Workshop, Drs. Sharon Walker and Dean McManus

Wednesday, 24 May

Objectives:

- Identify the unique opportunities for the National Science Foundation's, Divisions of Ocean Sciences (NSF/OCE) and Undergraduate Education (NSF/DUE) to enhance Ocean Sciences education
- Panels will be composed of people with shared educational interests as Educational Sector Panels(See attached)
- Prioritize opportunities identified by Panels

7:00 a.m.	Breakfast, registration, and setting up of participants' posters in designated area
8:00 a.m.	Welcome and Introductions, Dr. Elizabeth Day and Ms. Lisa Rom (NSF/OCE)
8:15 a.m.	Keynote Address, Dr. Margaret Leinen (NSF/GEO), introduced by Dr. Mike Purdy (NSF/OCE)
8:45 a.m.	Charge to Panels, Drs. Sharon Walker and Dean McManus
9:00 a.m.	Educational Sector Panels convene to begin defining unique opportunities for NSF/OCE and NSF/DUE to enhance Ocean Sciences education based on needs (see attached) identified by COSEE Steering Committee
10:00 a.m.	Break
10:15 a.m.	Educational Sector Panels continue defining opportunities
12:00 p.m.	Lunch

1:00 p.m.	Educational Sector Panels continue defining opportunities and begin the prioritization of these opportunities
3:00 p.m.	Break
3:15 p.m.	Plenary meeting: Interactive panel summaries of opportunities and priorities
4:00 p.m.	On your own. (Steering Committee meets to review panel summaries and define Common Educational Thread Panels on the basis of conclusions common to most of the Educational Sector Panels.)
6:00-8:30 p.m.	Dinner-Chappy's Restaurant in Long Beach via charter bus

Thursday, 25 May

Objectives:

- Develop strategies for fulfilling themes in the opportunities identified by Educational Sector Panels
- Share and record ideas in newly formed "Educational Thread Panels" composed of "switching" COSEE participants from the original Educational Sector Panels to these Educational Thread Panels
- Apply the strategies recommended by the Educational Thread Panels to develop strategies under the original "Educational Sector Panels" when they reconvene at 1:30 p.m. this afternoon
- Record recommendations for strategies

7:00 am	Breakfast.
8:00 a.m.	Welcome and Introductions, Dr. Dorothy Stout (NSF/DUE)
8:20 a.m.	Plenary meeting: Where are we? Announcement of Threads and Educational Thread Panels, Drs. Walker and McManus
8:30 a.m.	Educational Thread Panels convene, to develop strategies for fulfilling the opportunities according to threads
10:30 a.m.	Break
10:45 a.m.	Educational Thread Panels reconvene to write recommendations
11:30 a.m.	Lunch. Dr. Jay Grimes, Dean, Institute of Marine Sciences, USM.
12:30 p.m.	Plenary meeting: Interactive Thread Panel summaries of strategies
1:30 p.m.	Original Educational Sector Panels reconvene to develop strategies for fulfilling opportunities according to primary education interest, using Educational Thread strategies as appropriate
4:00 p.m.	Educational Sector Panels begin to write recommendations
4:30 p.m.	Change clothes for Schooner Sail and board motor coach for trip to Biloxi
5:00 p.m.	Sunset sail and reception
7:00 p.m.	Return to Gulf Park
7:30 p.m.	Dress for Dinner

8:00 p.m.	Board Bus for Mary Mahoney's Restaurant
8:30-10:00 p.m.	Dinner

Friday, 26 May

Objectives:

- Report each Educational Sector Panel's recommendation for opportunities, priorities, and strategies
- Discuss each Panel's report
- Determine action list for additional tasks and deadlines

7:30 am	Breakfast
8:30 a.m.	Educational Sector Panels complete writing recommendations
10:00 a.m.	Break and check out of dormitory rooms
10:30 a.m.	Educational Sector Panels' reports and discussion (5 minutes each for the seven panels)
11:30 a.m.	Open discussion of COSEE organizational structure. Comments by Mr. H. Lawrence Clark (NSF/OCE)
12:15 p.m.	Lunch
1:00 p.m.	Workshop Wrap-up with action list for additional tasks, deadlines, and appreciation expressed to the participants, Ms. Rom, Drs. Day, Walker, and McManus
1:15 p.m.	Workshop Evaluation and Adjournment
3:00-5:00 p.m.	The Steering Committee will begin writing the reports of the Educational Sector Panels and Educational Thread Panels

Saturday, 27 May

7:30 a.m.-2:00 p.m.	The Steering Committee will continue writing the panel reports. "Working lunch."
2:15 p.m.	Steering Committee Members depart for return flights

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Appendix 3. List of Workshop Participants

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Appendix 4. COSEE Organizational Structure

Of the various organizational structures that might be considered for COSEE, the structure thought by the workshop participants to have the most advantages consisted, at least in part, of several regional hubs distributed across the nation. These hubs would serve as "Ocean Sciences learning communities." Regional hubs could build support for COSEE at the regional and local levels, where support is essential. Hubs could tap into resources at these levels, such as aquariums, museums, and marine laboratories, and influence school principals and superintendents more readily than a national center could. They could also connect more easily with teachers and science education faculty, who typically have little access to funding for travel to national locations, and they could allow many regions of the country to be involved in the initial design of the concept, including non-coastal regions. Hubs might be formed by consortia representing as many educational sectors of the Ocean Sciences as possible, in order to increase the diversity of participation. These consortia could be connected to the hub electronically. If hubs were to be located at sites of informal education, such as aquariums, they would be more accessible to the entire range of potential users than they would be at formal education sites. They would also be less intimidating to populations that are not comfortable within the environment of formal education. If hubs were located at sites among underrepresented groups in science, they could attract greater participation in Ocean Sciences education by these groups. For a site to be selected as a hub should be deemed an honor. The selection might follow a competition, which would encourage more collaboration between Ocean Sciences education organizations. Some examples of the hub structure are the NASA Astrobiology Institute, with its 11 hubs, and the NSF-funded South Carolina Statewide Systemic Initiative to Advance Achievement in Mathematics and Science Education, with its 13 regional hubs.

Disadvantages to the hub structure include the possibility of a breakdown in consistency among hubs, the choice of a site at a location where underrepresented groups are not encouraged to participate rather than in a diverse community that would encourage participation, potential competition for funds and user attention with the host organization at the site, and the choice of a site at a location lacking the connection to high bandwidths of the Internet that are essential for data transmission.

In contrast to a hub structure, COSEE might be organized with a central office, which if located in Washington, D.C., could have closer interaction with NSF and other Federal agencies than hubs could. Regardless of location, a central office could develop and coordinate large, national themes. The disadvantages of a central office include remoteness from regional and local interaction, lack of familiarity with regional issues, and the non-equitable attention given to the region where the office is located. The last-mentioned disadvantage could be alleviated by rotating the office throughout the nation at regular intervals, such as five-year periods. An example of a central office that is rotated regularly, without rotating personnel, is the NSF-funded office of the Joint Oceanographic Institutions Deep Earth Sampling (JOIDES) program.

A structure consisting of a small central office and several regional hubs would possess the advantages of both structures while canceling out many of the disadvantages. For instance, the central office could supervise and coordinate the hubs and regional opportunities while the hubs maintained regional connections.

Regardless of the organizational structure, the governing of COSEE should include an advisory board that represents as many stakeholders as possible, especially the underrepresented groups. These boards, whether national or regional, or both, should ensure a high degree of consistency among the regional centers in goals and commitment to the "signature threads" recommended in this report and provide the necessary communication and leadership from the national level. The advisory board should also ensure that funds are spent mainly on achieving COSEE goals and not on administration.

In considering its organizational structure, COSEE should review the structures of organizations that have similar educational goals as part of their overarching goals. Some of these organizations are federated partners of DLESE,

an arrangement with DLESE that COSEE should explore. Two of these organizations, the University Corporation for Atmospheric Research (UCAR) and the Incorporated Research Institutions for Seismology (IRIS), are primarily university research consortia consisting of universities with research interests in that field of science, but they also have active educational components. Funding for the organizations comes from the NSF, other Federal agencies, universities, and private foundations. The Earth System Science Education (ESSE) Program, by contrast, is solely an educational program. It is the cooperative university-based program for Earth System Science. It is sponsored by NASA through the Universities Space Research Association and has several universities participating in the program. The Alexandria Digital Library at the University of California, Santa Barbara is a consortium of researchers, developers, and educators-from academia, the public, and private sectors-that provides access over the World Wide Web to geographic data sets. The BRIDGE is a clearing house of Ocean Sciences education information. It is supported by the National Oceanographic Partnership Program (NOPP) and is sponsored by the National Marine Educators Association (NMEA) and the national network of Sea Grant educators. Although none of these organizations has goals or membership that are identical to those expected of COSEE, they offer elements of organizational structure and sustainable funding arrangements that could be applicable.

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Appendix 5. Changing the Culture of Research Universities and Research Institutions to Value Faculty and Graduate Student Teaching

COSEE should act on behalf of the Ocean Sciences in efforts to change the culture in research universities and research institutions so that teaching is accorded value comparable to that of research. The present culture discourages faculty from full participation in education and molds the attitudes of graduate students along the same lines. It is a culture inimical to the recommendations in this report. A cultural change should honor the risk-taking efforts in "novel educational approaches" as a legitimate part of an academic career. Promotion in the academic system should honor educational efforts that break the traditional boundaries, for example, by raising the awareness of large, non-specialized audiences or by developing innovative techniques to address small, specialized audiences, like undergraduates wanting to prepare for graduate work in the Ocean Sciences.

Very few graduate students in the Ocean Sciences receive any preparation to be a future faculty member. Teaching, a skill that they will use throughout their professional life, is commonly deemed by the faculty so trivial an activity that no preparation is needed for its successful application in the classroom. After all, no one prepared current faculty members to teach. As a result of the current attitude and a lack of opportunity to prepare for the future, neither the present faculty nor the future faculty is well prepared to participate in the reform in science education that is crystallized in the vision statement:

"All students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology, and all students learn these subjects by direct experience with the methods and processes of inquiry." (National Science Foundation, 1996, ii)

If one adds to this lack of awareness a reward structure in which research is overwhelmingly valued over teaching, the lack of funds for "faculty development"-a term unknown to many faculty members-and the lack of leadership by many administrators to improve education, then one can understand the lack of response in research universities and research institutions to calls for reform in science education and the resulting complaints from employers that university graduates are not educated to meet employers' needs. Most important, one can also gain some insight at to why the Ocean Sciences community has been lagging behind in the reform of science education.

The lack of reward for pedagogical activities in general, and excellence in teaching specifically, has been criticized for years in national reports, for example, the National Science Foundation (1996), *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology*, the National Research Council (1996b), *From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology*, the Boyer Commission (1998), *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. These and other reports, for example, the National Academy of Sciences (1995), *Reshaping the Graduate Education of Scientists and Engineers*, the conference on *Re-envisioning the Ph.D.* (2000) funded by the Pew Charitable Trusts, <<http://depts.washington.edu/envision/>>, and the current *The Ph.D. Site*, <<http://www.phds.org/>>, have also criticized graduate education that is restricted to a narrow research specialty. The need for change in this culture is mentioned in the NSF strategic plan, *NSF in a Changing World* (National Science Foundation, 1995), and, indeed, NSF has programs that are helping support this change, for example, the Faculty Early Career Development Program (CAREER), the recently cut Postdoctoral Fellowship in Science Math Engineering and Technology Education (PFSMETE) Program, Graduate Teaching Fellows in K-12 Education (GK-12), and Integrative Graduate Education and Research Traineeship Program (IGERT).

COSEE should develop strategies to help change the culture. COSEE could encourage the application to teaching of the reward system for research. Working with DLESE, COSEE should promote recognition by department faculties of the equivalence of a rigorous review system for the educational contributions to COSEE and the review system for research contributions to journals. In addition, COSEE should assist in developing the scholarship of

teaching and learning in the Ocean Sciences, one of the sciences not yet developing such scholarship on a national scale. Interaction could be explored with the Carnegie Academy for the Scholarship of Teaching and Learning, a major initiative of the Carnegie Foundation for the Advancement of Teaching. The program involves both science faculty in higher education and K-12 teachers and "...seeks to support the development of a scholarship of teaching and learning that will: foster significant, long-lasting learning for all students; enhance the practice and profession of teaching; and bring to faculty members' work as teachers the recognition and reward afforded to other forms of scholarly work" (<http://www.carnegiefoundation.org/OurWork/OurWork.htm>). Here is a national effort to encourage faculty acceptance of similar reward systems for teaching and research.

Regardless of the strategies taken by COSEE, the active integration of research and education in the Ocean Sciences will not reach fruition until excellence in education is valued on a par with excellence in research.

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Appendix 6. The Dashboard

Harvard Professor Richard Chait (Chait, Holland, and Taylor, 1996, p. 103-109) has proposed a useful concept for measuring and tracking performance of programs and organizations. He refers to it as the "dashboard" and the challenge is to identify the performance indicators to be included on the dashboard. The following performance indicators were identified to be on COSEE's dashboard. It was recommended that these be tracked on at least an annual basis.

- The number of new collaborations, involving different kinds of Ocean Sciences education and research organizations, that create new Ocean Sciences educational materials and programs for which COSEE can claim at least partial credit.
- The increase in the success of reaching diverse audiences and underrepresented communities with Ocean Sciences programs for which COSEE can claim at least partial credit.
- The increased awareness of the public concerning the importance of the oceans and the Ocean Sciences in the lives of people, their children, and all future generations.
- The awareness of COSEE by the constituencies represented in this workshop and by the media, and decision-makers.
- The increase in the number of users of COSEE over time and the degree of client satisfaction.
- Special NSF initiatives to create COSEE and to ensure its success.

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Appendix 7. Workshop Evaluation Data

Answers to two of the questions forming the summative evaluation of the COSEE Workshop, and a list of Additional Comments by the participants, indicate participant attitudinal evaluations of the workshop and its various components. This Likert Scale instrument was collected from the participants at the conclusion of the Workshop, as described in the Workshop Evaluation section of this report. Following the comments by the participants, pie diagrams of the evaluation data are presented.

Question 1: Was there adequate time for each activity?

Yes - 39

No - 7

Somewhat - 3

No Comment - 3

Please explain:

Yes:

- Reasonably Ok, organizers restructured the schedule throughout the workshop in response to progress.
- Arrangements and staff support were excellent.
- Overall, there was plenty of time to accomplish the objectives of the session.
- You were very responsive to any suggestion we made to panel facilitators-for example, I was happy to see opportunity for questions after the 2nd plenary summations. That way, everyone has opportunity to contribute to all panels.
- Yes, but only because the organizers were very responsive to altering the "final" agenda as needed.

No:

- Not enough time for reflection on Thursday
- Not enough time to make important contacts for future collaboration
- The schedule was packed to the gills!! This is common when much needs to be done in a brief time frame. One more full day together may have allowed for a less hectic pace.
- Workshops are always faced with too much content for time available. There is value in team building and networking, and opportunity for this is needed. Nevertheless, I'd have opted for less off-site activity (e.g. omit sailing trip.) Well, I wrote that comment before the sail, it was wonderful and very pleasant.
- The final group reports were cut short due to time. It would have been good for us to hear complete reports-we were short changed by not enough time for final group's full report.
- Sometimes I felt rushed, but also sometimes fatigue interfered.
- Plenary meetings were not long enough for the group summaries (or the summaries were too long!)

Somewhat:

- There was enough time for participants but perhaps more time for facilitators to process/work.
- I thought there was adequate time for "themes" but I felt confused about the purpose of these sessions. It seemed the structure of the report was already decided (shared educational interests) before we started discussions. I thought this weakened the "creativity" of the process, and made the themes seem like a detour or a digression to our real purpose, hard to re-integrate.
- Yes, but I think we could have spent more time on the boat, and skipped dinner the last night.

Question 2: What single suggestion would you make that would have improved this workshop?

- Needs assessment is something I've not done before. It would have been good to have a better advance understanding of the process.
- Phones in rooms to make long distance & internet connection
- More frequent "nature" breaks!
- Can't think of any other than more time, but that's always an issue and never enough, no matter what is planned.
- Less time spent on buses to get to extra curricular activities. The activities were great fun, but it might have been better to switch the Schooner excursion to the same evening as dinner at Chappy's so we weren't out "late" the last night of the workshop.
- Facilitators needed more time and effort on synthesizing group discussion to make more effective presentations. This should have included coordination among presenters to streamline presentations.
- Well, done
- The last day of the Shared Educational Interest Panel was more of a recognition of some of the earlier discussions. It may have been better to re-format the participants into "heterogeneous groups" to discuss some of the ideas about implementing COSEE
- More representation from new faculty (undergraduates).
- I would have included a representative from the young, but growing field of instructional design-the people who are actively building technologies into the curriculum. They are the ones who are devising and developing the tools that will help educators implement many of the strategies implemented.
- Create more opportunities for informal conversation, sharing and creation of insight collaborations
- Goals and objections could have been emphasized at the beginning of each session to clarify and keep groups on task. Facilitators did an excellent job of summarizing group discussions.
- Limit presenters (facilitators) to less time - e.g. Thursday was way too long. Ask them not to repeat information if already stated.
- Have it Sunday through Wednesday or Monday through Thursday.
- Initially, when I saw the schedule, I was skeptical of its outcome. However, at the end, I feel that this was outstanding event run by outstanding people.
- Email access.
- Shared interest panels were good - and useful - but they tended to segregate us by interest. It would have been helpful to find more ways to mix up the groups, so that we had to listen to each other's perspectives. These panels were one way to do that, but we needed more of that cross-interest dialogue. It's hard, sometimes, to assimilate such disputed views, but if we cant do that, who can?
- Thank you for this marvelous opportunity. I am honored to be a part of this historic event on behalf the Oceans and Ocean Science.
- Rooms were too cold. More students on panels.
- Susan Humphris did a wonderful job of moderating. Other moderators were not as focused and task oriented. Quite a bit of time was spent on the theme panel talking about unrelated topics.
- If more lead time was available a package, ready packages, was distributed prior that addressed some of the items/possibilities were within the common knowledge of all i.e. current models that do work on past that were not successful.
- Shorter "report-backs" - perhaps a professional facilitator could help the panel tie major themes together and coordinate report-backs.
- Have the facilitators help designate members of interest group into themed groups randomly placing them did not work in most cases.
- Eliminate "theme" component. I think that we would have arrived at the same conclusions without the "theme" process.

- Some way to avoid the Thursday afternoon burnout. That session was the only one that had low productivity from our group. I'm not sure what the solution would have been, but you asked for a suggestion and I'm having trouble coming up with other complaints.
- Keep the panel facilitator's presentations to 5 minutes; instruct them to present a simple, readable outline (the last round was an improvement).
- Less structured activities in the evening. Keep the group meal, set aside time before and after dinner for informal discussions.
- Invite more underrepresentative groups to participate. Better travel arrangements.
- I think that if you were to put more emphasis on awareness rather than collaborations, linkages, liaisons, and reteaching teachers, then you would not only receive a better ocean science awareness impact, you wouldn't have to worry about trying to find collaborations, linkages, liaisons, and reteaching teachers because COSEE will be successful and people will be begging to sign-on to this program.
- A flow diagram at the start of the workshop would have helped me to understand better how the overall groups would feed into our final presentations.
- Use networked laptops within each discussion group to get ideas recorded digitally - This makes organization of ideas much easier and helps our group facilitators be more efficient at summarizing and communicating groups products. There is software that does this.
- Better representation of OS research, including grad education. I thought stereotypes about researchers were often expressed ('ivory tower,' 'out of touch,' 'not interested in education,' well-funded and not very busy,' 'opposed to public ed.') and were allowed to go uncorrected. This weakened attempts to think about how to structure contact with researchers. Remember, many researchers also teach. And researchers are citizens of our communities - we vote, we have kids, we live in our communities, we visit museums, and aquaria, etc. We wouldn't have tolerated equivalent stereotypes about teachers being expressed.
- I think it would have been helpful to have focuses panel-specific questions to help get our discussions started.
- I would arrange schedules or create an agenda where the last day of the meeting ended in the evening and people left the next morning. This would allow everyone to stay through the very end of the meeting without having to leave for early flights. It would also allow people to return home early in the day. I spoke with 2 people who commented that they couldn't arrive home until sometime between 2 and 3 am. I think that people could be encouraged not to leave early if a major social activity was scheduled for that last evening (sunset cruise, Mary Mahoneys, etc.)

Additional Comments:

- Well done all in all folks. Thank you, well organized.
- The lodging facilities are fine as far as they go, but I had not expected to have limited access to telephone and online links. If I'd known, I'd have prepared better. I don't mind the absence of maid service and the less than fancy rooms, these are ok.
- Thanks for this opportunity to be involved. Great job!
- Thank you! For the opportunity to communicate and interact with such a vital, motivated exceptional group. I feel like we will produce far-reaching results due to this workshop.
- The presence of the key notes of NSF tops was marvelous - great support for our best effort. Did not feel that the intensive exercise was going into a "black hole." Personal high - again, excellent selection of participants.
- This was truly an excellent workshop. I was impressed by the way every one remained focused and engaged in the discussion. Sharon and her colleagues ran an extremely effective meeting. My compliments - I have organized similar events and I know what it takes to accomplish this under-taking. I hope the follow up will be equally effective. P.S. I rode the bus with Howard 5 times! I now know an incredible amount about the highlights along Highway 90. You should exploit his talents as a stand-up comedian- and give us medals for tolerating it!!
- Sharon Walker set the ideal tone for this conference-coming into it with the expectation that we would all work hard, have productive interactions and enjoy ourselves. I think all those expectations were exceeded. I'm delighted

to have participated in this conference and to have visited this beautiful region of Mississippi.

- Overall a good meeting, I look forward to seeing recommendations.
- A good workshop, perhaps this process needs to be repeated on a regional level, bringing together the same type of people.
- The strong presence of NSF in this conference was impressive and noted by all as necessary-it also validated what we were doing, and helped us address these tasks with feeling that our efforts would be considered-that nothing was wasted.
- How can we provide feedback at a later time? And further input into the process?
- The workshop was very informative and a lot of fun too. As a researcher, I never, or hardly ever, attend education meetings or workshops, so I found this very informative. I came away with a number of ideas for collaboration with educators.
- Thanks for such a great job organize this workshop!!
- Hopefully the first step of a truly rich, fruitful program that will quickly manifest itself in productive ways to the education community. Throughout the process please keep our students in focus. This was a marvelous experience...the time and efforts put into preparation manifest the attention to detail throughout our stay.
- Overall this was an incredibly valuable workshop, well organized with a good balance of time spent on "work" and "fun". Sharon and her team at USM have done an excellent job. I look forward with great anticipation to progress on the COSEE effort.
- One group leader had his own agenda and did not listen to participant's ideas like he should have.
- Excellent program as this is a tough audience and varied group to facilitate. More was accomplished within the groups than I thought possible through the discussions and mediation within the group.
- shorter "report backs", perhaps a professional facilitator could help the panel tie major themes together & coordinate report-backs.
- Supply web addresses with individual's information. Great workshop!!
- I appreciate the gracious hospitality. Thank you!! And, the opportunity to participate in the productive workshop.
- There were many advantages to the format of this workshop. E.g. meeting others in the OS community, finding out about other programs around the nation. The organizers and facilitators provided an excellent, well-organized event. A superior feature was the mix of many different OS groups from research to university to K-8 to informal.
- Remote, isolated site is ideal. We spend all our time working.
- Excellent workshop, extremely valuable.
- Thank you for this opportunity. I was thrilled to have the opportunity to see how NSF "works." Thank you.
- Loved the site, the friendship oak was awesome. Some of us weren't familiar with NSF structure-A chart in our packet of info. Or a brief presentation of how the NSF programs are currently structured would be useful early in the game. NSF speakers each referred to various programs but no one actually gave us the big overview.
- I think the terms marine sciences/ocean sciences are very broad. That's a good thing, but I think there are challenges unique to different parts of these fields. It may be a lot different translating marine biology into the classroom than blue water physical oceanography, for example.
- Sharon and her staff did an outstanding job. The members of the steering committee did an outstanding job. I think that this was a very productive and exciting workshop.

Summative Evaluation Data

The summative evaluation of the COSEE Workshop was undertaken with a Likert Scale instrument to solicit participant attitudinal evaluations of the workshop and its various components. The responses were compiled into percentages within categories representing strength of agreement with evaluative statements. The data on responses to thirteen evaluative statements, and explanations of those statements, are as follows:

<p>On the morning of May 23, Dr. Margaret S. Leinen, Assistant Director of the National Science Foundation gave the keynote address. Dr. Leinen's address was evaluated by the 68 participants as 89% Very Valuable or Valuable, 9% Average Value, and 2% Limited Value.</p>
<p>Following the Keynote Address, the 68 participants met in seven pre-selected Educational Sector Panels to determine the needs and priorities of the Ocean Sciences community. These Educational Sector Panels perceived their pre-selection of these identified stakeholder groups as being 98% Very Valuable or Valuable. Two percent of these participants believed these pre-selection groups were of Average Value.</p>
<p>The 68 participants were asked to evaluate the effectiveness of their discussions during the meetings, and 98% of the participants perceived their time as being well spent in the COSEE Educational Sector Panel discussions.</p>
<p>Following presentations of the Educational Sector Panels, participants were re-divided into groups representing major threads identified collectively among the original seven panels. These Common Thread Panels identified opportunities and needs relative to commonality of these presentations. Following these discussions, the original Educational Sector Panels reconvened to exchange their thoughts based upon the opportunities and priorities identified by the Common Thread Panels. The final summaries of opportunities and priorities were perceived by 74% of the participants to be Very Valuable or Valuable, by 12% to be of Average Value, and by 14% to be of Limited or Very Little Value.</p>
<p>In the final round of break-out meetings, the Educational Sector Panels identified specific strategies to address their respective needs. These specific strategies were perceived by the 68 participants as 72% Very Valuable/Valuable, 20% Average Value, and 8% of Limited/Very Little Value.</p>
<p>The 68 participants evaluated the specific actions identified by the Educational Sector Panels following summary presentations as 98% Very Valuable/Valuable and 2% of Average Value.</p>
<p>Participants were asked to evaluate the overall format and/or structure of the COSEE Workshop as it related to accomplishing the stated goals. The COSEE Workshop infrastructure was perceived to be 93% Very Valuable/Valuable in achieving its goals while 7% of the respondents deemed the format to be of Average Value in achieving the COSEE Workshop goals.</p>
<p>To provide an opportunity for social interaction for professional relationship development, and for personal growth while on the coast of Mississippi, participants enjoyed an evening reception on a 79' replica of a historic, Biloxi Schooner. Of the 68 respondents, 90% believed the Schooner Sunset Sail was Very Valuable/Valuable, 6% believed this activity to be of Average Value, and 4% believed this activity to be of Limited Value as related to achieving the COSEE Workshop goals.</p>
<p>Participants were treated to local seafood cuisine at one of the coast's historic restaurants located within walking distance of the conference headquarters and housing on the Gulf Park Campus of The University of Southern Mississippi. Of the total number of COSEE workshop attendees, 92% believed Chappy's cuisine/service and the social interaction to be Very Valuable/Valuable. Six percent of the participants believed Chappy's cuisine/service and social interaction was of Average Value and 2% believed this event to be of Limited Value as related to</p>

achieving the COSEE Workshop goals.
<p>Located in one of Biloxi's oldest original structures, Mary Mahoney's Restaurant was the location of the final dinner event for the workshop. Of the 68 COSEE Workshop participants, 88% perceived dinner/service and the social interaction as Very Valuable and Valuable; 10% believed this activity was of Average Value; and 2% believed the dinner/service and interaction were of Limited Value as related to the COSEE Workshop goals.</p>
<p>The discussion groups at the COSEE Workshop were facilitated to encourage participant focus and to maintain the schedule. These individuals also served as the Workshop presenters to summarize group discussions throughout the week. Of the 68 respondents, 94% believed the COSEE Workshop facilitators were Very Valuable and Valuable. Six percent of the participants believed the facilitators were of Average Value concerning their responsibilities in serving in this COSEE Workshop role.</p>
<p>Participants were provided housing in the Conference Center dormitories at the USM-Gulf Park Campus. These are spartan, "college dorm" type rooms, but were used to afford easy movement from housing facilities to meeting rooms. Sixty-eight percent of the COSEE Workshop participants deemed these housing accommodations as Very Valuable and Valuable; 32% perceived these accommodations of Average Value.</p>
<p>Breakfasts and lunches were provided in the cafeteria at the USM-Gulf Park Campus. These meals were served in typical, cafeteria-line fashion, as opposed to sit-down table service. Eighty percent of the COSEE participants believed this type meal service to be Very Valuable and Valuable while 20% believed this cafeteria -type service to be of Average Value.</p>

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Appendix 8. Glossary

AGU - American Geophysical Union

AISE - American Indians in Science and Engineering

ASLO - American Society of Limnology and Oceanography

AWG - [Association for Women Geoscientists](http://www.awg.org) <http://www.awg.org>

AWIS - [Association for Women in Science](http://www.awis.org) <http://www.awis.org>

BRIDGE - [Ocean Sciences Education Teaching Resource Center](http://www.vims.edu/bridge/) <http://www.vims.edu/bridge/>

Chautauqua - Originally a summer school in the town of Chautauqua, New York. A popular, roving educational and recreational assembly that flourished in the late 19th and early 20th centuries and provided lectures, concerts, and plays. A similar educational circuit found today.

CIMI - [Catalina Island Marine Institute](http://www.guidediscoveries.org/cimisite/school.htm) <http://www.guidediscoveries.org/cimisite/school.htm>

COAST - [Consortium of Oceanographic Activities for Students and Teachers](http://www.coast-nopp.org/) <http://www.coast-nopp.org/>

CORE - [Consortium for Oceanographic Research and Education](http://core.ssc.erc.msstate.edu/) <http://core.ssc.erc.msstate.edu/>

COSEE - Center for Ocean Sciences Educational Excellence

DLESE - [Digital Library for Earth System Education](http://www.dlese.org/) <http://www.dlese.org/>

EHR - National Science Foundation, Directorate for Education and Human Resources

ENC - Eisenhower National Clearinghouse

ERIC - [Educational Resources Information Center](http://www.accesseric.org/) <http://www.accesseric.org/>

ESS - Earth System Science

ESSE - [Earth System Science Education Program](http://www.usra.edu/esse/) <http://www.usra.edu/esse/>

GIS - Geographic Information Systems

GK-12 - [NSF Graduate Teaching Fellows in K-12 Education \(GK-12\) Program](http://www.ehr.nsf.gov/EHR/DGE/GK-12.htm), Division of Graduate Education <http://www.ehr.nsf.gov/EHR/DGE/GK-12.htm>

GLOBE Program - [Global Learning and Observations to Benefit the Environment Program](http://www.globe.gov/) <http://www.globe.gov/>

[High School Opportunities](http://www.grants.nih.gov/training/careerdev/hsopport.html) - A National Institutes of Health intramural program for research training and career development <http://www.grants.nih.gov/training/careerdev/hsopport.html>

IRIS - [The Incorporated Research Institutions for Seismology](http://www.iris.edu) <http://www.iris.edu>

JASON - Scientific expeditions designed to excite and engage students in science and technology and to motivate and provide professional development for teachers. <http://www.jason.org/>

JOIDES - [Joint Oceanographic Institutions for Deep Earth Sampling \(JOIDES\)](http://www.joides.geomar.de/). <http://www.joides.geomar.de/>

MARC - National Institutes of Health [Minority Access to Research Careers Honors Undergraduate Program](http://grants.nih.gov/training/careerdev/colopporte.html#cmarcustar) <http://grants.nih.gov/training/careerdev/colopporte.html#cmarcustar>

MARE - Marine Activities Resources and Education Leadership Institutes

MATE - [The Marine Advanced Technology Education \(MATE\) Center](http://www.marinetech.org/) <http://www.marinetech.org/>

MBRS - National Institutes of Health [Minority Biomedical Research Support \(MBRS\) Program](http://www.nidr.nih.gov/opportunities/diversity/mbrs.htm) <http://www.nidr.nih.gov/opportunities/diversity/mbrs.htm>

MentorNet - [The National Electronic Industrial Mentoring Network for Women in Engineering and Science](http://www.mentornet.net). <http://www.mentornet.net>

[Middle Grades Science Textbooks Evaluation](http://www.project2061.org/newsinfo/research/textbook/mgsci/criteria.htm) - AAAS Project 2061 <http://www.project2061.org/newsinfo/research/textbook/mgsci/criteria.htm>

MIMSUP - [Minorities in Marine Science Undergraduate Program](http://www.ac.wvu.edu/~spmc/) <http://www.ac.wvu.edu/~spmc/>

MIRT - National Institutes of Health [Minority International Research Training \(MIRT\) Grant](http://www.nih.gov/fic/programs/mirt.html) <http://www.nih.gov/fic/programs/mirt.html>

NAGT - [National Association of Geoscience Teachers](http://www.nagt.org) <http://www.nagt.org>

NABGG - [National Association for Black Geologists and Geophysicists](http://iapetus2.bgsu.edu:1003/nabgg.html) <http://iapetus2.bgsu.edu:1003/nabgg.html>

NARST - [National Association for Research in Science Teaching](http://www.narst.org/) <http://www.narst.org/>

NASA - [National Aeronautics and Space Administration](http://www.nasa.gov) (http://www.nasa.gov)

NASA/ESE - [NASA Earth Science Enterprise](http://www.earth.nasa.gov/) <http://www.earth.nasa.gov/>
NASA NOVA - [NASA Opportunities for Visionary Academics](http://education.nasa.gov/nova/) <http://education.nasa.gov/nova/>
NOAA - [National Oceanic and Atmospheric Administration](http://www.noaa.gov) <http://www.noaa.gov>
NGO's - Non-governmental organizations
NMEA - [National Marine Educators Association](http://www.marine-ed.org/) <http://www.marine-ed.org/>
NOPP - [National Oceanographic Partnership Program](http://core.ssc.erc.msstate.edu/NOPPpg1.html) <http://core.ssc.erc.msstate.edu/NOPPpg1.html>
NSF/DUE - National Science Foundation, Division of Undergraduate Education
NSF/EHR - National Science Foundation, Directorate for Education and Human Resources
NSF/ESIE - National Science Foundation, Division of Elementary, Secondary, and Informal Education
NSF/GEO - National Science Foundation, Directorate for Geosciences
NSF/MGE - National Science Foundation, Minority Graduate Education Program
NSF/OCE - National Science Foundation, Division of Ocean Sciences
NSTA - [National Science Teachers Association](http://www.nsta.org) <http://www.nsta.org>
ONR - Office of Naval Research
PFSMETE - NSF Postdoctoral Fellowship in Science, Math, Engineering, and Technology Education Program
REU - [Research Experiences for Undergraduates](http://www.nsf.gov/nsf/nsfpubs/nsf96102/nsf96102.htm) <http://www.nsf.gov/nsf/nsfpubs/nsf96102/nsf96102.htm>
REVEL - [Research and Education: Volcanoes, Exploration, and Life](http://www.ocean.washington.edu/outreach/revel/)
<http://www.ocean.washington.edu/outreach/revel/>
SACNAS - [The Society for the Advancement of Chicanos and Native Americans in Science](http://www.sacnas.org/)
<http://www.sacnas.org/>
SEA - [The Sea Education Association](http://www.seaeducation.org/) <http://www.seaeducation.org/>
SEA CAMP - [Sea Camp](http://www.guidediscoveries.org/cimisite/summer/seacamp/seacamp.htm) is a three week program offered for youths 13-17 years old.
<http://www.guidediscoveries.org/cimisite/summer/seacamp/seacamp.htm>
[THE PH.D. PROJECT](http://www.phdproject.com) - A project to increase minority representation in American business.
<http://www.phdproject.com>
UCAR - [University Corporation for Atmospheric Research](http://www.ucar.edu) <http://www.ucar.edu>
WISE - [Center for Women in Science and Engineering](http://www.eng.washington.edu/uwwise). <http://www.eng.washington.edu/uwwise>

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