COSEE Decadal Review Committee Report

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COSEE Decadal Review Committee Report
Executive Summary

The COSEE Decadal Review Committee (CDRC) met at the National Science Foundation July 12-13, 2011 to review COSEE's progress to date and its plans and promise for the future. The Committee found the COSEE network of regional and thematic centers to be healthy and active, populated with dedicated and self-reflective scientists, educators, evaluators, staff, and advisory committee members. Since COSEE was first established in 2002, both NSF and public expectations have grown for scientists to provide meaningful access to their research. In turn, there has been growing interest within the scientific community in making societal connections. Over the years, COSEE has functioned as an important asset for ocean research and ocean scientists in facilitating professional interactions with educators and education and outreach venues. COSEE is growing increasingly visible as a responsive and proactive community resource. COSEE is now challenged to implement best practices across the Network, put in place quality control measures on programs and products, and disseminate the highest quality outcomes more broadly so as to transform science research and education. Looking ahead, the CDRC found that COSEE needs to be more strategic in their planning and functioning. In making decisions regarding future support for COSEE, the CDRC strongly recommends that NSF analyze COSEE's role within the context of existing and emerging GEO as well as Foundation-wide priorities.

In accordance with NSF priorities, participation in COSEE programs and development of COSEE materials has enabled individual ocean scientists to explore and articulate a wider perspective on their research, to make connections between their research and societal implications, and to learn science education practices – which they in turn report using to make their own teaching more effective (70% teach), and to establish connections in their local community through education and outreach events. Because COSEE programs and materials are developed in association with educational experts and practitioners, they use best practices, thus elevating the activities that scientists could have developed on their own. Surveys of participating scientists, educators, students, and members of the public indicate that COSEE activities are helpful and meaningful. Surveys also indicate that COSEE scientists feel better prepared and view education and outreach more positively, thus increasing their accessibility to educators and the public.

In terms of impact on ocean research at large, COSEE has played important roles in several major national endeavors that promise to increase public interest and knowledge of the oceans. The early COSEE community played a significant role in drafting the Ocean Literacy Principles and COSEE has continued to advance their use. COSEE-California has led the Ocean Literacy Scope and Sequence that maps learning progressions for teachers. With this as background, COSEE contributed to the reformulation of the framework being developed by the National Research Council released in July 2011 that will ultimately lead to new national science education standards. As a result, ocean science is likely to play a much larger role in the K-12 curriculum. These activities are important because they will support a future workforce that is more literate about ocean science and better prepared to deal with ocean-related challenges.

Regarding COSEE operations, in the early stages, COSEE's priorities were on establishment and development of the individual centers, with the network primarily serving as a communication forum. As the centers matured, connections were made between and among the centers through shared practices. Around 2008, COSEE began to function more as a coordinated network: use of a common logo and web presence were embraced, the evaluation working group was reconstituted in 2009, first

COSEE-wide educator engagement survey took place in 2009, first COSEE-wide scientist engagement surveys in 2009 and 2010, COSEE-wide workshop on best practices in the professional development of educators in 2009, COSEE-wide workshop on best practices in the engagement of ocean scientists 2010. The synergy from collaborative teams is an important outcome of COSEE, for this provides the foundation to move forward in addressing gaps, needs, and strategic initiatives across the Network.

Complications with two different network evaluators have led to COSEE not having adequate analysis of network development and functioning, nor of its advancement of core activities across the centers. No evaluations of the network were provided to the CDRC. The surveys of scientists and educators conducted by the reconstituted Evaluation Working Group are a great start towards analyzing cross-center impact, but are only a beginning step on the road to high quality evaluation.

The CDRC found that the National Advisory Committee has served COSEE extraordinarily well and many of their recommendations are reflected in the ones we offer below. While in the early years, their excellent advice was often not implemented, since about 2009, the COSEE Council has responded directly to their input.

The portfolio of COSEE activities evolved since 2002 for a variety of reasons, ranging from strategic development of new resources to implementation of best practices, support for individual interests, and responses to local or national opportunities. Center evaluations have provided valuable formative information for each to help improve its unique programs and products. There is evidence of needs assessment (front end) evaluation to help design approaches and products. Furthermore, the evaluations have provided the opportunity to solidify innovative approaches through pilot test data on the participant-perceived quality and effectiveness of the center offerings. Some programs and materials have been widely disseminated, for example, the COSEE-CA Communicating Ocean Science curricular resources are now used by 27 institutions. Others appear to have been developed at a high cost for unclear objectives. And others may be missing opportunities: for example, were the best practices developed at the two COSEE-wide meetings later adopted and adapted by multiple Centers?

To optimize efforts, COSEE needs to be explicit about the outcomes it expects to achieve. We recommend that COSEE determine critical audiences and leverage points through a coordinated, network wide-assessment, grounded in the literature. They can then use this assessment to focus on making strategic, high impact, investments with evidence-based outcomes in mind. Using design principles, the Centers can tailor activities to meet specific goals. Once determined by rigorous evaluation to be of high quality – see for example the COSEE-California ocean literacy survey instrument– activities should be tested in several Centers, in order to explore implementation options. To maximize impact, projects should have deliberate dissemination and impact assessment plans, beyond the COSEE community, most likely in collaboration with partners.

We agree with COSEE's future focus on increasing diversity. We recognize the challenges inherent in achieving and demonstrating impact on this issue and we commend the activities of individual centers, for example the Science Fairs of COSEE-Alaska, the cultural competency workshop developed by COSEE-Mid-Atlantic, and the fact that two annual meetings focused on broadening participation. However, we are disappointed with the lack of systemic, network-wide progress in the past and are pleased to learn that the next COSEE-wide best practices workshop will be on diversity.

The CDRC recognizes that these recommendations for assessment, synthesis, coordination, implementation, and dissemination will put greater pressure on the Network. Therefore the CDRC recommends that NSF provide more resources for COSEE Network intellectual and operational leadership and staffing as well as for the Centers to participate in Network-wide activities. While it is a testimony to the strength of community established by COSEE that many people voluntarily donate time to make things work, it is not appropriate for the program to run continuously on "heroic" efforts.

With these modifications, the CDRC finds COSEE to be very well positioned to play critical roles in support of ocean research and researchers, for example:

- Systemic approaches to engaging diversity
- Meaningful implementation of the revised Broader Impacts criterion
- Helping scientists meet K-12 demand for current, standards-based ocean science educational materials in view of the revised standards
- Integrating ocean research with quality of life and national prosperity

In conclusion, the COSEE Decadal Review Committee found that COSEE has successfully supported the ocean science and the ocean research community in the past and is poised for significant contributions in the future. Based on our analysis of past activities and future promise, the CDRC recommends that NSF continue funding of COSEE, with the modifications detailed above: greater focus, evaluation and dissemination of strategic investments and strengthening of network management to support central functions. Because the CDRC was not in a position to evaluate all of the centers critically or to rank the centers for return on investment, we did not assess whether it was essential to have all of the centers in order to maintain a productive network and achieve program goals. A critical mass of centers is required, in order to serve the large and multifaceted needs of the ocean research community, however, establishing strategic partnerships is another important way to extend COSEE's future reach.

That said, the overall NSF landscape of programs and expectations has changed substantially since COSEE was established nine years ago. OOI, SEES, CIF21, R2R and Earth-Cube are just a few of the major initiatives that intersect with the expertise and capacity built through GEO's long term support of COSEE. In order to coordinate future investment in COSEE with NSF's other existing and emerging programs, we strongly recommend that NSF map COSEE expertise and activities against Foundation priorities to determine gaps, clarify goals for COSEE, and then develop a plan for how to fill them, potentially through collaboration with other directorates – especially Education and Human Resources.

COSEE Decadal Review Committee Report

The COSEE Decadal Review Committee was charged to review the COSEE Program in its entirety and provide comments and recommendations to the Division Director for Ocean Sciences on the success of COSEE in achieving its stated goals of:

- establishing a network of coordinated Centers that facilitate collaborations and communications between ocean science researchers and educators;
- fostering the integration of ocean research into high quality educational materials and programs;
- effectively engaging ocean researchers in ocean sciences education and outreach;
- providing educators with an enhanced capacity to understand and deliver high-quality educational programs in the ocean sciences; and
- promoting a deeper public understanding of the ocean and its influence on each person's quality of life and our national prosperity.

Education and Outreach

Accomplishments

Over the years, COSEE has functioned as an important asset for ocean research and ocean scientists in facilitating professional interactions with educators and education and outreach venues. COSEE is growing increasingly visible as a responsive and proactive community resource.

COSEE accomplishments identified by the CDRC as transformative, are:

A1. What are the major accomplishments to date of the individual Centers? In what ways and to what degree have these accomplishments been transformative?

The Network: COSEE successfully formed a functioning network that is engaged and self-reflective with an established community of practice. For example, as a community, they succeeded in reconstituting an active evaluation working group. They also assembled materials into a thorough and cohesive report for the Decadal Review.

Community engagement: Over the past 9 years, the Centers have contributed to the professional development of many scientists and educators, facilitating the two-way transfer of knowledge regarding ocean science and science pedagogy. Participants report being satisfied by their COSEE experience indicating that the interaction has helped them improve their work. By forming partnerships among scientists, educators and the public, COSEE has contributed to the growing recognition by the ocean science community of the importance of effectively communicating the societal impacts of their work.

Responsiveness: Because of their size, long term funding, and connectivity, COSEE can speak as a community and respond coherently to both internal and external issues. For example, COSEE provided input to the development of the ocean literacy initiative as well as the ocean literacy scope and sequence, and contributed ocean content to the NRC science education framework that will be translated into new national science standards.

`Model: COSEE is beginning to serve as a model for other communities. For example, the ocean literacy effort spawned one on climate literacy. In discussions regarding changing the NSF Broader Impact merit review criterion, COSEE is considered a model for how organizations might play a larger role in focusing, professionalizing, and facilitating broader impact activities. Similarly, NSF used its experience with the COSEE RFP to develop the Climate Change Education Partnership solicitation, which teamed climate researchers with practitioners and learning experts.

Other major accomplishments include:
Activity: The Centers report numerous efforts that have resulted in noteworthy programs or resources – see below.
Focal and leverage points: Because of their critical mass of resources, engaged scientists and educators, and visibility, the Centers have become focal points for broader impacts activities within their local communities. They often leverage the NSF investment through connections with other organizations and agencies, for example, NOAA and EPA.
Positioning: COSEE Centers and the Network are well positioned to respond, adapt and become proactive on future ocean research issues. For example, now that the new science education framework includes stronger references to ocean science, COSEE will be the organization that will be consulted regarding education standards and to find out about the most current ocean science.
Developing and sharing best practices: The Network has organized two best practices workshops -- one on professional development of educators in 2009, and one on the engagement of ocean scientists 2010 -- that resulted in collection and sharing of experiences and relevant literature. The next important step will be dissemination of findings, both through peer-reviewed literature and through development of handbooks.

Noteworthy accomplishments of individual centers (see also "Highlights" section of COSEE's background report):

COSEE-California (2002-current)
CA has leveraged a large amount of funding from the $500,000 per year from COSEE to about $2 million per year. CA developed and disseminates the Communicating Ocean Sciences courses (scientists, informal and about K-12 and courses for instructors of these courses). CA has developed an ocean sciences set of curricular materials to be used as core science materials by entire school districts—The Ocean Sciences Curriculum Sequence for Grades 3-5 and Grades 6-8. CA has done very comprehensive work toward the development of an ocean literacy assessment instrument.

COSEE-West (2002-current)
COSEE West is exemplary in the growth of its array of partnerships from the initial set of partners which included USC, UCLA, The College of Exploration, Los Angeles Unified School District, and the Aquarium of the Pacific, to include scientists from 12 universities and research institutions, educators from 8 informal science education centers, and 100s of teachers from school districts around the country. A notable aspect of COSEE West's partnership development activities is the COSEE West Colorado Collaborative, funded with NSF support in 2008, which supports a teacher exchange program that promotes the involvement of educators in inland areas.
Innovative offerings developed by COSEE West that target key leveraging of partners include the Informal Educator Professional Development Series which directly involves marine scientists in deepening the capacity of informal educators to bring cutting edge marine science to their museums, science centers and aquaria; the Online Workshops which have been offered twice per year since 2008

and have communicated current marine science research to geographically dispersed educators, and the Marina del Ray Summer Workshops which provide professional development to teachers in a newly formed middle school to integrate marine sciences across the curriculum. The students in the MDR middle school perform better on the state wide CA science test than their peers from other schools, attesting to the effectiveness of the curriculum developed with support from COSEE WEST.

COSEE-Great Lakes (2002-2011)

COSEE-GL provided a School for Scientists with 11 sessions at the IAGLR (International Association for Great Lakes Research) conference with about 50 participants at each session. The sessions were designed to bridge the communications gap in achieving meaningful collaboration by assisting scientists in use of appropriate pedagogy and familiarizing them with opportunities, tools and techniques for improved educational outreach. GL measured the effect of their programming by examining change in the accuracy and complexity of concept maps developed pre and post by participants.

COSEE-Southeast (2002-2011)

COSEE-SE's Basic Observation Buoy – BOB --program is developed in partnership with NOAA. The program engages participants in designing sensors for a scaled down, instrumented buoy, and then in using ocean observing data. BOB has been adopted by the research-based South East Atlantic Coastal Ocean Observing System (SEACOOS) as its signature STEM effort.

Ocean Sciences Leadership Institutes run by COSEE-SE from 2003-2010 led to development of Ocean Awareness Days at more than 14 aquaria, museums and science education centers through SEPORTS: South East Portal of Ocean Research for Teachers.

COSEE-SE states that they have "led the National COSEE Network in overt efforts to broaden participation in all aspects of its programs and activities." Over 16% of participants in COSEE-SE events are non-white.

COSEE-Central Gulf of Mexico (2002-2011)

Central Gulf of Mexico: The COSEE Central Gulf of Mexico Center has primarily focused on core (routine) teacher professional development programs, including summer institutes with embedded scientists as well as distance learning. Perhaps most impressive are the professional development programs at sea that have been offered by COSEE CGoM in partnership with the U.S. Navy. For the teachers that participate, this is likely a once-in-a-lifetime authentic field-based research experience. Note this Center was not renewed and closes in 2011.

COSEE-New England (2002-2007)

COSEE-NE, in collaboration with TERC, developed "Telling Your Story," a workshop and handbook that provides guidance on planning effective K-12 classroom visits by scientists. The guidance includes using concept mapping – which links with the work by COSEE-OS – and establishing scientist/teacher teams.

COSEE-Florida (2002-2005)

COSEE Florida's goal was to engage ocean researchers, educators, and the general public throughout Florida with a focus on both regional and national ocean literacy.

COSEE-Ocean Systems (2005-current)

Ocean Systems: The COSEE Ocean Systems Center developed the concept mapping tool in Partnership with Raytheon Web Solutions that is now used by several other Centers in the Network and by NASA for staff training. While concept mapping is not a new tool, it can be an effective means of organizing and

communicating complex ideas. COSEE uses this tool in professional development for scientists, to help them better communicate with educators. A second highlight from Ocean Systems is that they were selected (along with COSEE NOW) to serve as the Education and Public Engagement (EPE) Implementing Organization for the Ocean Observing Initiative. This demonstrates how COSEE is helping make real-time ocean science data available and useful to educators.

COSEE-Alaska (2005-current)

The most notable accomplishment of this center is the successful integration of cultural knowledge with ocean science knowledge. Activities such as symposiums, science fairs for coastal communities and educational products generated by this center such as the Faces of Climate Change Videos reflect a balanced and synergistic partnership between native communities and the scientific community. By acknowledging the value of native knowledge and perceptions in informing science, the center has produced material/activities that engage native communities and also respond directly to regional public concerns about ocean productivity and global climate change. This approach has been transformative in that it redefines the ocean researcher as a partner in pursuing a common need for knowledge relevant to a particular group rather that as an expert translating technical knowledge to the general public. Incorporating cultural knowledge and perceptions about current environmental problems of target groups may be a useful approach for COSEE centers to generate greater participation of underrepresented groups.

COSEE-Pacific Partnerships (2007-current)

This COSEE targets educators and audiences at community colleges, and at organizations engaged in informal education (e.g. Oregon Naturalist Program). This center is relatively young (2007) and accomplishments so far include building relationships and testing, assessing and refining ideas. The focus on community colleges and informal education organizations has high potential of engaging diverse audiences particularly of minority groups that have high representation in community colleges.

COSEE-Coastal Trends (2007-2010)

The Scientist-Educator Partnership program links scientists, graduate students, teachers and undergraduates. Evaluation indicates that scientists and graduate students learn education and communication techniques. Both teachers and undergraduates learn more about the research process. Teachers also advance their understanding of ocean science, and undergraduates both build teamwork skills and develop professional contacts.

COSEE-Networked Ocean World (2007-current)

The COSEE-NOW thematic center focuses on improving public access to ocean observing data and information as well as linking scientists and educators, for example through podcasts which feature the professional and personal life of scientists. The podcasts are biweekly and are designed to highlight the broader impacts on people of ocean science.

COSEE-NOW has also contributed to the COSEE Network through conducting an annual scientist survey. The 2009, joint with the American Society of Limnology and Oceanography (ASLO), found that over half of respondents 54% had attended or participated in at least one COSEE activity, program, event.

COSEE-Ocean Learning Communities ([2005] 2010-current)

COSEE-OLC, a regional center first funded in 2005 and then renewed in 2010, serves Washington State. COSEE-OLC launched a marine volunteer learning community that includes 700 individuals, representing over a hundred institutions/organizations. The community is supported through a series of

workshops and events. For example, the "Exploring the Spectrum of Citizen Science Workshop" in 2009, focused on engaging citizens in ocean/marine science research. Dozens of agency-based researchers participated. Data show that citizens are applying the strategies they learned. Another activity, SoundCitizen, engaged more than 1000 K-12 students and adult volunteers to collect water samples and data, which has subsequently been incorporated into peer-reviewed publications.

COSEE- Ocean Communities in Education and Social Networks (2010-current)

COSEE Ocean Communities in Education and Social Networks (OCEAN) is a new thematic center (2010, UMass Boston, American Society of Limnology and Oceanography, or ASLO, New York Hall of Science and Boston Public Schools) that brings an emphasis on partnership with professional scientific society networks such as ASLO whose 4000 scientist members are excellent targets for the range of professional development opportunities for marine scientists developed across the COSEE network. In addition, COSEE OCEAN will leverage prior investments in the network by working to broaden the implementation of a tested upper elementary school curriculum, Ocean Science Sequence, developed by COSEE California and published by Carolina Biological, first in the Boston Public School system and then with other school districts nationwide.

COSEE Technology and Engineering for Knowledge (2010-current)

COSEE Technology and Engineering for Knowledge (TEK) is a new thematic COSEE (2010, primary partners are University of Connecticut's Northeast Underwater Research Technology and Education Center (NURTEC), the Department of Marine Sciences and Sea Grant program, Project Oceanology, and The Mystic Aquarium/Institute for Exploration) that aims to advance the overall COSEE network by leveraging the natural linkages between science, technology, and engineering in the field of oceanography and providing educational resources that highlight the history, breadth, and advancement of oceanographic technologies.

COSEE Florida: Water as Habitat (2010-present)

COSEE Florida is a new Center focused on the theme of Water as Habitat. Primary partners are Indian River State College (IRSC), the Smithsonian Marine Station, Florida Institution of Technology (Florida Tech), Ocean Research and Conservation Association. The Center has preservice teachers as a primary audience and is developing two undergraduate level ocean science courses as part of the teacher certification program at IRSC. Additionally, they are offering summer Research Experiences for Preservice Teachers (REPT). For scientists, Florida Tech is conducting Presentation BootCamps, a program initially developed in their GK-12 program. For the public and informal educators statewide, they are conducting a series of lectures on the topic of Water as Habitat.

Matching Achievements with Goals

Goal 1"establishing a network of coordinated Centers that facilitate collaborations and communications between ocean science researchers and educators"

This goal has been achieved. The CDRC found the COSEE network of regional and thematic centers to be healthy and active, populated with dedicated and self-reflective scientists, educators, evaluators, staff, and advisory committee members. As an example, the network was

A2. To what extent have the program's goals outlined in the COSEE solicitation and in subsequent COSEE strategic plans been achieved? To what extent are the major accomplishments balanced across the program's goals?

able to quickly create or collate materials for STEM and informal education in response to the Deepwater Horizon event. COSEE was able to disseminate their materials to teachers through multiple venues including regional listservs of teachers, NSTA and through science educator at Natural History museum in DC.

Goal 2 "fostering the integration of ocean research into high quality educational materials and programs"

The COSEE Decadal Review documented many examples of ways that ocean research has been integrated into educational materials and programs – including current ocean science principles, data, tools, and authentic scientific practices. Examples include the TOS supplement, which is available for download, with hands-on classroom activities and physical oceanography principles; integration of the research process into education through BOB – COSEE Southeast; and COSEE NOW podcasts. The programs seem useful, they are based on good practice, and feedback from participants indicates that they like the activities and think they work.

However, the CDRC noted that the design of educational materials were not uniformly based upon best practices drawn from the cognitive and learning science nor incorporate tools that support evaluation of student learning. The CDRC felt that taking a more design experiment approach to development, including vetting to ensure the development produces high quality materials, would be useful. This design approach would capitalize on the strengths of scientists in making explicit the current state of ocean science knowledge, authentic scientific practices of ocean scientists, and the use of experimental and computational tools that support the advancement of scientific understanding of the ocean system.

The development should also include consideration of wide spread implementation of what is produced in addition to local use. This would include incorporation of methods of access to the materials that are user friendly and allow the materials to be easily located. To increase effectiveness, COSEE should also include other groups, e.g. learning experts, to provide knowledge about cultural context, diffusion models, the environment for the audience, etc., that could be incorporated into the materials. Finally, the ultimate impact of the materials on the intended audiences needs to be evaluated.

The CDRC felt that the main emphasis so far has been on programs targeting specific research areas, which is good, however in the future broader efforts are required. For example, COSEE could have had a more comprehensive response to the tsunami in Japan. OOS provides an area of great potential and expansion of the concept mapping could be fruitful. It is also important to continue the work of COS and COSIA in helping scientists become more effective in communicating about their research and transferring that research to both formal and informal learning environments. Incorporating the state-of-the-art knowledge, practices and tools that allow COSEE scientists to learn about ocean systems into formal and informal learning environments has the potential to allow novices participate meaningfully in the ocean science community – the best outcome that would support transforming ocean science education in the United States. Looking ahead, Center leadership should play a stronger role in advancement of selected activities – see "Network Operations" section below, and project impact should be leveraged and expanded through partners – see "Partnership" section below.

Goal 3: "effectively engaging ocean researchers in ocean sciences education and outreach"

The survey of scientists shows that COSEE is engaging scientists. Surveys were used to first identify barriers, and then COSEE did a good job lowering them: stimulating motivation, knowledge and environment factors that allow researchers to be easily engaged in formal and informal ocean science education.

The CDRC questions the extent to which COSEE has measured the real effectiveness of engagement of ocean researchers. As noted below in the section on evaluation, while surveys indicate scientists like it and feel that they are being affected by it, we recommend that assessments go farther. The CDRC sees great opportunity for COSEE to investigate the impact of participation in education and outreach on the careers of participating scientists. The COSEE Network could also play a high profile role in systematically tackling the recognition of the value of education and outreach in considerations for promotion.

Goal 4 "providing educators with an enhanced capacity to understand and deliver high-quality educational programs in the ocean sciences"

Progress has been made towards this goal. COSEE has engaged a large number of educators in a wide variety of programs that seek to help educators overcome barriers to incorporate ocean science content in their lessons including their content knowledge, their understanding of scientific practice, and the availability of instructional materials. Participants have drawn from both formal (60% of total participants) and informal (40% of total participants) educator communities. Surveys of educator participants indicate that they feel they have an increased capacity to teach ocean science content and that they feel their participation in ocean science research teams engaged in laboratory and field science has been rewarding. Excellent examples were provided of sustained delivery of ocean education – including the AP biology class using marine material and a recently formed, CA middle school that integrates marine sciences across the curriculum. There are also a variety of examples of activities that increased the capacity of informal educators.

Unfortunately, self-reported surveys of participants rarely provides definitive evidence of the effect of professional development programs on changing teaching practice in formal and informal educational settings. In order to formally evaluate COSEE programs in terms of this goal, there needs to be a more systematic evaluation of the change of participant's knowledge and skills that can effectively lead to changes in classroom practice. This effort will likely require a coordinated network effort where the goals of educator change are explicitly defined, the quality of the artifacts of collaborative instructional material development is evaluated, and there is direct evidence of changes in classroom practice and, perhaps, even student learning. These evaluation efforts should be explicitly aligned with the goals of the national science education standards to support the greatest dissemination of COSEE impacts.

Due to the richness of work in this area, the CDRC recommends that COSEE categorize its quality programs targeting educators at the network level –by discipline, audience such as grade level, formal/informal, etc., distribution/reach, duration, service to high need audiences, level of engagement. This serves multiple purposes by disseminating effective models to all COSEEs and also allowing gap analysis in terms of audiences and or disciplinary areas not currently served.

The CDRC finds that there is a real opportunity for the COSEE network to not only disseminate strong models, developed based on sound theory and evaluated for effectiveness but also to generate truly robust models that have been implemented and further evaluated in the rich variety of contexts the

COSEE network can afford. This work could address important questions re scaling up best practices including what adaptations have to be made, how different types of partnerships affect implementations in various ways, etc. and would place COSEE in a scholarship role that would benefit science education more broadly.

Goal 5: promoting a deeper public understanding of the ocean and its influence on each person's quality of life and our national prosperity.

High profile examples of quality work exist, for example the COSEE lecture series (with interactive programming strategies such as use of clickers), feeding ticker tape of ocean information, and the COSEE educator at the Smithsonian SANT Hall (funded by NOAA, but organizes speaker series funded by NSF).

The CDRC recommends that COSEE increase their focus on participatory science – such as the SoundCitizen program in Washington, which connects undergraduates, scientists, and citizens in projects focused on coastal issues. There is enormous potential for future development of activities like this that engage those who are out of school, both students and lifelong learners. Participatory science is a two-way process, where both citizens and scientists benefit. COSEE activities in this area could run the gamut from inviting individuals to get involved in their local community with a focus on marine issues to connecting citizens with data of specific, often niche, interest through a central web presence where groups can access data, conduct analysis and share their knowledge with others. Network-wide open-ended data analysis challenges could prove fruitful. The CDRC also recommends that COSEE identify opportunities to explore gaming strategies to engage new audiences.

Catalytic Activities

A5. COSEE Centers are intended to be catalytic in nature, triggering reactions outside their Center. To what degree have the COSEE Centers been catalytic in their activities?

Evidence for the catalytic nature of COSEE is rich and varied. As one indicator, COSEEs have raised significant percentages of their budgets, as much as 3:1 for some Centers, from external sources. Funds from the NSF COSEE program have thus successfully lowered the barriers to garnering funds for activities consistent with the COSEE mission from federal sources such as NOAA, NASA, and other parts of NSF, as well as private and corporate sources. Another indicator of catalysis is the spawning of regional networks that include COSEE Center partner institutions but also others, such as the California Aquarium Collective, and a similar regional network in New England.

COSEEs have consistently triggered reactions beyond themselves as evidenced by the following examples documented in the decadal review materials:
(1) Application of the sound pedagogical approach of Concept Mapping to teaching and learning about marine science by COSEE Ocean Systems and then spreading the utilization of that tool to other Centers;
(2) The dissemination of the Communicating Ocean Sciences and Communicating Ocean Science to Informal Audiences courses for beginning graduate students by the originating Center to other COSEE Center partner institutions and beyond (some 27 institutions now teach adapted versions of these courses); and
(3) The development of a new framework for scientific literacy - The Ocean Literacy Principles, which itself involved bringing together stakeholders from across the country, both within and outside of the

COSEE network; and has since triggered the development of several additional science literacy principles (Climate, Atmospheric, Geography, etc.) spearheaded by entities entirely outside the COSEE network.

Diversity

COSEE's decadal report underscores the importance of broadening participation in geosciences for both the individual Centers and the Network. This commitment to diversity is one of the main goals in the Strategic Business Plan.

A4. Most Centers have increasing participation of diverse audiences in ocean science education as a goal. Five Centers have the goal of integrating cultural knowledge with ocean science knowledge. To what degree has COSEE been successful in engendering greater participation of under-represented groups in its programs?

At the network level, efforts to achieve diverse participation included establishment of a Diversity Working Group (DWG), discussions to share information and develop strategies, and partnerships with organizations dedicated to improving participation of under-represented groups (e.g. SACNAS, AGU/ASLO/TOS and Institute for Broadening Participation). The DWG compiled a bibliography of relevant resources for broadening participation. At the individual Center level, efforts included production of materials and approaches for diverse audiences, workshops, awards and activities to recruit and engage diverse audiences, and partnerships with community colleges with diverse student populations. In addition, five centers (Alaska, California, OLC, Pacific Partnerships and Southeast) specifically sought to integrate cultural knowledge with ocean science knowledge. While some centers (e.g., COSEE AK) made great headway towards achieving this goal, there appears to have been no concerted effort across the Network to adopt and adapt effective means of reducing barriers and enhancing diversity. The Network diversity working group is essentially stagnant, with no significant activities according to Council records.

Efforts that incorporate relevant local/community culture and native/traditional knowledge seem to be most promising. In this regard, the COSEE-Alaska model seems to be the most developed and successful. This Center's activities such as symposiums, science fairs for coastal communities and educational products such as Faces of Climate Change Videos reflect a balanced and synergistic partnership between native communities and the scientific community. By acknowledging the value of indigenous knowledge and perceptions in informing science, the center has produced material/activities that engage native communities and also respond directly to regional public concerns about ocean productivity and global climate change. This approach has been transformative in that it redefines the ocean researcher as a partner in pursuing a common need for knowledge relevant to a particular group rather that as an expert translating technical knowledge to the general public. Incorporating cultural knowledge and perceptions about current environmental problems of target groups may be a useful approach for all COSEE centers to generate greater participation of underrepresented groups. Other efforts that the CDRC noted were COSEE-OLC's work to develop culturally responsive, place-based environmental curricula and their minority apprenticeship program, and COSEE-Pacific Partnerships focus on community colleges. Missing from both the Alaska and OLC efforts is dissemination of their models within COSEE: they are not propagating it to the network.

To guide the work towards broadening participation, COSEE Southeast conducted a survey to determine benchmark data on diversity in ocean-science related agencies and universities. A second survey by an

independent organization (Inverness Research) evaluated how COSEE centers rated the strength and efficacy of their efforts. Preliminary analysis of the second survey data indicated that, overall, Centers were strongly satisfied with their efforts to broaden participation of teachers and scientists and to build the capacity (resources and approaches to support diverse audiences). Centers generally rated their efficacy lower than their efforts. Weaker ratings were also associated with the degree of collaboration across Centers on the issue of broadening diversity.

For recommendations, see section below on "Broadening Participation."

Evaluation

A3. Each Center has conducted evaluation of their major program elements. To what degree has this evaluation documented in a rigorous manner the impacts of COSEE and the best practices implemented?

As noted above in respect to the COSEE Southeast diversity evaluation, evaluations have provided valuable formative information for each of the centers to help improve its unique programs and products. There is evidence of needs assessment (front end) evaluation to help design approaches and products. Furthermore, the evaluations have provided the opportunity to solidify innovative approaches through pilot test data on the participant-perceived quality and effectiveness of the center offerings. Each individual center evaluator and his/her evaluation have unique strengths and have provided valuable information for their respective centers.

The committee recognizes that leadership in evaluation is not a responsibility of the present CCO. In the first 5 years, there was a network evaluator tied to the COSEE coordinating office, but in 2008 that became an independent function of an external evaluator that reported to NSF. We understand that NSF terminated the cooperative agreement with the external evaluator in 2010 because the focus of his work was not relevant to achieving the kinds of information that NSF needed to guide its management of the program.

The across center Evaluation Working Group has been very active since about 2009 and has provided improved efficiency in the development of evaluation strategies and instruments across the centers. The working group also produced the surveys of scientist and educator participants across the centers which involved building consensus about definitions of variables and about what might constitute effectiveness as well as collecting the data and providing analyses. These data were useful as documentation of the participation in the network overall and as providing individual centers more data relevant to its own programming. It also appears that the evaluation working group has matured into a true community of practice with extensive support for new members and a culture of supportiveness and reflection. The evaluators are candid, reflective and transparent in their discussion of the strengths and weaknesses of their individual evaluations and of the capacity of the network to conduct evaluations overall which is indicative of their consciousness and awareness.

Despite the considerable strengths of the individual center evaluations, there is room for improvement. The evaluations overall are more concentrated on the collection of formative information rather than on the collection of data for summative or impact information. Both types of information are important but as the centers and their programs mature more emphasis should be placed on summative information. Ideally baseline data would have been collected at the inception of COSEE program that

would now be available to show change. But that was not the case, so impact will have to be assessed using different approaches. Overall, and speaking in general terms, the evaluations provided for us to read reached only the beginning stages of an evaluation continuum. This probably reflects the amount of support provided for the evaluation efforts but the evaluations need to increase in sophistication as well as moving toward a more summative impact oriented emphasis now that the COSEE program is more mature. The level and type of evaluation is confounded by the different levels of maturity and funding available for the different centers. A center that is just beginning its programs should be more formative in its evaluation focus than one that is more mature. Even so the evaluations were of mixed quality and focused on the assessment of different outcomes even when similar programs were assessed. For example, COSEE CA described the very sophisticated development of a scale to assess ocean literacy whereas other evaluations used somewhat ad hoc surveys of participant perception. Another example would be COSEE Great Lakes which used concept mapping to show growth in depth of conceptual understanding whereas most others used participant opinion of effect. A suggestion for the center evaluations might be to use a design based experimental approach which is strategic, theory/hypothesis based, incremental and useful in a development process. Once programs or products are optimized through the design experimentation, broader based evaluation techniques could be employed (perhaps still in a design orientation) to determine how best to apply and disseminate the innovation. Additionally the level of sophistication of the evaluations could be increased. Some of the sophistication should be supplied at the network level, but even at the center level more attention to disaggregating the data and considering what would be expected results would improve the analyses. Also more precision in what was really found, clarifying the exact results rather than making generalized inferences, would be helpful.

The evaluations of the network have been plagued with problems which have been dealt with but leave residual questions about how network evaluation should be addressed. One possible approach might be to conceptualize an overall evaluation of the COSEE program. An overall or cross center evaluation of the program could be considered as distinct from an evaluation of the network. Network evaluation traditionally looks at the development of the network, e.g., increasing numbers of interactions and outcomes of the network, for example new programming, rather than the impact of the centers involved in the network. A network evaluation of this sort would be valuable but would not provide an adequate evaluation of the COSEE program impact—just the network component of it.

Part of the impact of the centers involved in the COSEE program might be obtained as a 'core' evaluation, i.e., what impact has been produced across the centers at a minimum. In other words what impacts have been concentrated on and achieved by the centers as a whole. This underestimates the total effect because each center would accomplish more than the 'core' objectives based on their unique efforts. However, combining the core evaluation results with evaluation results of the unique aspects of each center, and of the network from the network evaluation effort, would provide a comprehensive indication of the impact of the COSEE program overall. This is traditionally determined by examining the impact across the centers, e.g., the change in communications skills of scientists who participated in network programming either as compared to baseline measures or as compared to matched scientists who didn't participate. A core evaluation would focus the attention along with expertise and support for participatory development of instruments and data collection and analysis procedures that would allow the centers to show their collective impact. The development and administration of valid and reliable instruments would be a critical component of a core evaluation and should be accomplished with the cooperation and consensus of the center evaluators. This type of multi-site 'participatory' evaluation generally produces more comprehensive and valid data collection,

more relevant results, more nuanced and accurate data analyses and interpretation, and ultimately higher quality evaluations.

The surveys of scientists and educators conducted by the evaluation working group would be examples of the type of evaluation that could be conducted by a core evaluation effort. Standardization of definitions and instruments allows for the aggregation of data across the centers and benefits everyone. The existing surveys are a great start but are only a beginning step on the road to high quality core evaluation. The survey itself needs to be improved through the use of standard measurement techniques and more nuance in terms of items needs to be included—just what does 'it affected my research' mean? There needs to be more interview or focus group data collected to improve the items and their focus. In terms of the analyses, there could be much more disaggregation. For example, just how do graduate student participants differ in their perceptions in comparison to the more mature scientists, are there differences by location or type of involvement, etc.? Additionally each center should be encouraged to use these data and compare it with other data they have collected. Once the data are collected and analyzed, follow-up interviews or focus groups would be useful to 'unpack' the findings, using the example noted above: what does it mean that 28% of the scientists said participation in COSEE affected their research? This 'unpacking' would allow for much more nuanced items in future surveys that would more accurately describe COSEE impact. It also needs to be made clear that these data are from people who have chosen to work with COSEE and as such are a biased sample. Future work should allow for more comparative studies of ocean scientists in general in comparison to those choosing to participate in COSEE—somewhat like the COSEE Now scientist survey. It seems possible that most of the data collected in these survey efforts could be relegated to a monitoring evaluation function where the centers carefully input tracking data of all of the people involved in center programs and their characteristics into a network wide data base that would be available for anyone to use. Availability of large data sets could facilitate publication of results in peer reviewed journals which would help with dissemination.

It makes sense for the centers to be involved in investigating the applications of the findings from cognitive science research as part of a translation of learning sciences results to ocean science contexts. The centers could provide an appropriate venue for application studies at the efficacy and effectiveness levels because they have ready access to large and diverse populations. On the other hand, it seems that the actual cognitive science research should be supported through other funding mechanisms: this might be an area where GEO could partner with EHR and SBE. The COSEE centers could provide the venues for the application investigations of the cognitive research findings and determine the relationships within the ocean science arena.

To optimize the evaluation efforts the COSEE centers need to be explicit about the outcomes they expect to achieve. This means that the strategic plans need to provide specific outcomes and targets, i.e., realistic, measureable impacts, not processes or activities (see "Future Directions" for more recommendations regarding the outcome-based planning). Furthermore, any evaluation efforts should help to provide information relevant to NSF reporting requirements. The monitoring and core evaluation efforts suggested above should prove useful in this regard although it will require careful consideration of the strategic outcomes expected from the COSEE program. In support of this effort, the panel spent some time brainstorming possible metrics for impact on scientists. Examples include:

Number of scientists involved in COSEE (perhaps with indication of the numbers that could be involved)
Numbers mentioning COSEE in proposals

Impact on scholarship of scientists participating in COSEE related to their involvement in education and outreach

- Consideration of the applications of their scholarship on stakeholders
    - Better understanding of societal impact
    - More willingness to participate in taking knowledge to action
    - Better understanding of the science underlying critical issues – and how their research is connected to them -- as they are called to talk about them to diverse audiences
- Better practice of science
    - Better understanding of the process of science as they teach it to teachers
    - Better organizational skills
    - Better communication skills
    - More team work and interdisciplinary skills
    - More of an applied, problem-solving, or solutions orientation
    - Increased interest in researching local issues
    - Incorporating broader impacts or a broader context in their science writing
    - Increased writing for a broader audience
- Better retention of scientists especially women and minorities because they are more drawn to the societal connections made through engagement in these public and educational programs. A caveat with this is that there may be advancement concerns in the competition between research output and time spent on education and outreach
- Production of a more diverse and competitive ocean science workforce
- Increased accessibility of ocean scientists to the public – more willingness to participate in additional educational and outreach activities
- Broader use of the data products that the science enterprise has developed/iteration between science and education
    - Better links into cyber-infrastructure
    - Increased amount of public data mining/access
    - Improved access to data bases through better data management and more user-friendly access designs
    - Increased attention to commercial, recreational, and other applications, e.g., surfing
- Determine the impact of different modes of scientist involvement. What does scientist participation add to educational programs? How best should they be incorporated? What is the optimal or most cost effective 'dose' of involvement? 3 hours? 3 days?
- Overall determine impact of COSEE engagement of scientists on the list of broader impacts such as infrastructure or workforce development
- Follow-up analysis of the impact that participation at these special working sessions have had on Centers

Network Governance, Operations, and Impacts

The COSEE Network has implemented increasing levels of governance and management over the past nine years to facilitate communication, collaboration, and dissemination, and to improve efficiency.

Network Governance and Impacts

Establishing a functioning COSEE network is among the major accomplishments of COSEE. COSEE Network functionality is maintained by regular communication (phone, email, web, or face-to-face) among the Council members and working groups, as facilitated by the National Coordinating Office, and by a set of shared agreed-upon operating and governance procedures.

B7. The intent of linking the Centers in a Network is to make the whole much greater than the sum of the parts. What is the overall impact of the Network on the outcomes of COSEE?

While it may have experienced some growing pains early on, all indications suggest that COSEE Centers and the broader ocean science research and education communities are better served by having a network of Centers, rather than unconnected, independent Centers. An established Network has the potential to facilitate communication, collaborations, and dissemination of best practices and products. Without the Network, COSEE wouldn't be the voice of the community. This is demonstrated by COSEE's role in the development of the Ocean Literacy Principles and the influence COSEE (and other science organizations) have had on the new National Science Standards. NSF also turns to the COSEE Network when they need input into ocean science education issues.

Collaboration and communication within the Network has led to somewhat more efficient, more deliberate, and more reflective collaborations than would likely have occurred without a Network. In particular the development of working groups would likely not have happened as easily or efficiently if the centers were not linked in a network. The working groups function as collaborative teams. The synergy from collaborative teams is an important outcome of COSEE, for this provides the foundation to move forward in addressing gaps, needs, and strategic initiatives across the Network.

That working groups have the potential to increase communication and collaboration of Centers on critical issues that affect the entire network, is demonstrated by the outcomes of the evaluators working group. Of all of the documents supplied to the Review Panel, those supplied by the EWG were the most reflective and realistic about where COSEE is as a Network, where it needs to be, and posed ideas on how to get there. The unified message from the evaluators is a direct result of their working group participation – they have evolved into a collaborative team. Other working groups, in particular the diversity working group, have been far less effective. On topics that COSEE, NSF, and the larger ocean sciences communities deem critical, it would serve COSEE well to follow the evaluators' working group model, so that the intellectual leadership can help COSEE move forward to address critical needs.

The Network has increased the visibility and access to COSEE programs and products. Its presence at national science and education meetings and the common web portal for COSEE are the primary avenues for visibility and access. Perhaps the COSEE program and products with the greatest visibility and impact on the broader ocean science research and education communities are the widely disseminated COSIA college course (taught at 27 locations), the publication of the Ocean Literacy Principles, the booklet on Education and Public Outreach - A Guide for Scientists, and the booklet on Teaching

B6. To what degree are the networking efforts effective in increasing collaboration, dissemination of effective practices and programs, and efficiencies? For example, how and to what degree are the results of COSEE Centers disseminated across the network, the larger ocean education community, and beyond?

Physical Concepts in Oceanography. The Network has the capacity to expand visibility and access though such high-impact efforts as meeting-associated workshops, short courses, and peer-reviewed publications, resource development.

Given NSF's major investment in COSEE, the committee is concerned that only a handful of notable programs /products have been highly disseminated. Individual COSEE centers have developed many other programs that have not been disseminated as products or models. In some cases it is sufficient that they have value within a Center alone or only within COSEE, but broader dissemination of selected projects should be a high priority (see "Future Directions" section below).

A well functioning network should be able to identify best programmatic practices, and adopt and disseminate these within and beyond the network. Currently, the results of COSEE Centers are disseminated across the Network at regular Council meetings and working group meetings usually through an informal process where some PIs advocate for their projects. This was the way that concept mapping (developed by the Ocean Systems Center) spread as an effective means of connecting scientists with educators. This sharing of new developments should be strengthened and formalized as an ongoing process.

As one way to move beyond ad hoc information sharing, COSEE has held some special work sessions dedicated to the Network-wide dissemination of:
(1) Best Practices in Professional Development of Educators, and
(2) Best Practices in Engagement of Ocean Scientists.
These special working sessions are on focused topics of broad interest across the Network and are therefore likely an effective and efficient means to disseminate and strengthen collaborations within the Network. The Decadal Review Appendix reports on these topics are rich with ideas, evidence, and strategies for addressing these two important topics. The long-term outcomes of the special meetings are less clear to the Review committee: Were the best practices which were disseminated at these meetings later adopted and adapted by multiple Centers? A follow-up analysis of the impact that participation at these special working sessions have had on Centers may be of value to COSEE as they work to become more strategic and efficient as a Network in the future.

Regarding dissemination to the broader ocean research and education community, COSEE uses their web presence, presentations, booth activities, and a few workshops at professional ocean science and education meetings (e.g., AGU, ASLO, Ocean Sciences, NMEA, NESTA), and a few magazine-like and peer-review publications. COSEE's presence at national science and education meetings is a good way to maintain visibility. Offering more meeting-related workshops would increase visibility and also increase adoption of COSEE materials. Barriers to adoption are removed though the hands on experience such workshops can offer potential adoptees.

The benefits of peer-review publications cannot be underestimated; it improves credibility, assures quality control, and is a means of disseminating COSEE outcomes to intellectual leaders and practitioners. At present the publication rate is widely-ranging from Center to Center (e.g., 12 in 4 years for COSEE NOW, and 0 in 6 years for COSEE AK) and there are no synthesis publications from the Central Coordinating Office, which presumably should share in the intellectual leadership of COSEE. The average COSEE center publication rate (not including those centers funded in 2010 which have no publications; calculated for data provided in Part III of the Decadal Review documents) is 0.8 peer-reviewed papers per year. In comparison, individuals (let alone whole centers) would have difficulty getting tenure at

many institutions with a peer-review publication rate at that level. While many COSEE PIs are not in tenure track positions and are not required by their institutions to publish, all NSF awards are given to advance understanding of the field and peer-review publication should be a priority for the COSEE Network. Also, COSEE is mandated to serve the ocean research community, and researchers of all types (ocean science, learning science, communication science) place high value on peer-review publications.

COSEE is now challenged to implement best practices across the Network, put in place quality control measures on programs and products, and disseminate the highest quality outcomes more broadly so as to transform science research and education.

Partnerships

B8. COSEE has developed more than 200 partnerships. What is the nature, substance, and impact of these many partnerships on integrating, expanding, and strengthening the collective COSEE efforts?

The committee commends COSEE on developing a diverse set of partnerships – over 270 partners who bring some 2000 members to the network; that are varied in terms of intent, level, nature of funding for the partnership activities, etc. Nearly all of the partnerships are at the center level (98%), which reflects the fact that the emphasis during the first 9 years of the COSEE program's tenure, has been on developing the individual COSEEs, with the coordinating office serving to support each COSEEs needs. The committee also notes that the partnerships have been generative in terms of integrating ocean science researchers into a broad range of COSEE activities, and can be understood to operate at 3 levels: (1) service to the community, such as programs for local community organizations including scout groups, rotary clubs, etc.; (2) targeted professional development for K-12 and informal educators offered in partnership with school districts and informal institutions in the vicinity of a particular COSEE; and (3) high-level innovative partnerships that result in new programs or products that at their onset have an eye towards scaling up and/or broader dissemination, such as the partnership with ASLO that is part of COSEE OCEAN.

The committee recommends that COSEEs continue to engage in partnerships at all three levels, and sees the opportunity to enhance the effectiveness of COSEEs work by (1) centralized coordination of a growing set of assets to support programmatic activity at the service level – standardized presentations and activities that can be readily adapted by ocean science researchers and educators to incorporate recent ocean science research activities and discoveries to use for community organization level engagement; (2) coordinated dissemination of best-practice professional development programs and products for K-12 and informal educators from center to center; and (3) strategic support from the COSEE national coordinating office to develop new partnerships at the center level (or perhaps two or more centers, from the onset of the new partnership) that uniquely generate broader impacts from ocean science research activities and discoveries.

When resources are scarce it is important that partnerships be integrative and collaborative. The committee recommends partnership development with the Department of Education that explore the interface between ocean science and cyberinfrastructure and sustainability initiatives, with COSEEs bringing their unique capacity to tap into hundreds and even thousands of ocean science researchers as well as major ocean science initiatives. COSEEs most effective path towards scaling up is through high

level partnerships including, for example, the current exploration of a network level partnership with GOOGLE Earth, as well as partnerships with major educational publishers, broadcast media, etc.

Network Operations

The National Coordinating Office (NCO) is responsible for providing centralized management support for the National COSEE Network (NCN). This includes organizing and supporting national COSEE governance structures of the effort, maintenance of a national website, representing COSEE at various national oceanographic and educational conferences, organizing efforts to ensure that COSEE assists ocean scientists across the nation develop connections to educational efforts regardless of their affiliation with a regional center, and enhancing communication and collaboration among the Centers. The COSEE National Coordinating Office budget is ~ 7.6% of the annual COSEE budget.

B10. Has the NCO been an effective source of communication within the COSEE community and the ocean sciences community? How effective is the COSEE Network News and theCOSEE.net website? To what degree has the NCO fostered activities that increase the impact of the Network as a whole? What other services or assistance could the NCO provide to be an even more effective vehicle of the community's needs? Is the cost of NCO operations appropriate considering the services and coordination provided? If not, what other mechanisms might be adopted to achieve the same services and coordination more cost-effectively?

The National Coordinating Office uses this budget to maintain a network website, to conduct strategic planning, to organize network meetings, and to support telecons. This budget also supports the COSEE presence at national meetings of professional societies. A key responsibility and budget-related item is the organization of workshops for the network that deal with "Best Practices". Two examples of these are workshops on best practices on diversity and on evaluation.

The committee felt that the role of the NCO was two-fold. First, the NCO is needed to organize, coordinate, and foster communication with the network. The CDRC felt that this important role was currently being fulfilled. A second role is to stimulate and provide the network with intellectual leadership. While the committee felt that the NCO had fulfilled many responsibilities in this area, it was recognized that these two roles of the NCO are quite different. In many organizations these two roles are fulfilled by a strong intellectual leader backed up by strong operational support from other people. An intellectual leader may have less patience with day-to-day operations and vice-versa. The committee would like the NCO to explore whatever models are appropriate to ensure that the intellectual leadership of the network is a high priority (see "Guidance on Network Structure" section below). Equally important is the maintenance, encouragement, and support of the operational network to support the centers. The committee is not criticizing the level or quality of the intellectual leadership presently done by the NCO and the Executive Director. Rather, the success of this leadership at the NCO has encouraged the committee to believe that the NCO can nimbly lead the network in a variety of new, interesting, and experimental directions if additional resources can be allocated to the NCO. In short, the committee recommends that greater emphasis be placed on intellectual leadership and innovation by the NCO with thought given as to how to maintain the very successful current operational work.

The NCO has done an excellent job of branding by working with Centers to maintain a uniform appearance on the web for the different Centers (exception: COSEE West). This approach to utilize a

uniform-looking web presence makes it easier for users from any site to navigate and find the resources they might need on any particular site. It also helps make navigation easier for outside users. However, the ongoing effort to harness resources and share them through the central website is hampered by the limited search and filtering tools available in the resource area. As more products (as opposed to programs) are developed in the COSEE Network, the search function on the website will need to improve; a topical key word search would help users more easily and efficiently find material on the COSEE website. Information from and about the four working groups is also somewhat hidden in the "About COSEE" section.

Center Contributions to Network

The requirement that each COSEE Center must devote 8% of its budget to the COSEE network operations and associated meetings and working groups has been an important requirement that reinforced the importance of the network.

B9. Each Center must devote 8% of its budget to the COSEE network operations e.g. serving on working groups, attending semi-annual meetings, etc. Is this an appropriate level of investment for the outcomes of the network management and operations activities?

However, the 8% level is inadequate for a future network that will play an even more prominent role. The committee felt that the allocation of more resources in this area is critical to the achievement of the future overall program. Additional network interactions by the NCO will make a large difference in the future. These additional levels of interaction will require additional funding. To realize the future potential of COSEE, additional resources will be needed in the areas of data collection, synthesis, and analysis for the Evaluation Working Group and for additional activities to help invigorate the other working groups, for example the Diversity Working Group (see "Diversity," section above and "Broadening Participation," section below). Additionally it was felt that the NCO needs additional monies to be able to provide support for the centers to implement some new "Best Practices".

Given that each Center has brought unique and specific new expertise to the network, each center is already positioned to be an intellectual leader in that area and could lead dissemination efforts: expanding the program or best practice to the other centers. To some degree, this kind of leadership is the scholarly part of the role of each Center and the pathway to publications. In addition, the coordinating office could work with an individual center and provide it additional resources in order to advance a particular strategic priority across the Network.

In particular for the network as a whole, diversity-related initiatives and the Diversity Working Group need to be mobilized and to proceed in formulating and achieving strategic goals. This effort should provide a concerted effort across the Network to adopt and adapt effective means of reducing barriers and enhancing diversity. Similarly the strategic involvement of community colleges needs to be examined and a plan for addressing the value and role of community colleges needs to be formulated and executed by the NCO (see "Broadening Participation" section below).

The NCO plays a key role in setting and maintaining an overall level of quality in the COSEE programs and products and should also be responsible for synthesizing programs and products as needed. The

NCO should also be responsible for creating publications that synthesize and represent the overall accomplishments of the network.

These network initiatives and the associated intellectual leadership by the network and NCO will not be easy to achieve but need to addressed creatively from the NCO. The NCO plays a role similar to that of a corporate headquarters in a company with diversified products and plant locations. In this role strategic planning, quality control, and creation of programs to apply the most successful experiments/programs from individual sites to all the sites are some of the responsibilities of the core office leadership. The coordinating office plays a key role in disseminating the highest quality outcomes more broadly so as to transform science research and education throughout the network.

The coordinating office also should explore and initiate new high-level partnerships that can benefit the network as a whole. This might include partnerships to enhance cyberinfrastructure and ties with major educational publishers as well as with organizations such as the Department of Education and Google Earth, for example.

National Advisory Committee

The CDRC recognizes the very high quality of the National Advisory Committee (NAC) members. The advice the NAC has provided over the years (as provided to the committee through the NAC prepared description of their activity) aligns very well with the opinions and recommendations provided through this decadal review. The NAC is active, engaged, proactive and very perceptive and should continue to play a major role in advising COSEE in its future operations.

The National Advisory Committee (NAC) now appears to well positioned to achieve desired outcomes. The present arrangement grew out of a past where the NAC was not as involved, as influential, or as well informed as they are now.

The liaison to the Council facilitates direct contact. The process of listing the advice given by the NAC and the actions that were taken by the network in response to them, ensures adequate attention to the advice as well as providing specific documentation of changes in operations. The committee supports having the NAC members serve three year staggered terms and suggests that criteria for the appointment of NAC members might be more explicit to facilitate the strategic identification of members to replace those rotating off the NAC.

The NAC appears to be performing its role in a way well above the level of effort in a typical advisory committee. Despite the fact that they are not paid for their service except for expenses, they are dedicated to helping COSEE improve and go out of their way to learn about the program. They routinely request detailed

B11. The COSEE National Advisory Committee is tasked with providing continuous advice and focus for the COSEE Program. Its membership is voluntary and its composition ideally reflects a wide range of expertise that complements the goals and objectives COSEE is trying to achieve within its Centers and the Network. Are the current tasks ascribed to the NAC appropriate? Are they appropriately engaged and informed about COSEE to perform their work? To what degree has advice from the NAC been translated into actions that have improved the services offered by COSEE?

information about the program in a timely manner before meetings. They each have 'adopted' a center so that they could become familiar with local operations and share that in-depth knowledge with each other at the NAC meetings. They also are each members on working groups so that they can understand and share that aspect of the network operation as well. This direct access to real-time information allows them to provide directly contextualized advice based on their high level of expertise in the diverse fields they represent. Just one example of their exceptional dedication was their offer to read and comment on the decadal report before it was provided to NSF.

Future Structure of the Program

The Decadal Review process offers the opportunity for revisions to the program goals and structure. The Committee should consider alternative models that have the potential for increased impacts and opportunities at lower costs in its advice to NSF.

C4. Does COSEE provide a unique and useful complement to other education and outreach programs within the GEO Directorate and NSF? How might it be modified to improve connections to other existing programs?

Since COSEE was first established within GEO in 2002, both NSF and public expectations have grown for scientists to provide meaningful access to their research. In turn, there has been growing interest within the scientific community and NSF in making societal connections. As a result, the overall NSF landscape of programs and expectations has changed substantially since COSEE was established nine years ago. OOI, SEES, CIF21, R2R and Earth-Cube are just a few of the major initiatives that intersect with the expertise and capacity built through GEO's long term support of COSEE. In making decisions regarding future support for COSEE, NSF should analyze COSEE's role within the context of existing and emerging GEO and foundation-wide priorities. In order to coordinate future investment in COSEE with NSF's other existing and emerging programs, we recommend that NSF map COSEE expertise and activities against Foundation goals to determine gaps, clarify goals for COSEE, and then develop a plan for how to fill them. NSF could then follow through to make logical connections with other initiatives – for example, when relevant, sending new PIs information on using COSEE as a relevant resource. Co-funding from other directorates – especially EHR – should be considered, in order to maximize and leverage the potential established by NSF's long-term investment in building COSEE.

<u>Future Directions</u>

C5. In view of COSEE's past accomplishments and future plans, as described in the Decadal Review report, should the program continue with its current suite of initiatives? What directions are most likely to be most important for the future of ocean sciences education and most useful to the ocean research community?

Based on COSEE's accomplishments and strengths, the CDRC recommends that the COSEE program continue, but with modifications. Looking ahead, the CDRC found that COSEE needs to be more strategic in their planning and functioning. Specifically, the CDRC recommends that COSEE become more:

- strategic in terms of assessing community needs, and then in terms in of selecting projects for major development and investment

- oriented towards achieving outcomes that are well defined (see below) and high impact
- oriented toward addressing the needs of ocean scientists, in keeping with their support through GEO, although this could broaden should NSF decide to expand support for COSEE from other directorates
- focused on assessment of program and resource quality, moving beyond documentation of participant satisfaction to more explicit measurement of outcomes that are a direct result of COSEE activities
- professional with respect to dissemination, including publication of findings in scholarly journals, developing dissemination plans, this could be facilitated by a dissemination working group, and leveraging dissemination through strategic partnerships
- focused on making and documenting systemic progress on diversity and cultural awareness, across all networks
- supportive of central functions with stronger network management

COSEE has identified the following future priorities (from a "Vision of COSEE Future" and from the Powerpoint presentation on the COSEE Future):

1. Develop a more cohesive and broader integration of ocean sciences research and education.
2. Develop a richer diversity of talent and perspectives to advance ocean sciences research and education
3. Profoundly increase the scope and stature of ocean sciences education
4. Expand and sustain the Network which is dedicated to excellence in ocean sciences education

Each of these priorities (or goals) contain embedded visions, some of which demonstrate their desire to align with NSF initiatives and opportunities in cyber-infrastructure, real time data collection (e.g., ocean observing), and cross-division collaborations. However, the CDRC found it difficult to identify in the decadal review documents or in the presentations what the proposed strategies are that COSEE plans to use to reach each of these priorities. We also were challenged to identify the anticipated measurable outcomes that would indicate their four priorities were achieved. It is important to note that the strategic planning documents (supplied to us on CD) do demonstrate strategic planning for issues of governance, capacity building, dissemination, and partnership expansion. However these are more issues of functionality, not of strategic broader impacts including educational planning.

C1. How significant are the identified future education plans for COSEE? How likely are they to lead to transformative ocean science education? Are they appropriate and achievable with the currently available and anticipated future technology and research opportunities? What other activities or roles not currently undertaken by COSEE might be appropriate in the future?

The 1st priority "Develop a more cohesive and broader integration of ocean sciences research and education" reflects COSEE's origins: "These Centers foster the integration of ocean research into high-quality educational materials" – from the RFP solicitation. Priorities #3 "Profoundly increase the scope and stature of ocean sciences education" and #4 "Expand and sustain the Network which is dedicated to excellence in ocean sciences education" are rather general; both emphasize the desire to grow. All 3 of these priorities beg the question – to what end? What is the purpose of growth? In a tight, or reduced, budget situation, growth for growth's sake is unsustainable – there has to be a well-articulated reason.

Why is it necessary to "increase the prominence of ocean sciences"? Beyond improving the broader impact activities of individual scientists, is the intent that achieving these 3 visions will increase science literacy, engage more people in STEM, stimulate more students to become oceanographers, help citizens make better decisions with respect to ocean issues, broaden appreciation of ocean science, and/or achieve scale in dissemination and impact of COSEE sanctioned resources and programs? It is important to define the intended outcome in order to develop targeted programs. For example, if better decision-making is a goal of integrating research with education, then priority can be placed on programs that integrate oceanographic research most relevant to typical decision-making by citizens. We recommend that COSEE decompose these into outcomes that then could be targeted and measured.

That said, Priority #2 "Develop a richer diversity of talent and perspectives to advance ocean sciences research and education" is certainly of high importance as we stress in this report (see sections "Diversity," "Center Contributions to the Network," "Broadening Participation"). We are pleased to see that COSEE has recognized that this issue requires focused attention and that they have elevated it to be one of their 4 highest priority endeavors. The next step will be developing strategies and outcome measures.

- COSEE should also develop systemic approaches to engaging diversity: The ocean community recognizes that its past efforts to engage more diverse participation in ocean science have not been successful. COSEE, through its members, partners and affiliates, can reach many audiences, with the potential for increasing diversity in ocean and other sciences. COSEE experiences and strategies could be ramped up to national scale.

Besides diversity, the CDRC found COSEE to be well positioned to be useful to the ocean research and education communities in a number of other areas:

- Meaningful implementation of the revised Broader Impacts criterion: The National Science Board's review of NSF's merit review broader impacts criterion was based in large part on community concerns about how to address them. PIs were concerned about being asked to develop and implement education and outreach activities, when they did not have the professional training to do so in efficient and high impact ways. COSEE was put in place to address these needs for ocean scientists. Therefore, when the criteria are revised, other science communities will be able to look to COSEE for best practices in these areas specifically required under America Competes: improved pre-K-12 STEM education and teacher development, improved undergraduate STEM education, increased public scientific literacy. If a larger role for institutions and organizations is encouraged within the revised criteria, COSEE can be proactive in sharing their best practices for how they supported broader impacts through centralized offices.
- Helping scientists meet K-12 demand for ocean science educational materials: The new K-12 science education framework released by the NRC in July 2011 includes a stronger emphasis on ocean science. This will result in nation-wide demand for high quality, vetted, standards-appropriate and current ocean science educational materials and resources. Ocean researchers will be upon called to meet this demand. Given COSEE's access to both the ocean research and education community and past work in this area, it is uniquely positioned to facilitate development and dissemination of resources appropriate to meet the needs of teachers, at the same time that they showcase and efficiently involve the ocean science community.

- Integrating ocean research with quality of life and national prosperity: COSEE has fostered development of a large number of ocean scientists who are cognizant of the needs of educators and the public through their training and participation in COSEE education and outreach projects. In turn, 28% of scientist respondents said that their COSEE experience impacted their research. COSEE could capitalize on this reciprocal relationship through strategic development of participatory/citizen research challenges, extending beyond COSEE-Ocean Learning Community's Sound Citizen. Some stakeholders and sectors of the public are becoming increasingly sophisticated regarding accessing and using data. COSEE could facilitate technology based, individually accessed resources, connecting ocean observations with societal needs. COSEE's investment in the COSEE Ocean Systems concept mapping tool and the future plans to increase ocean data access (e.g. COSEE-Southeast's Basic Observation Buoy-BOB) and visualization (e.g. OOI), could be leveraged in connection with NSF's CFI21 and R2R initiatives.
- Partnering with learning sciences: COSEE access to educational settings provides an ideal setting for the application of the findings of learning science research in effectiveness trials and perhaps in moving to scale, with co-funding from EHR and SBE.

To strengthen COSEE educational planning, the review panel sees the need for COSEE to become more strategic in the way it identifies and supports activities, and has the following recommendations:

(A) Identify gaps in the ocean disciplinary and ocean literacy (Ocean Literacy Principles) coverage of the current COSEE programs and products at each of the Centers and across the Network. We recommend that NSF do similar analysis of complementary programs outside of COSEE to identify gaps and be more strategic in future educational funding initiatives. COSEE should target initiatives to address identified gaps, and prioritize based on where COSEE can be most effective.

(B) Approach educational planning at COSEE Centers and across the Network on three levels distinguished by creativity and level of effort:

1) Transformative: These are programs or products that are experimental and may have high impact. They are innovative and potentially catalytic. Priority (funding, time, and intellectual energy) should be given to figure out how to do these well, to address one or more of the identified goals, one or more of the identified educational needs (from the gap analysis), using design principles and formative assessment.
2) Core: These are the core, or routine, programs that COSEE has already identified (e.g., COSIA). The resource needs are known, and evaluation shows that these are important, high impact, and should continue. These core programs are now ready to be disseminated and adopted across the network.
3) Service: There is also a role for ad hoc activities largely at the Center level. These are activities that provide basic service to the ocean science research and educational communities. These are generally low cost, and at base level. These may be in response to requests for service (e.g., presentations at local youth organizations), are activities that help keeps partnerships healthy, and maintain or expand community involvement. These activities do not need extensive evaluation. These are not transformative, but address a necessary level of community and partnership maintenance.

(C) Approach educational planning using a multidisciplinary team of research scientists, educators, and learning science specialists.

(D) Identify measurable outcomes for each of the educational goals (i.e., priorities). As strategies are implemented to reach these goals, collect rigorous evaluation data to measure progress and effectiveness.
(E) Develop (or adopt) and implement quality control measures on the science and the pedagogy used in COSEE educational programs and products to assure credibility and merit in the activities and materials that are developed, disseminated, and adopted by the broader ocean sciences community.

Catalytic Impacts

C3. How might COSEE increase its catalytic impacts?

The committee recommends that the COSEE Network expand its efforts to identify best practice ocean science education programs and products that leverage the work of current ocean science researchers developed within Centers, including investing in evaluation to demonstrate quality and effectiveness. Spreading these from Center to Center as part of continued testing for the purpose of scaling up should be viewed as the day-to-day business of the COSEE network, and disseminating them beyond the network should be the goal, ideally supported by funds external to the COSEE program. Excellent examples are the Communicating Ocean Science and Communicating Ocean Science to Informal Audiences courses – developed by COSEE California, being taught now by 27 institutions from within and outside the COSEE network, and spread with support from NSF EHR.

The committee also recommends that the COSEE network increase its dissemination efforts through workshops and other offerings at professional society meetings, including AGU, GSA and ASLO (and the partnership with ASLO which is integral to COSEE OCEAN is notable in this regard); peer reviewed publications; and partnerships with major publishers and other educational partnerships such as Science Now. Powerful catalysis will likely come from network level efforts, in which innovations are pushed from center to center and then, if proven successful, pushed beyond the network.

Broadening Participation

C2. If it is to continue, what more can COSEE do to accomplish the goals of broader participation?

It is evident that COSEE is committed to broadening participation and has made progress in achieving this goal. The CDRC identified the following limitations in the current approaches and made the following recommendations.

- Efforts, successes and associated documentation have been uneven across Centers. There are data on numbers of increasing participation but these are sparse and not available for all Centers. Partners such as school districts, MESA, community colleges may have the participation/tracking/retention data to document COSEE's contributions.
- The Inverness survey provides information on the perceived strength of the accomplishments, but this evaluation does not provide information regarding actual impacts of the efforts. For example, increased capacity and opportunities directed to minorities may not result in increased participation. There is no systematic and quantitative process by which the impact of the approaches is evaluated within Centers and in the Network. More informative evaluation tools could be developed through partnerships with diversity experts.

- COSEE does not have a clear, systematic, unified approach to strategically address broadening participation issues. While each Center has different resources and faces different challenges there is much to be gained from a coordination of efforts – as noted above in the "Future Directions" section. This coordination could include the identification of target populations for the strategic allocation of efforts/resources. Sample populations could be K-16 or undergraduate non-science majors needing general science credits. A coordinated effort could take the form of an introductory oceanography course offered online with linked resources and designed to address current events (oil spill, tsunami and etc.).
- Sharing of successful practices/models could be improved. Centers focusing on integrating culture and science have been successful and can work to identify the elements of their best practices that are transferable to other Centers. They can also be pilots/test beds for the rest of COSEE. Best practices can be refined and disseminated through COSEE community workshops. We were pleased to learn that the next best practices COSEE workshop is on diversity.
- Only 4 community colleges appear as official COSEE partners. Community colleges tend to have large student populations of under-represented groups. COSEE-Pacific Partnerships is focusing on these institutions, but more Centers should also consider working strategically with community colleges to broaden participation.
- The DWG is an important resource to guide COSEE efforts. DWG has assembled a bibliography of resources, but there is no plan on how to apply this information to address specific COSEE issues.
- COSEE diversity programs should link with other diversity initiatives supported by GEO, including the OEDG program, a new post doc program for minorities in ocean sciences, a new small grant program in OCE for beginning minority scientists, and the two OCE-supported REU sites that are specifically focused on minorities.

The CDRC findings are consistent with COSEE's reflection that the next challenge in their efforts to broaden participation is the development of a unified framework that facilitates coordination and the efficient sharing of best practices.

<u>Guidance on Network Structure</u>

C6. If it is to continue, is the Program's current structure of large Centers linked through a national Network facilitated by a National Coordinating Office still appropriate to achieve the stated future ocean sciences education goals or should the structure be modified in some way?

A major recommendation from the CDRC is for COSEE to be much more strategic in its operation. Although the programs developed to date appear to be well done and appreciated by the participants, they also appear to be somewhat ad hoc or opportunistic. While being alert to opportunities and developing a variety of programming approaches is fruitful, a strong and consistent focus on programs and products that clearly address the ultimate goals of COSEE is necessary. NSF Ocean Sciences views COSEE as an important service to the ocean sciences research community and because of that NSF's focus is on the scientists. Therefore COSEE center programs and products that most effectively serve the ocean sciences research community to achieve broader impacts are the highest priority for continued funding from the GEO Directorate. Professional development for

scientists providing forums for connecting their research to the public through education and access to data are just some examples of how ocean science researchers not only can participate in COSEE, but benefit from COSEE.

For any COSEE program or product the question of how will this accomplish the ultimate goal of "*engaging scientists and educators to transform ocean sciences education for all"* needs to be asked. Activities need to be linked to specific measurable outcomes through a pathway that will clearly produce the specified impact. A portfolio of high and low risk activities could be implemented, tested and evaluated. Once activities that clearly produce the desired impact have been identified, they need to be spread throughout the network, and beyond, to expand the effect. This may involve decreasing or eliminating some present activities, or supporting them through other funding. There is an opportunity cost to everything, and more is not always better. The centers need to look for low impact, high cost activities and activities that might be redundant within COSEE or with other parts of NSF or other agencies to cut or defer. A gap analysis that looks at how well all audiences (e.g., k-12, after school, museums, community colleges); all sub-disciplines of ocean sciences (e.g., biological, chemical, geological, and physical oceanography); and all ocean science topics (e.g., all of those in the ocean literacy principles), are being addressed by existing programming could be beneficial. An efficiency analysis examining the most cost effective ways to deliver programming and develop products to obtain outcomes could also be advantageous. Dialog within the network, and between the network and NSF, might be worthwhile in this regard to determine how to best use the gap analysis to make the difficult choices.

The committee believes that there are increased network function needs as outlined in the responses to questions above. Although the present structure has many strengths, the panel believes that it does not provide enough support and/or time to provide the consistent, proactive intellectual leadership necessary to analyze the overall "big-picture' landscape, to think about strategic opportunities, and to plan for larger impacts. As noted in the section above on "Network Operations," we recommend modifying the existing structure to promote strong intellectual leadership grounded in a more strategic network-wide focus and based on measureable outcomes. This change would advance the network efficiency, and effectiveness as well as the cohesiveness of the COSEE centers. There are several mechanisms that might provide the necessary support and time. For example, the COSEE structure may benefit from expanding the role of the Executive Director to provide intellectual leadership, in addition to operational leadership, under the guidance of the rotating council chair; this job would be their only or very major commitment (3/4 time or full time). Another structural change could be increasing the time that a person is chair of the council to two or three years (plus the time as chair elect and past chair). A longer term as chair, along with additional support, would allow them to work closer to full time as chair (probably taking a leave from their role in their center) and be more effective in identifying and implementing network-wide initiatives. Other mechanisms are possible, such as detailing of a person from a site to the NCO for a year or so in residence at the NCO to lead particular initiatives or the network as a whole.

We recognized the value of each Center having representation on the Council. Decisions that affect the Network are generally made when consensus is reached among the Council members, which encourages operational and intellectual buy-in by Centers and offers opportunities for collaboration. However, the downside of decision by consensus is that it can be slow, and may not always be strategic, efficient, or responsive. Furthermore, it is apparent from the documents supplied to the review panel that the Council has been getting very good advice from their Advisory Committee (see "National

Advisory Committee" section above), but is not always strategic or timely in their response. For example, the Advisory Committee has made repeated recommendations to the Council to broadly disseminate their best practices and products (e.g., in 2005 "Publish fast! Carpe Diem!), yet this is one of the key areas that still needs improvement across the COSEE Network.

Another need is in evaluation. As described above, the individual center evaluations need to be more sophisticated, e.g., moving up on the Guskey triangle shown in the report (note, the triangle is applicable to all evaluation even though it refers to professional development). There should be a monitoring database put in place to track activity and participation across the network. A 'core' evaluation function could provide valuable assistance to all of the centers, as well as providing high quality across center outcome data. An evaluation of the network functionality itself (which is distinct from the recommended core evaluation) could provide useful information about that aspect of COSEE.

Should NSF and COSEE be faced with reduced funding in the future, creative options will need to be found based on strategic planning, evidence based evaluations at the network level, and efficient dissemination of peer-reviewed programs and products. One possibility is to cut the number of centers. COSEE could remain an effective network even with fewer centers, especially if regional centers became more thematic in focus, if best practices were more effectively disseminated and implemented across the network, and if the network as a whole prioritized their products and programs based on the recommended gap analyses. While the CDRC supports funding of both regional and thematic centers because they have complementary priorities, COSEE may want to shift somewhat more towards the creation of thematic centers and implementation sites. A center might be responsible for linking scientists with educators to provide professional development and have links to several sites where the PD would take place. Another strategy for cutting centers would be to have only regional centers that would be responsible for the full range of activities, and adopting best practices at each center. A second approach to continue to function in a reduced funding environment would be to substantially cut the budgets of all of the centers allowing them to focus on only their most successful activities directly related to COSEE outcomes with COSEE money and supporting other activities as the centers could obtain additional funding. This could encourage the centers to become much more entrepreneurial and independent if they wanted to remain in existence. In this scenario, the network (at least the portion funded by COSEE) would be much smaller —relating only to the activities supported by COSEE – but could set up a structure of incentive funds or supplemental funds to support special initiatives. Strategic partnerships with more points of implementation are another important way to extend COSEE's future reach. A third possibility would be to blend the COSEE centers with other NSF (or other funding agency) GEO initiatives so that this synergy would provide the necessary funding to maintain the centers.

<u>Concluding Remarks</u>

The COSEE Decadal Review Committee finds that COSEE has made significant progress in addressing the goals established by NSF in the COSEE solicitation:

> *"The Division of Ocean Sciences seeks to establish new and/or renewed COSEE Centers in a network of coordinated centers that facilitate collaborations and communications between ocean science researchers and educators.*

These Centers

- *foster the integration of ocean research into high-quality educational materials,*
- *enable ocean researchers to gain a better understanding of educational organizations and pedagogy,*
- *provide educators with an enhanced capacity to understand and deliver high-quality educational programs in the ocean sciences,*
- *and provide material to the public that promotes a deeper understanding of the ocean and its influence on each person's quality of life and our national prosperity."*

The challenge now, for both NSF and the COSEE, is to maximize the potential of the COSEE Centers and Network to achieve current and future Foundation goals. Strategic investments will be required that leverage linkages and partnerships with other initiatives, directorates, institutions, and organizations.