

PART III
OCEAN STEWARDSHIP:
THE IMPORTANCE OF EDUCATION
AND PUBLIC AWARENESS

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CHAPTER 8: PROMOTING LIFELONG OCEAN EDUCATION

Strengthening the nation's awareness of the importance of the oceans requires a heightened focus on the marine environment, through both formal and informal education efforts. Curricula for kindergarten through 12th grade should expose students to ocean issues throughout their formal education, with the next generation of ocean scientists, managers, educators, and leaders being prepared through diverse higher education opportunities. In addition, because formal curricula only reach students for a limited time, informal education aimed at the entire population is needed to foster lifelong learning. An education office located under the National Ocean Council and empowered by federal agency leadership will provide a national focal point to improve ocean-related education efforts, facilitate coordination of ocean-related education among federal agencies, and enhance collaboration among the research community, state and local education authorities, and the private sector.

STRENGTHENING THE NATION'S OCEAN AWARENESS

A recent national survey indicates that the American public has only a superficial awareness of the importance of the ocean to their daily lives, let alone its importance to all life on the planet.¹ The ocean is a source of food and medicine, controls global climate, provides energy, supplies jobs, supports economies, and reveals information about the planet that cannot be gained from any other source. The ocean conceals the highest mountains and deepest canyons on Earth. Exploration of the ocean has revealed amazing organisms straight out of science fiction and entire ecosystems previously unknown to humankind. But the extent of what we do not know—what remains undiscovered—sparks the imagination. With so much of the marine environment still unexplored, the ocean can be viewed as the final frontier on Earth.

While most people do not recognize the number of benefits the ocean provides, or its potential for further discovery, many do feel a positive connection with it, sensing perhaps that the vitality of the sea is directly related to human survival. This connection can be a powerful tool for increasing awareness of, interest in, and responsible action toward the marine environment, and is critical to building an ocean stewardship ethic, strengthening the nation's science literacy, and creating a new generation of ocean leaders.

Ocean Stewardship

To successfully address complex ocean- and coastal-related issues, balance the use and conservation of marine resources, and realize future benefits from the ocean, an interested, engaged public will be needed. The public should be armed not only with the knowledge and skills needed to make informed choices, but also with a sense of excitement about the marine environment. Individuals should understand the importance of the ocean to their lives and should realize how individual actions affect the marine environment. Public understanding of human impacts on the marine environment should be balanced with recognition of the

benefits to be derived from well-managed ocean resources. Because of the connection among the ocean, the atmosphere, and the land, inland communities need to be just as involved as seaside communities.

Science Literacy

Ocean-related education also has the potential to stem the tide of science illiteracy threatening to undermine the nation's health, safety, and security. The scientific literacy of U.S. high school graduates is well below the international average.² This progressive loss of literacy weakens the nation's ability to maintain its traditionally strong foundation in science and mathematics. Only 15 percent of American adults now describe themselves as well informed about science and technology issues.³

Children have a natural curiosity about the world around them. By the ninth grade, however, this innate interest has too often faded or been transformed into apprehension—or even fear.⁴ Capturing children's attention early, and continually nurturing their inherent scientific curiosity, is critical to achieving scientific literacy and would be well served by employing the natural, multidisciplinary allure of the ocean as a basis for teaching science, mathematics, and engineering concepts.

This allure could be parlayed into higher achievement in other subjects as well. The influence of the ocean on nearly every aspect of daily life, and the central role it plays in the development of the nation, make ocean-based studies ideal for enhancing student performance in areas such as geography, history, economics, policy, and law. Strengthening science literacy, therefore, encompasses not only natural sciences, but a full suite of social sciences.

Future Ocean Leaders

The nation needs a diverse, knowledgeable, and adequately prepared workforce to enhance understanding of the marine environment and make decisions regarding complex ocean- and coastal-related issues. In 1929, the National Research Council emphasized that advances in ocean knowledge would depend on an ocean-related workforce sufficient in size and ability, with ample educational opportunities at its disposal.⁵ In today's competitive world of knowledge-based, technology-driven economies, with increasing demands on ocean and coastal resources, this need is even more relevant and urgent.

The education of the 21st century ocean-related workforce will require not only a strong understanding of oceanography and other disciplines, but an ability to integrate science concepts, engineering methods, and sociopolitical considerations. Resolving complex ocean issues related to economic stability, environmental health, and national security will require a workforce with diverse skills and backgrounds. Developing and maintaining such a workforce will rely, in turn, on programs of higher education that prepare future ocean professionals at a variety of levels and in a variety of marine-related fields.

Crosscutting Themes

While this chapter is organized into several sections—a collaborative education network, K-12 education, higher education and the workforce, and informal education—problems identified in each of these areas often affect the others. For example, inadequate funding is a concern throughout K-12, graduate, and informal education. Likewise, increased coordination is needed within and among all educational areas. One critical issue that recurs throughout this chapter is the need to bridge the gap between the research and education communities. Ocean-based professional development for teachers, scientifically sound ocean-based curricular materials, and up-to-date information for the public are just a few of the educational concerns that will depend on strong, vibrant connections between researchers and educators.

Another focus of this chapter is the role of the federal government in education. Although states are the leaders in K-12 education, federal agencies are a critical component of the education community. Ocean agencies will need appropriate direction and resources to fulfill this important role.

BUILDING A COLLABORATIVE OCEAN EDUCATION NETWORK

To achieve meaningful, lifelong learning on ocean issues, the efforts of federal agencies, state and local authorities, nongovernmental entities, and professional societies with roles in education need to be better coordinated.

Participants in Ocean Education

Although not all ocean-related federal agencies have a specific education mission, most have made efforts to reach out to students, teachers, and the public to inform them about ocean issues, sometimes by adding ocean-related components to larger science and environmental education efforts. Agencies that have developed educational programs related to planetary, environmental, and scientific processes include the National Oceanic and Atmospheric Administration (NOAA), U.S. Navy, National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), U.S. Environmental Protection Agency (EPA), Minerals Management Service, National Park Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey. These programs increase public understanding of the Earth's systems and the environment. While it is valuable for ocean-related information to be included as part of broader environmental and science education efforts, it is also important to support educational efforts that focus specifically on oceans, coasts, and the human relationship with them.

Of course, the U.S. Department of Education has the overarching responsibility of ensuring equal access to and fostering excellence in education across the nation. The department is engaged in a partnership effort with states and school districts to implement education reforms, including requirements that each state meet certain goals in core subject areas, such as science, math, and reading.

Two national-level ocean education programs of particular importance are the Centers for Ocean Sciences Education Excellence (COSEE) and the National Sea Grant College Program (Sea Grant). COSEE is an NSF initiative, with additional support from the Office of Naval Research (ONR) and NOAA, that has established a number of regional centers and a national office to create a coordinated program for ocean science education. Sea Grant, a partnership between NOAA and U.S. universities, is a national program implemented at the state level to further ocean-related research, education, and outreach.

While federal programs provide many opportunities for ocean-related education, education is essentially a state responsibility, and control is exerted primarily at the local level. Therefore, the interaction and involvement of education administrators at the state, district, and individual school levels will be fundamental to the success of any effort to use ocean-based examples to enhance student achievement.

Aquariums, zoos, and other informal education centers also provide the public with opportunities to learn about the marine environment. Teachers rely on these informal venues as another way to educate students about the oceans. The involvement of those who educate teachers, including subject-specific and professional development instructors, is critical to providing teachers the knowledge, confidence, attitudes, and ability to teach ocean-related information. A number of groups and associations also have a significant role in ocean-related education, including professional societies, such as the National Marine Educators Association (NMEA), the National Science Teachers Association, and the American Association for the Advancement of Science.

Coordinating Ocean Education

Despite the existence of many positive efforts, ocean education remains a patchwork of independently conceived and implemented programs and activities. These efforts cannot provide the nationwide momentum and visibility needed to promote sustained ocean education for students, teachers, and the general public. Within the federal government, there is little discussion of ocean education, even among those agencies with the greatest responsibility for ocean issues. Different programs and funding mechanisms are not coordinated and resources are seldom leveraged. Even within individual agencies, offices that have education components often do not collaborate or communicate.

Existing Coordination Efforts

Existing efforts at coordination have failed to take hold nationally. For example, NMEA is a national organization that brings together individuals concerned with marine-related education. However, it is strictly a volunteer initiative, with limited resources and capacity to develop, support, and sustain national-scale efforts. The Federal Task Force on Environmental Education, chaired by EPA, has had some success in bringing together federal agencies to support joint programs in environmental education. However, these programs tend to be relatively small in scale and scope, with limited attention devoted to ocean issues. The National Science and Technology Council's Committee on Science recently formed a Subcommittee on Education because of a recognized need for improved coordination of all educational programs among federal agencies. The subcommittee is intended to help reduce fragmentation and duplication and to bring about a coordinated set of programs. While this new body has the potential to unite agency education efforts, it too lacks an ocean focus.

One program that does focus on ocean issues is the National Oceanographic Partnership Program (NOPP), a statutory collaboration of fifteen federal agencies intended to provide leadership and coordination of national oceanographic research and education programs. Primarily through its grant program, NOPP has provided support for innovative education and outreach projects. NOPP's Ocean Research Advisory Panel recently drafted a national ocean education strategy to improve ocean literacy and science education.⁶ This strategy has great potential, but it has yet to be formally approved or adopted. Further, while NOPP has provided a venue for agencies to jointly fund ocean education activities, it does not provide a coordination mechanism for existing programs.

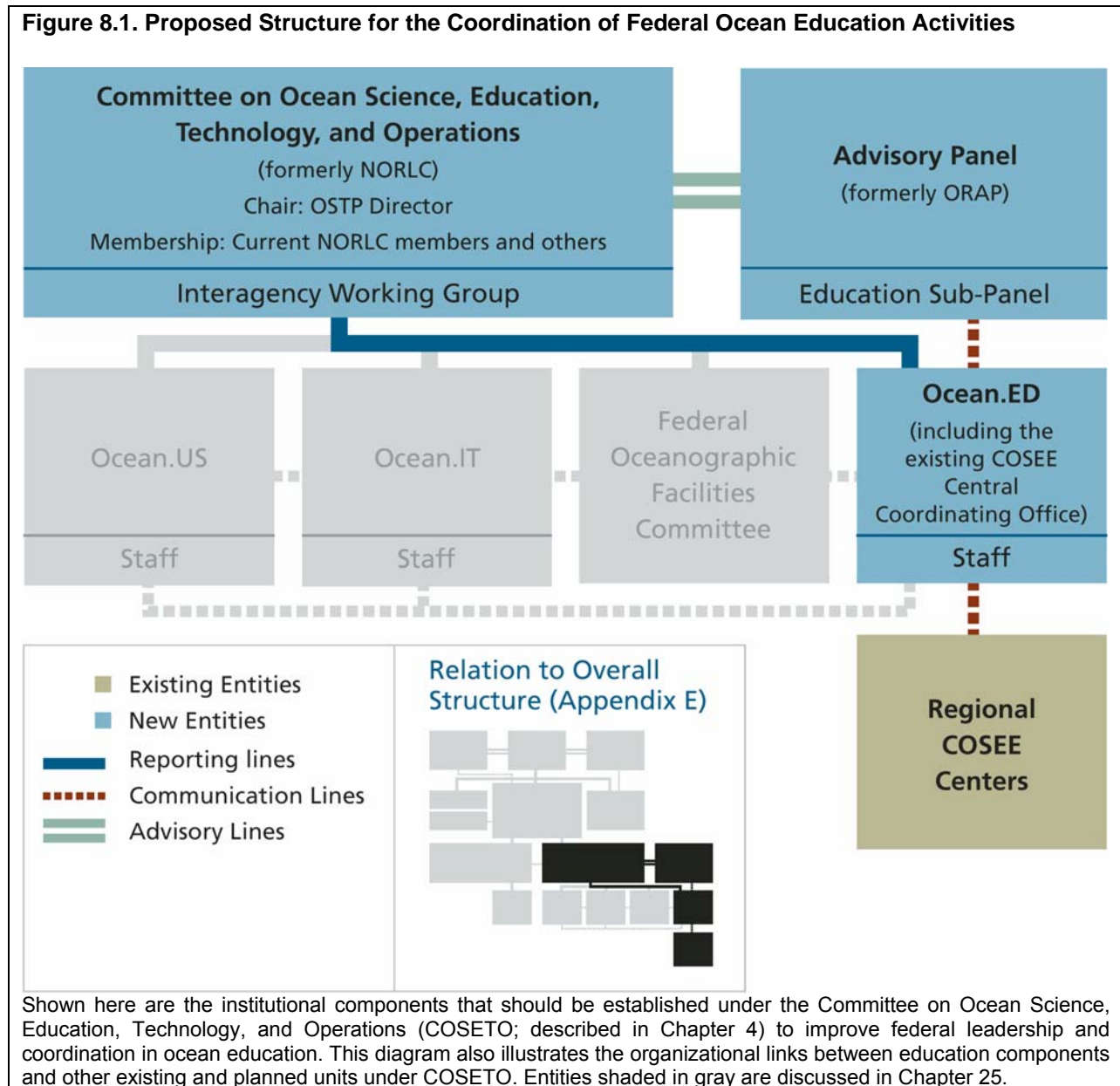
The coordination activities described above, while helpful, do not combine federal resources across agencies in a coherent, planned, and visible way. Without leadership, no common vision for ocean education has been developed, and no path for achieving such a vision has been laid out.

A National Ocean Education Office

As discussed in Chapter 4, the National Ocean Council, to be established within the Executive Office of the President, would serve as the federal coordinating body for all ocean-related activities. NOPP and its associated offices and committees would be incorporated within this structure. By strengthening and expanding NOPP's governing body (currently the National Ocean Research Leadership Council, but reconstituted pursuant to Recommendation 4-7 as the Committee on Ocean Science, Education, Technology, and Operations [COSETO]), and placing it under the National Ocean Council, the original NOPP goal of bringing agencies together on ocean research, operations, observing, and education efforts is more likely to be fulfilled. A national ocean education office would be an integral part of COSETO, serving as the education component of the enhanced NOPP (Figure 8.1). Such an office would coordinate the various federal ocean-related education efforts and perform many of the functions outlined in the education strategy crafted by NOPP's Ocean Research Advisory Panel. The education office would work closely with the other NOPP

offices and committees, including Ocean.US, the office responsible for coordinating development of the Integrated Ocean Observing System which includes several education efforts.

Figure 8.1. Proposed Structure for the Coordination of Federal Ocean Education Activities



A national ocean education office would coordinate and integrate federal agency programs and leverage resources, serve as a central, visible point of contact for K–12, university-level, and informal education partners, and work with all parties to develop coherent, comprehensive planning for ocean education efforts. In doing so, the national office should also interact with the regional ocean councils, as one avenue for ensuring consideration of regional needs.

Recommendation 8–1. The National Ocean Council should establish a national ocean education office (Ocean.ED) under its Committee on Ocean Science, Education, Technology, and Operations to strengthen ocean education and coordinate federal education efforts.

In particular, Ocean.ED should have the following responsibilities:

- *development of a national vision for enhancing educational achievement in natural and social sciences and increasing ocean awareness.*
- *creation of a strategy to implement the vision, including promotion of creative programs that transcend the traditional mission boundaries of individual agencies, and guidance on investments in ocean-related education activities.*
- *development of a medium-term (five-year) national plan for ocean-related K–12 and informal education, working with federal, state, and nongovernmental education entities.*
- *coordination and integration of all federal ocean-related education activities and establishment of links among federal efforts, state and local education authorities, informal education facilities and programs, institutions of higher learning, and private-sector education initiatives.*

Recommendation 8–2. Congress should provide funding for Ocean.ED operations and program implementation as a line item in the National Oceanic and Atmospheric Administration (NOAA) budget, to be spent only at the direction of the National Ocean Council (NOC). NOAA should develop a streamlined process for distributing Ocean.ED funds to other federal and nonfederal entities as approved by the NOC.

This national effort is not meant to replace other successful programs and activities, but rather provide a mechanism for communication, coordination, and joining of forces. Once created, Ocean.ED will need staff support and sustained funding, and should be overseen by an interagency committee chaired by NOAA and reporting to the National Ocean Council. While Ocean.ED will focus on ocean-related education, these efforts will have a greater chance of success if they are linked with efforts to improve education in other subjects, including natural sciences, technology, engineering, math, and a range of social sciences. Therefore, participation should extend beyond the current NOPP agencies, including the Department of Education. The new education office will also need an external advisory body to ensure involvement of and communication with professional teaching organizations and other experts.

The ability of a national-level ocean education office to effectively coordinate and promote ocean education efforts depends on every ocean-related federal agency acknowledging education as a priority. NASA and NSF have long embraced this approach, but it has been more difficult for many of the more mission-oriented agencies. Nevertheless, NOAA’s strategic plan for fiscal years 2003–8 includes environmental literacy, outreach, and education as a crosscutting priority⁷ and the agency recently created an Office of Education and Sustainable Development to coordinate its education activities. By passing an organic act for NOAA that includes education as part of the agency’s charge, as recommended in Chapter 7, Congress can encourage these positive developments.

Funding and Assessment

In addition to the functions of Ocean.ED outlined above, the office, working through the National Ocean Council process, should help ensure that adequate funding is available to carry out ocean-related education programs and activities. It should also work with the education community to develop a process for periodically assessing and evaluating ocean education efforts.

Sustained Support for Ocean Education

Adequate funding will be needed to meet the goals outlined in this chapter, but it is particularly important that funding for ocean-related education be sustained over time (for periods of at least five years) to allow programs to become established, produce results, and identify potential nonfederal funding sources.

Continuity of funding ensures that successful education efforts can be continued, expanded, and replicated. A dedicated, secure, sustained source of support for formal and informal ocean education efforts is needed to supplement existing low levels of ocean education funding. Such funding could be distributed through the existing NOPP funding process.

Evaluation and Assessment of Ocean Education Efforts

If ocean-based K–12, informal, and professional development programs are to serve as the basis for enhancing ocean awareness and increasing knowledge among students, educators, and the public, it will be critical to determine the effectiveness of these programs. For professional development efforts, accurate, properly conducted evaluation and assessment is vital to know how to modify existing programs and establish effective new efforts that provide educators with a productive and valuable experience. Likewise, identification and evaluation of best practices for incorporating ocean-based concepts into K–12 and teacher preparation coursework will help ensure continual improvement. Assessment mechanisms are needed to determine whether ocean-based coursework and programs are enhancing students' academic achievement and to promote materials and programs that provide the most enriching learning experiences.

Evaluation and assessment mechanisms are also critical to determining whether public education programs have been effective at delivering their messages. This information, combined with data on the state of public knowledge, provides the basis for program development and modification.

Recommendation 8–3. The National Oceanic and Atmospheric Administration, National Science Foundation, Office of Naval Research, and National Aeronautics and Space Administration should strengthen their support of both formal and informal ocean-related education, including appropriate assessments and evaluation of these efforts.

In particular, these agencies should:

- *develop, with assistance from Ocean.ED, a cooperative system of dedicated, sustained, multi-agency funding for formal and informal ocean education. This funding should be explicitly linked to the national ocean education plan.*
- *provide support for development and implementation of ocean-related education materials and activities with a requirement that evaluation and assessment mechanisms be included as a component of every program.*

Recommendation 8–4. Ocean.ED should lead the development of a framework for evaluating and assessing the effectiveness of ocean-related education programs, ocean-based K–12 professional development programs, best practices for incorporating ocean-based examples into K–12 education, and public education programs.

Linking the Research and Education Communities

Collaboration between the research and education communities must be improved if ocean-based information, including ocean data and new discoveries, is to be transformed into exciting and accessible materials to stimulate student achievement and enhance public awareness. Some efforts do exist to make these connections, most notably through the COSEE and Sea Grant programs.

Centers for Ocean Sciences Education Excellence

The COSEE network includes regional centers and a central coordinating office that work to integrate oceanographic data and information into high-quality curricular materials, provide ocean scientists with opportunities to learn more about educational needs and requirements, provide K–12 teachers with the knowledge and skills they need to effectively incorporate ocean-related information into their lessons, and deliver ocean-related information to the public.

Though recognized as a model for enhancing education and bringing accessible ocean-related information to the public, COSEE currently has only seven regional centers, each serving a limited number of schools in its area. The program does not have the level of committed, long-term support required to fully realize its potential.

While COSEE is currently an NSF program, placing it within the National Ocean Council structure as a NOPP program would enable the other NOPP agencies to more easily support COSEE, capitalizing on the tremendous potential to enhance and expand the program. The placement of COSEE within NOPP should not alter the relationships established between the central coordinating office and the regional centers, or among the regional centers and their partners. Before COSEE is expanded significantly in scale and scope, the regional COSEE centers should be evaluated to ensure that all participating centers address educational needs most effectively.

Recommendation 8–5. The National Ocean Council (NOC), working with the National Science Foundation, should relocate and expand the Centers for Ocean Sciences Education Excellence (COSEE) within the NOC structure as a program to be organized, overseen, and funded through Ocean.ED.

Expansion of COSEE should include:

- *tripling the number of regional centers to 21, with each center receiving at least \$1.5 million a year for an initial five year period.*
- *expanding the reach of each center beyond its immediate participants.*
- *identifying models for successful partnerships between scientists and K–12 teachers.*
- *devising strategies to incorporate the expertise of university science education specialists.*
- *implementing professional development programs for K–12 teachers and university research professors.*

The National Sea Grant College Program

The National Sea Grant College Program was created by Congress in 1966 as a partnership between the nation’s universities and NOAA. Sea Grant programs sponsor research, education, outreach, and technology transfer through a network of Sea Grant Colleges and research institutions. Sea Grant uses the work of university scientists, educators, and outreach specialists to study marine and Great Lakes resource management, development, and conservation issues, and then shares that knowledge with coastal businesses, marine industries, government, educators, and the public.

Sea Grant has forged connections between the research and education communities since its inception. Its programs provide K–12 teacher preparation and professional development programs consistent with state education standards, offer hands-on educational experiences for students, and develop research-based curricular and communications materials for students and the public. The Sea Grant network relies on longstanding local partnerships, with many connections to populations that have been traditionally underrepresented and underserved by the ocean community.

Despite its successes, however, Sea Grant is currently an underutilized resource. The existing Sea Grant network could expand its roles and responsibilities, particularly in education and outreach. Such an expanded and strengthened role is not possible with Sea Grant’s current annual budget of just over \$60 million. Funding for Sea Grant education initiatives is particularly limited, amounting to approximately 5 percent of the program’s budget in fiscal year 2002 (excluding fellowship programs). Although Sea Grant is one of the few major education outlets for NOAA, not all state Sea Grant programs have even one full-time education

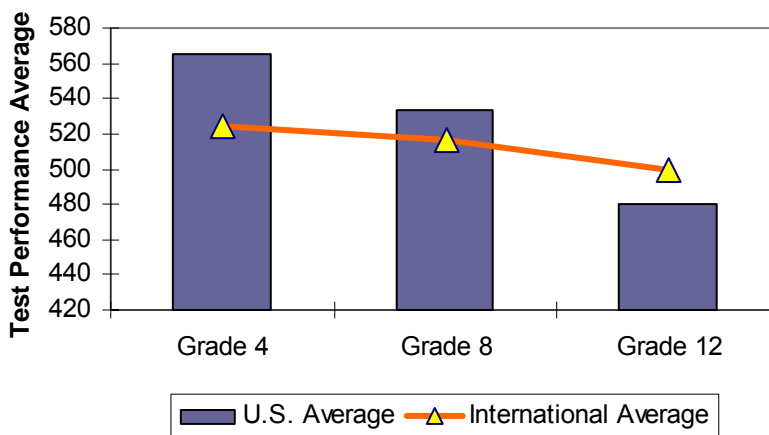
professional on staff due to funding limitations. Because of the value of Sea Grant’s educational activities, the program should be provided the resources to devote additional significant attention to that part of its charge. (An additional discussion of the Sea Grant program and the need to expand its capabilities is presented in Chapter 25.)

Because both the COSEE and Sea Grant programs play an important role in bringing together the research and education communities and both operate on national, regional, state, and local levels, there are natural links that could be established between them. While Sea Grant programs currently participate in many of the regional COSEE centers, these two programs could enhance their partnership by developing links in all of the regions in which they both operate. In addition, COSEE and Sea Grant should be closely connected with the regional ocean information programs discussed in Chapter 5.

INCORPORATING OCEANS INTO K–12 EDUCATION

International studies show that the United States is not preparing its citizens to sustain and build on the nation’s past scientific and technological accomplishments and compete successfully in an increasingly complex and technical world (Figure 8.2). At the same time, a lack of public awareness about the importance of the ocean hampers efforts to develop a balanced approach to the use and conservation of marine resources. Incorporating ocean-based learning experiences into K–12 education can help redress both these deficiencies.

Figure 8.2. U.S. Students Fall Behind in Science Knowledge

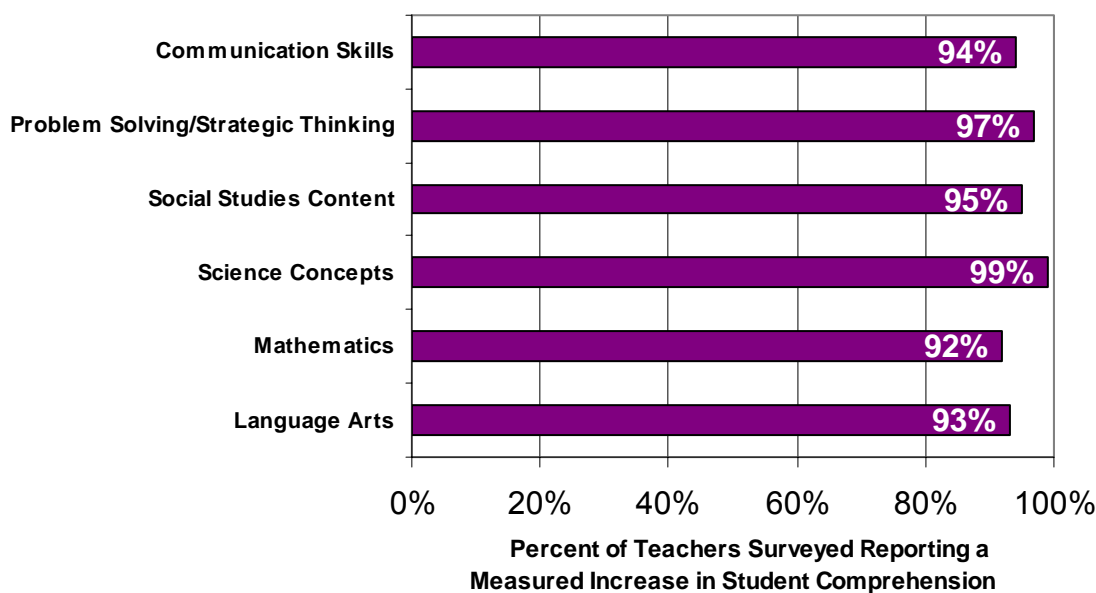


U.S. students at the fourth grade level score above the international average in science achievement, as calculated by test performance in the Trends in International Mathematics and Science Study. However, as students approach their final year in secondary school, the performance average in U.S. schools drops well below the international average.

Source: Calsyn, C., P. Gonzales, and M. Frase. *Highlights from TIMSS* [Trends in International Mathematics and Science Study]. Washington, DC: National Center for Education Statistics, 1999.

A study of forty schools in twelve states found that integration of environment-based programs into the overall education system increased student academic achievement in a number of areas (Figure 8.3), underscoring the power of using the student’s world, including both natural and sociocultural environments, as a conduit for reaching and engaging students.

Figure 8.3. Environment-based Education Boosts Overall Academic Achievement



In a recent study, a high percentage of teachers reported increased achievement among students when natural and sociocultural environments were used as a context for learning a range of subjects.

Source: Lieberman, G.A., and L.L. Hoody. *Closing the Achievement Gap: Using the Environment as an Integrated Context for Learning*. Poway, CA: Science Wizards, 1998.

The passage of the No Child Left Behind Act in 2002 reemphasized education—including science education—as a national priority. With the laudable goal of improving educational quality and student achievement, the Act calls for all states to establish standards in various subjects, with science education standards required by the 2005–6 school year. To ensure that students are reaching the goals set for them, science achievement must be tested beginning in the 2007–8 school year. This requirement offers an opportunity to demonstrate how the oceans can excite students about science and other subjects by incorporating ocean-related concepts into K-12 curricular materials.

Using Ocean-based Examples to Meet Education Standards

There are two primary sets of science literacy guidelines at the national level: the American Association for the Advancement of Science’s 1993 *Benchmarks for Science Literacy*, and the National Research Council’s 1996 *National Science Education Standards (NSES)*. Despite similar goals of outlining what students should know, understand, and be able to do in science at various grade levels, the *Benchmarks* include ocean sciences and ocean-related issues, while the *NSES* contain few explicit references to the oceans or ocean sciences.

A recent survey revealed a clear preference among educators for using the *NSES* rather than the *Benchmarks* when aligning science lessons with instructional standards (Appendix 3). And where statewide science standards exist, they are also typically based on the *NSES*. Thus, the notion of using the oceans to meet science requirements is not commonly incorporated at the state or local level, slowing the adoption of ocean-based curricular materials in K-12 classes.

Nonetheless, while the *NSES* do not highlight oceans explicitly, they do endorse a new approach to teaching and learning science that emphasizes inquiry-based education as the ideal way for students to gain knowledge and an understanding of the world around them. The oceans are an excellent vehicle for implementing this

new approach. The hands-on, interdisciplinary and multidisciplinary nature of ocean-based studies lends itself to teaching the basic principles of biology, chemistry, geology, physics, and mathematics in an engaging, novel manner. Principles of the core sciences, many of which are relatively abstract, become more tangible and easier to grasp when introduced through ocean examples.

The centuries-old ties between the marine environment and human experience make the ocean an equally powerful resource for teaching literature, economics, history, and other social sciences. Ocean-based examples focusing on these areas can be a valuable tool for K-12 teachers to not only enhance student achievement but educate young people on the many ways the oceans influence and are influenced by human activities.

The value of ocean-based learning must be recognized within local school districts to create a demand for ocean-related education products. A well-informed network will be needed to advocate inclusion of ocean-based examples in state and local requirements and assessments. This network could begin with organizations and efforts that have established local connections—such as COSEE, Sea Grant, NMEA, and the National Science Teachers Association—to serve as facilitators. A potential model to examine is NASA’s education program, which involves translators and liaisons who work directly with teachers and administrators at the local level to produce high-quality, research-based curricula that are tailored to the needs of the school system and aligned with state and national standards. In addition, professional teaching and ocean-related societies should encourage their members to become active participants on boards and committees that decide content for statewide science achievement tests.

Because scientists typically do not know what type, level, or format of information K–12 teachers require, and because teachers generally are not aware of how ocean-related data can be used to advance student achievement, collaborative efforts will be needed to develop research-based, ocean-related curricular materials that are aligned with state and national educational standards and meet the needs of teachers.

Recommendation 8–6. Ocean.ED, working with state and local education authorities and the research community, should coordinate the development and adoption of ocean-related materials and examples that meet existing education standards.

Specifically, Ocean.ED should:

- *assess existing ocean-based curricular offerings, highlighting exemplary materials that are aligned with national standards.*
- *ensure the creation of National Science Education Standards companion materials that are based on ocean data and research findings (including social and economic fields); provide ocean-based examples and assessment questions that link to the concept standards in physical and life sciences, geography, history, and other topics; and clearly demonstrate the value of oceans in teaching fundamental concepts. Development of these materials should be coordinated with ongoing efforts by the National Marine Educators Association, the National Geographic Society, and others to establish basic ocean literacy concepts.*
- *promote the development of case studies that stress the interconnected nature of the ocean, land, and atmosphere.*

Bridging the Gap between Scientists and Educators

The extent to which the nation is able to enhance ocean awareness, boost student achievement, and prepare future generations of ocean professionals depends not only on the teachers and administrators who guide students on a daily basis, but on the commitment of the research community to prepare students to be responsible, knowledgeable, and competitive members of the global society. The National Research Council has highlighted the need for scientists to be fully engaged in the process of K–12 education in our nation, noting that teachers and researchers possess different strengths and resources and that they must be equally dedicated partners committed to improving educational opportunities.⁸ As noted above, collaborations are

needed in the development of ocean-related curricular materials, but they are also needed to broaden opportunities for students and teachers to gain first-hand field and research experience.

Teaching the Teachers

Higher expectations for our youth mean higher expectations for teachers as well. Students cannot achieve without instruction by capable teachers who are knowledgeable in the topics being presented. Thus, improving the quality of science and math education must begin with improving preparation of undergraduates studying to be teachers (referred to as pre-service teachers) and professional development for certified teachers in the classroom (referred to as in-service teachers).

The Need for Qualified Science Teachers

A 2000 National Research Council report confirmed that there is a strong relationship between the level of knowledge of science and math teachers and the achievement of their students in these areas.⁹ Nevertheless, many science and math classes continue to be taught by unqualified or under-qualified instructors. Thirty-nine percent of public school students taking life science or biology classes in grades 7–12 are taught by teachers without even a minor in these fields, while 56 percent of grade 7–12 students in physical science classes are taught by teachers without even a minor in physics, chemistry, geology, or earth science.¹⁰

The lack of content knowledge among educators is particularly pervasive on ocean topics. The college science courses taken by pre-service teachers form the basis of their scientific understanding and determine their comfort level in teaching science. Because very few universities provide pre-service teachers exposure to ocean topics,¹¹ they remain poorly equipped to incorporate ocean-related concepts into their instruction.

Similarly, in-service teachers have few opportunities to learn about ocean concepts and how they can be introduced into lessons. First-hand, in-depth involvement of teachers in research and field experiences is a proven way to connect science teaching and science learning. The ocean research community is brimming with potential for engaging K–12 educators in the excitement and satisfaction of the scientific enterprise, and the nation’s research infrastructure provides significant opportunities for formal preparation, hands-on involvement, and teacher certification. Although several public and private sector programs can provide teachers with research experience in ocean-related topics, access to these programs is quite limited, very few have long term, stable funding, and the different efforts are poorly coordinated.

For example, NSF’s Research Experiences for Teachers program could be expanded to include ocean-based opportunities and NOAA could build on successful programs such as Teachers-at-Sea and Ocean Explorer. Federal ocean agencies could also provide incentives for ocean research institutions to establish certificate programs for pre-service and in-service teacher preparation and development and include graduate courses that cover ocean-related concepts and how they can be applied in teaching. To help broaden the impact of such professional development programs, successful participants should be encouraged to serve as master teachers or resource teachers after a period of evaluation. The American Meteorological Society’s Project Maury and Project Atmosphere serve as excellent models for achieving this type of long-term impact.

Despite an abundance of good ideas and successful models, significant obstacles remain in developing lasting collaborations between ocean scientists and teachers. A 1996 National Research Council report found that researchers do not fully appreciate the roles and responsibilities of teachers, and teachers are not fully aware of the duties and functions of researchers.¹² Further, the existing academic culture can be a deterrent to scientists’ involvement in education and outreach activities. Although most faculty are expected to participate in research, teaching, and service activities, universities typically provide the greatest rewards for successful research, with teaching achievements a distant second, and little if any recognition for community service.

COOL Professional Development for Teachers

A partnership between the Jacques Cousteau National Estuarine Research Reserve and the Rutgers University Institute of Marine and Coastal Sciences generates a wealth of professional development opportunities designed to engage New Jersey teachers and school administrators in using the ocean to enhance student learning experiences. Programs range from field-based workshops to Web-based instructional modules dubbed the COOL (Coastal Ocean Observation Laboratory) Classroom. This partnership is an example of the type of innovative, relevant, and exciting educational opportunities that can be created when the research and education communities work together to bring the latest advances in ocean research into the classroom.

Federal agencies could help bring about a cultural change by providing incentives for universities to raise the visibility and rewards for faculty interactions with educators. Programs such as NSF's Faculty Early Career Development program and Graduate Teaching Fellows in K–12 Education program address this issue by providing support for involvement in K–12 education among graduate students and young faculty. But the limited size and scope of these programs have restricted their influence.

Effective partnerships between scientists and teachers will require new, long-term arrangements between the academic community and school districts. Large-scale programs such as NSF's Math and Science Partnership, which funds university scientists to work with teachers in areas such as professional development and curriculum enhancement, are urgently needed. The COSEE and Sea Grant networks could be tapped to coordinate such programs within the ocean community.

Recommendation 8–7. Ocean.ED, working with academic institutions and local school districts, should help establish stronger and more effective relationships between the research and education communities to expand professional development opportunities for teachers and teacher educators. The National Oceanic and Atmospheric Administration, National Science Foundation, the U.S. Navy, and National Aeronautics and Space Administration should support these efforts by providing secure and stable funding.

Specifically, these agencies should:

- *provide supplemental grants and other rewards to scientists who partner with teachers and teacher educators to include educational components in their research projects.*
- *establish a grants program for development and implementation of an enhanced core curriculum in science content that incorporates ocean concepts for pre-service teachers. Applicants should be required to demonstrate collaborations and partnerships among education, science, mathematics, and engineering faculty.*

Bringing Oceans and Students Together

Through field and laboratory experiments, oceans offer a natural avenue for students to gain first-hand exposure to science while developing an awareness of the importance of the ocean. Not all students are near, or able to travel to, the shore, but new ocean research technologies represent a tremendous and virtually untapped avenue to overcome this limitation, allowing students anywhere to be involved in real oceanographic investigations. The same remote-access technologies that make advanced ocean research possible can also help students and teachers participate in collecting, analyzing, and distributing ocean data. Enabling students to interact with practicing scientists, even if they are thousands of miles away, can help create a lifelong affinity for learning.

Today's Kids ... Tomorrow's Ocean Professionals

With regular field trips beyond the resources of most educators and school systems, the KidScience program serves as a model for bringing science to students through dynamic, relevant programs broadcast directly into classrooms. Produced cooperatively by the Hawaii Department of Education and Hawaii Public Television, this live, interactive series offers students in grades 4–8 two distinct types of learning opportunities.

Locally broadcast programs demonstrate hands-on lessons that involve students in a range of research activities and allow them to communicate with their on-screen instructor by telephoning or e-mailing questions throughout the broadcast. A more in-depth examination of selected topics takes place during three-part series that are broadcast not only in Hawaii but also in Micronesia and American Samoa and across the continental United States. These series combine live discussions with experts and pre-taped virtual field trips to expose students to topics ranging from “The Underwater Classroom” to “Living on a Volcano.” Students are also engaged in current events involving ocean and coastal environments through discussions of ocean-related policy questions.

The potential benefits of technological advances for science education should be further explored to help U.S. students regain their position among the best and brightest in the world. Federal agencies and academic institutions should find ways to provide students with opportunities to participate in ocean research and exploration, virtually or in person, including summer programs, field trips, remote participation in ocean expeditions, and, most important, after-school activities. Mentoring, especially near-peer guidance, is critical and should be a component of any student-oriented program.

Engaging Underrepresented and Underserved Groups

Social, economic, and cultural factors can play an influential role in inhibiting a student's access to education opportunities, especially science-based opportunities. These factors are typically even stronger among minority students and other groups that have been traditionally underrepresented and underserved in scientific fields, including marine sciences. Repairing this broken link will depend on exposing minority students to ocean-related studies early in their education, continuing that exposure throughout their school years, and demonstrating the possibilities and rewards of a career in ocean-related fields.

Enhancing the appeal and viability of ocean-related careers among traditionally underrepresented and underserved groups will not happen overnight. Such efforts will need to address social and cultural issues and must demonstrate the relevance and importance of the oceans in daily life. Success depends on students, their families, and their communities embracing an ocean career as “viable, socially responsible, and financially rewarding.”¹³

Recommendation 8–8. Ocean.ED should promote partnerships among school districts, institutions of higher learning, aquariums, science centers, museums, and private laboratories to develop more opportunities for students to explore the marine environment, both through virtual means and hands-on field, laboratory, and at-sea experiences. Ocean.ED should ensure that ocean-based educational programs and materials acknowledge cultural differences and other aspects of human diversity, resulting in programs that expose students and teachers from all cultures and backgrounds to ocean issues.

INVESTING IN HIGHER EDUCATION AND THE FUTURE OCEAN WORKFORCE

Understanding the marine environment and meeting our many ocean-related societal needs will require a well-trained, diverse workforce, adequate in number, with expertise across a range of ocean-related subjects. In addition to acquiring scientific knowledge and research skills, the ocean leaders of the future need to engage interdisciplinary and multidisciplinary perspectives, use multiple contexts in solving problems, and communicate complex ideas to a broad audience. Fostering these critical abilities requires diversification of learning opportunities.

Stagnant or declining federal support for ocean-related research has eroded the ability of academic institutions to maintain certain educational programs, limiting the breadth of educational opportunities. For example, there are few vibrant schools of fishery science and management, though advances in these areas are critical to successful fishery management efforts. Likewise, strong graduate educational efforts in marine taxonomy and biodiversity are very limited, though understanding of these topics is a baseline for ensuring scientifically sound management decisions.

The graying trend in the existing federal and academic ocean workforce adds to the urgency of training new ocean professionals. Projections of federal retirements indicate that just over 30 percent of federal employees will leave the workforce in the next decade.¹⁴ This trend will result in the loss of a great deal of the intellectual power and creativity that has expanded our understanding and improved management of the marine environment. The nation will require a human resource base capable of building on advances of the past to solve the problems of tomorrow.

The Leadership Void

There is no lead federal agency to assess, nurture, and maintain a strong ocean workforce, both in numbers and in diversity of skills. As the nation's primary civilian ocean agency, NOAA would seem a natural candidate to fill this void. However, NOAA's involvement in education, which is generally limited to grant-specific research assistantships and a handful of policy and industry fellowships, falls far short of the effort needed on a national scale. NOAA provided only 18 percent of federal support for ocean-related academic research programs (on which much graduate student funding depends) for the 2001–2 academic year (Appendix 4). This level of support is inadequate given that NOAA is a major employer of ocean professionals. The approach is markedly different at the National Institutes of Health, which works hard to ensure a sufficient and knowledgeable workforce for the health sciences community.

The Navy, predominantly through ONR, has traditionally been a leader in supporting ocean-related graduate student education. However, Navy funding for academic-based basic ocean research has been on a downward trend.¹⁵ This leaves NSF as the primary supporter of ocean science graduate students, providing 36 percent of federal support for ocean-related academic research programs for the 2001–2 academic year.¹⁶ While education is a part of NSF's mission, the agency's proposal-driven approach is not ideally suited to meet identified national needs for ocean-related education and training. Furthermore, NSF graduate student support tends to emphasize the natural sciences and engineering, a component—but not all—of the ocean workforce. (A detailed overview of federal agency funding for academic ocean science programs can be found in Appendix 4.)

Academic institutions must also take responsibility for meeting future ocean-related workforce needs. Redesigned graduate programs can expose students to aspects of the marine field outside their primary focus, for example, exposing science students to policy issues and policy students to the scientific process. Ocean-related graduate programs should develop cross-disciplinary opportunities, partnering with other programs (for example in education, public policy, economics, communications, resource management, and engineering) in universities, federal facilities, or private laboratories.

Drawing Students into the Field

The ocean community must compete with countless other professions in attracting the talent it needs. Success lies, in part, in promoting marine-related career opportunities among undergraduate students from a broad range of disciplines. First-hand experiences in marine fields can be influential in demonstrating the possibilities and rewards of an ocean-related career. Intellectually stimulating and financially attractive options for pursuing graduate studies in an ocean-related field must follow, so a student's developing interest in ocean studies is not overshadowed by other professions that actively pursue, encourage, and support their future leaders.

Ocean sciences have another potentially important role to play at the undergraduate level. Marine science courses can be attractive options for non-science majors who need to fulfill science requirements for graduation, presenting an excellent opportunity to raise general ocean awareness.

Recommendation 8–9. The National Oceanic and Atmospheric Administration, National Science Foundation, and Office of Naval Research should support colleges and universities in promoting introductory marine science courses to expose students, including non-science majors, to these subjects.

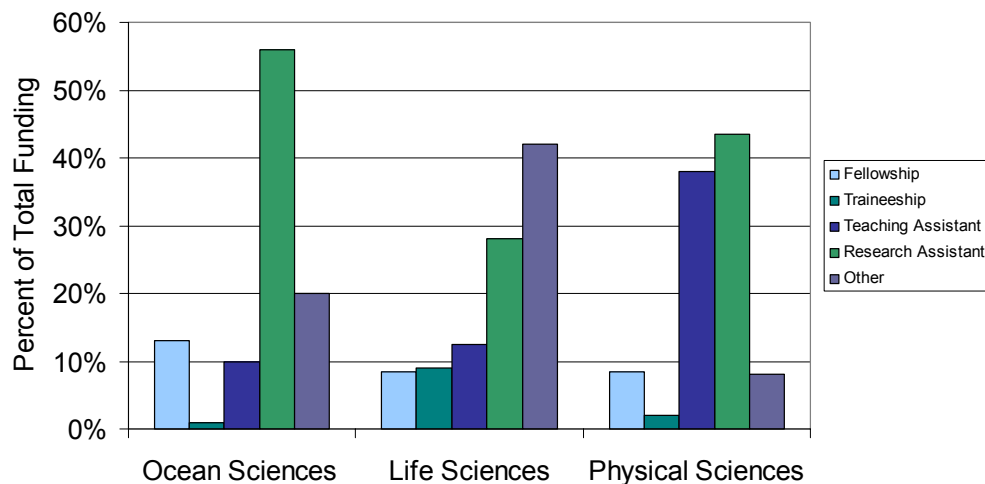
These agencies should support this effort by:

- *providing small grants to assist in course development, equipment purchase, faculty support, and field experiences.*
- *fostering collaborations between institutions with graduate ocean programs and others with a primarily undergraduate population.*

Expanding Graduate Educational Opportunities

How students are funded significantly influences their opportunities to develop research, engineering, teaching, management, and other skills. It can also limit or expand their awareness of the career paths and job sectors available to them. More than 55 percent of ocean sciences graduate students are supported by research assistantships, making the ocean community more dependent on this type of support than other fields (Figure 8.4). This is particularly striking in comparison with the life and physical sciences, in which students are supported through a more diversified combination of opportunities including traineeships, fellowships, and teaching assistantships.¹⁷

Research assistantships are important for budding scientists and should continue as a major student support mechanism. However, the ocean community's over-reliance on research assistantships can limit students' exposure to cross-disciplinary experiences that could better prepare them for addressing complex marine-related issues.

Figure 8.4. Graduate Students in Ocean Sciences Limited by Funding Source

When compared with the physical and life sciences, graduate programs in ocean sciences rely more heavily on research assistantships as a source for funding. Because of the requirements placed on students receiving this type of funding, they are potentially denied access to multi-disciplinary experiences that could better prepare them for examining complex marine-related issues.

Source: CORE Study: U.S. Academic Infrastructure in Support of Research and Education in Ocean Sciences and Related Fields, Appendix 4.

The ocean community could benefit from a better mix of fellowship and trainee programs. Fellowships allow top students to select a program best suited to their needs and interests. Traineeships allow graduate students to be assembled in a highly qualified research and learning environment. Student opportunities can also be diversified by getting both funding agencies and academic institutions to redefine what graduate research assistants are allowed to do. The NSF Integrative Graduate Education and Research Training program is an example of one attempt to move in this direction.

Because ocean science is fundamentally interdisciplinary, well-trained ocean professionals can find excellent careers in many areas including engineering, economics, education, law, management, policy, science, and technology. Individuals considering or pursuing graduate studies in a marine field should be aware of these options, and exploration of nontraditional marine areas should be encouraged. Equally important, professionals educated and trained in other fields should be made aware of the exciting opportunities available to them in marine-related fields.

Complementing the need to create an adequate workforce is the need to sustain and enhance that workforce through professional development and continuing education opportunities. Learning does not stop once the formal education process is complete; ocean professionals in all fields must be provided the means and liberty to continually build upon their knowledge and skills throughout their careers.

Recommendation 8–10. Ocean.ED should guide and promote the development of the nation’s ocean-related workforce.

In particular, Ocean.ED should:

- *promote student support, diversified educational opportunities, and investment in innovative approaches to graduate education that prepare students for a broad range of careers in academia, government, and industry.*
- *encourage, with targeted federal support, graduate departments of ocean sciences and engineering to experiment with new or redesigned programs that emphasize cross-disciplinary courses of study.*
- *set targets for federal stipends for ocean-related education to be competitive with other disciplines.*

Workforce Needs

As discussed above, most graduate ocean education has been linked to faculty research, an approach that pays little or no heed to the needs of the ocean-related workforce—which are poorly understood—or to national demographics, which are better understood but not well integrated into workforce preparation.

While the U.S. Department of Labor plays a role in assessing workforce status and trends, currently there is no data collection or analysis of ocean-related workforce supply or demand, including requirements for the maritime transportation system. Only sketchy information is available on how many new ocean professionals are being produced and in what fields. In a recent survey of ocean-related higher education programs, 26 percent maintained no data on initial employment of recent graduates.¹⁸ Even less effort has been put into projecting the types of professionals the ocean community will require in the future.

Federal ocean funding agencies will continue to operate in the dark without improved information on the status of the ocean-related workforce, with periodic follow-up to determine whether workforce needs are being met. Some of the necessary data can be found through the Department of Labor, NSF, and others, but additional analyses and a tracking mechanism will be needed. The Consortium for Oceanographic Research and Education survey of academic institutions can help in developing this tracking mechanism (Appendix 4).

Recommendation 8–11. The National Oceanic and Atmospheric Administration and the U.S. Department of Labor should establish a national ocean workforce database and compile an annual report for the National Ocean Council on trends in ocean-related human resource development and needs. This effort should include an information clearinghouse to facilitate career decisions, provide access to career guidance, and enable employers, guidance counselors, and others to develop effective strategies to attract students to ocean-related careers. Ocean.ED should organize an ocean workforce summit every five years to address the alignment of ocean education with workforce needs.

Specific Federal Responsibilities

Each federal agency with ocean-related responsibilities—most notably NOAA, NSF, and ONR—has a responsibility to help ensure a vibrant ocean-related workforce. These agencies need to develop interrelated and crosscutting educational opportunities at the undergraduate, graduate, and postdoctoral levels.

NOAA should be particularly concerned with creating a pipeline of students in areas it identifies to be of critical importance to the agency. Opportunities should include both research experiences, especially exposure to mission-oriented research, and experiences beyond the research arena. Student exposure can begin as early as the junior or senior level in high school, continuing through postdoctoral education. A range of programs will help identify and recruit the best and brightest to careers in marine-related fields and ensure a continuing source of essential human capital.

At the graduate and postdoctoral levels, NOAA can support fellowships and traineeships that emphasize interdisciplinary approaches and real-world experiences beyond the university setting, such as those provided by the Dean John A. Knauss Marine Policy Fellowship, the NOAA Coastal Services Center Coastal Management Fellowship, and the American Association for the Advancement of Science Fellowship. NSF's Integrative Graduate Education and Research Training program and NASA traineeships and fellowships offer other models. Within NOAA, Sea Grant plays a critical role in providing graduate-level education opportunities, a role which could be enhanced as part of an expansion of that program.

Recommendation 8–12. The National Oceanic and Atmospheric Administration (NOAA) should establish a national ocean education and training program, patterned after the National Institutes of Health model, within its Office of Education and Sustainable Development to provide diverse, innovative ocean-related education opportunities at the undergraduate, graduate, and postdoctoral levels.

Specifically, NOAA should:

- *support fellowships and traineeships at the graduate and postdoctoral levels that emphasize interdisciplinary approaches and real-world experiences outside the university setting, especially in areas critical to the agency’s mission.*
- *offer students at the undergraduate level experiential learning opportunities in a range of marine fields through summer internships or similar mechanisms.*

Also important is the need to encourage a recommitment to ocean studies within the academic community, particularly in areas critical to agency missions. The Navy has had success in partnering directly with academic institutions, providing support for distinguished scientists who, in turn, develop laboratories and educate students in areas of fundamental interest to the Navy. NOAA should establish similar competitive “Distinguished Professorships in Marine Studies” within Sea Grant Colleges or other leading institutions of higher education with a demonstrated commitment to marine programs. Disciplines of interest to NOAA for such professorships could include fisheries science, climate research, atmospheric studies, and marine resource economics, policy, aquaculture, genomics, education, and ecosystem studies. The intent would be to create a cadre of distinguished NOAA endowed chairs at universities around the nation. In a complementary effort, NOAA should consider establishing competitive national awards to recognize excellent teaching in marine-related topics.

At the undergraduate level, NSF’s Research Experience for Undergraduates program could be expanded to include more marine-related experiences. At the graduate and postdoctoral levels, opportunities could include fellowships that encourage cross-disciplinary research, interdisciplinary traineeships, and master’s degree fellowships. Programs such as NSF’s Integrative Graduate Education and Research Training program, Centers for Learning and Teaching, and Graduate Teaching Fellows in K–12 Education should be supported and enhanced both within NSF and adopted by other federal ocean agencies.

Recommendation 8–13. The National Science Foundation’s Directorates of Geosciences, Biological Sciences, and Education and Human Resources should develop cooperative programs to provide diverse educational opportunities at the undergraduate, graduate, and postdoctoral levels in a range of ocean-related fields.

The success of the Navy depends on a well-developed understanding of the environment in which it operates. Understanding the ocean environment—including the atmosphere above it, the seafloor beneath it, and the coastlines that encircle it—will always be a core naval requirement. Thus the Navy should play a central role in ensuring support for the education of future generations of ocean professionals.

Recommendation 8–14. The Office of Naval Research (ONR) should reinvigorate its support of graduate education in ocean sciences and engineering. This could be partly accomplished by increasing the number of ocean-related awards made under ONR’s National Defense Science and Engineering Graduate Fellowship Program.

Strength through Diversity

Human diversity has the power to enrich and invigorate the ocean community with a range of perspectives critical to the overall capabilities of the ocean workforce. Science and management professionals who are part of a particular cultural or ethnic community can help to engender understanding of marine-related issues within their communities and can serve as role models to help young people envision themselves as future ocean professionals. Nearly 90 percent of students enrolled in U.S. ocean-related graduate programs during the fall of 2001, however, were identified as white.¹⁹

While a number of minority-serving institutions (MSIs) offer degree-granting programs in marine sciences, only the University of Puerto Rico offers a Ph.D.-level program.²⁰ This could be a contributing factor to the lack of minority representation among ocean professionals with advanced degrees. In the United States, historically black colleges and universities enroll only 12 percent of all African American college students, but they award 40 percent of the science degrees earned by African Americans.²¹ There is great potential for building on this success and developing more avenues for underrepresented and underserved students to pursue advanced ocean-related studies. Member schools of the Hispanic Association of Colleges and Universities provide a similar opportunity for engaging Hispanic students in marine-related careers, as do tribal colleges and universities in the American Indian Higher Education Consortium.

One avenue that should be explored is support for collaborative programs that partner MSIs with research institutions to develop more graduate-level marine science programs at MSIs. One successful existing program that should be expanded to provide opportunities for more underrepresented and underserved students is NOAA's Educational Partnership Program with MSIs. A central element in this and similar programs must be the establishment of links between students and minority ocean professionals through a mentoring program.

While efforts should be made to expand opportunities for marine-related study at MSIs, all institutions need to provide an environment of cultural acceptance and instructional dedication to move students from diverse backgrounds forward academically.

Recommendation 8–15. The National Oceanic and Atmospheric Administration, National Science Foundation, Office of Naval Research, and National Aeronautics and Space Administration should encourage and increase the participation of traditionally underrepresented and underserved groups in the ocean-related workforce. Ocean.ED should facilitate collaboration between these agencies and institutions of higher learning to ensure that the appropriate mix of programs and opportunities exists to provide underrepresented and underserved groups ample access to and support for pursuing ocean-related graduate education.

BRINGING THE OCEAN AND COASTS TO ALL AMERICANS

While the public has a general sense that the ocean is important, most people lack a full awareness and understanding of the ocean, its health, the benefits it provides, and its connection to the nation's collective well-being. This information gap is a significant obstacle in achieving responsible use of our nation's coastal and ocean resources, empowering public involvement in ocean-related decision making, and realizing support for wise investments in and management of ocean-related activities.

The Ocean Information Gap

According to a recent national survey on ocean awareness, nearly 60 percent of Americans do not realize that more plants and animals live in the oceans than on the land; 75 percent mistakenly believe that forests, rather than oceans, are the major source of oxygen on the planet; and 40 percent are unaware of the essential role oceans play in regulating climate.²²

Although a healthy marine environment is a prerequisite for our continued enjoyment of ocean and coastal benefits, a recent survey shows that many people consider the health of the marine environment a second-tier environmental concern, overshadowed by the problems of air and water pollution and toxic waste disposal. The American public apparently feels little sense of urgency safeguarding our coastal and ocean resources. In addition, while most Americans realize the marine environment can be degraded as a result of human activities, they are less clear about the role individuals play in contributing to this damage. Nearly half the public mistakenly agrees with the statement, “What I do in my lifetime doesn’t impact ocean health much at all.”²³

Multifaceted Approaches

Such public misinformation points to the urgent need for raising awareness about the oceans. This Herculean task is currently being undertaken by a number of informal education facilities and programs, publicly and privately funded, struggling to make headway in advancing public knowledge about the marine environment.

The strength of the informal education community lies in the diversity of methods used. The varied formats, styles of presentation, and depth of detail, coupled with wide-ranging modes of access, result in an array of opportunities for reaching the public. Informal education facilities such as aquariums, science centers, zoos, museums, and marine parks, along with other outlets such as national magazines and television programs, local newscasts, traveling exhibits, and Internet sites, are all important contributors to the domain of public education.

What is Informal Education?

The National Science Foundation describes informal education as the life-long learning process in which every person acquires knowledge, skills, attitudes, and values from daily experiences and resources in his or her environment. Informal learning is self-directed, voluntary, and motivated mainly by intrinsic interest, curiosity, exploration, and social interaction.²⁴

U.S. aquariums, zoos, and other informal education centers welcome over 135 million visitors a year to their on-site displays and bring information to millions of additional guests through community outreach efforts.²⁵ These informal education centers endeavor to be equal opportunity teachers by employing mechanisms and instituting programs to reach traditionally underrepresented and underserved groups. Natural history museums and science centers also provide ocean-related educational experiences to millions each year. These facilities have a reputation for delivering accurate information about the marine environment and represent a powerful voice in the realm of public education. A recent public poll revealed that aquariums are a highly trusted source of environmental information.²⁶

In addition to informal education facilities, federal ocean-related agencies conduct public education and outreach. Opportunities range from first-hand exploration of the marine environment at a variety of marine sanctuaries, parks, and reserves to interactive Web sites that follow oceanographic expeditions in real time, to materials that translate scientific discoveries and relate them to everyday life. Federal agencies also support informal education by funding projects that aim to increase public understanding of scientific and

environmental issues. (Additional information on a sampling of programs and activities offered by informal education facilities and federal agencies is provided in Appendix 5.)

Coordinating Messages

While the many existing informal education efforts have made progress, they have not yielded the level of national consciousness needed to cultivate a broad sense of responsibility toward the use and conservation of the nation's marine resources. As discussed earlier in this chapter, lack of leadership and coordination, in both message and action, and lack of funding are usually cited as the most significant barriers to realizing the full potential of informal education efforts.

Although all ocean-related informal education efforts have a common goal, they generally lack the coordination, connectivity, and leveraging of resources needed to achieve the greatest long-term impact. While nascent efforts are working to bring about better collaboration among aquariums and other informal education facilities, additional leadership will be needed to realize a focused and coordinated informal education network for ocean and coastal information. Government agencies, aquariums, academia, professional societies, and all others involved in public education must play a role in coordinating messages on the importance and significance of oceans. A team approach will increase the longevity, breadth of delivery, and integration of messages coming from many sources.

Coordination is also needed between the informal and K-12 education communities. Informal education efforts can provide information that is used to develop K-12 classroom lessons and activities. While many aquariums and museums now routinely create programs that are linked to state and local education standards, a stronger connection between informal and K-12 education efforts is needed, and the requirements of K-12 educators and students should be a constant consideration.

Funding for ocean-related informal education is a major concern. At the federal level, there is no dedicated source of funding for ocean-related informal education initiatives. While NSF, EPA, and other federal agencies support informal education, the programs are relatively small and do not focus on ocean-related activities.

The kinds of aquarium and science center exhibits most likely to have significant impacts are costly to assemble. Without outside public or private support, aquariums and similar facilities are often forced to focus on those topics that draw the greatest attendance, generally marine biology rather than the chemistry, physics, or geology of the marine environment. Enhanced funding would allow facilities to present a more complete picture of the marine environment and even illustrate the application of scientific understanding in managing ocean resources.

Broad Outreach

Public information needs are as varied as our population is diverse. Some individuals will benefit from detailed information on how specific issues directly affect their jobs or business. Others may need information presented in a language and media tailored to their culture and community. Still others seek advice on how to alter their own activities to support responsible ocean stewardship. This information is as critical for those who live in the heartland as for those who live near the shore.

Equal Opportunity Educators

The Splash Zone program at the Monterey Bay Aquarium is one example of an informal education effort designed to reach and engage underserved members of the community. The program was developed in part to enhance Hispanic attendance, membership, and participation at the aquarium, which were far below their proportion in the Monterey area population.

The Splash Zone exhibit on coral reef ecosystems and the rocky shore forms the basis for additional educational activities and materials. Working with local Head Start offices, the aquarium is better able to reach and focus on Hispanic children and their families. The knowledge gained during visits to the aquarium is continued in the classroom. Appropriate activities and curricula are demonstrated to Head Start and other kindergarten through second grade educators during a week-long Teachers Institute. In addition, the program includes outreach to the schools through bilingual aquarium educators and family science nights in the neighborhood community center.

To continue the educational experience of the Splash Zone program, families can take advantage of the Shelf to Shore program. This complementary effort, conducted in cooperation with local libraries in largely Hispanic communities, allows individuals to check out a free aquarium pass for the entire family as easily as they would check out a book.

Informal education requires outreach programs, in partnership with local communities, to make contact with individuals where they live and work, regarding issues that affect how they live and work, in a style that speaks to them. Local organizations, including youth, senior, and other community groups, can play a pivotal role. They possess knowledge of the community and experience implementing various strategies to reach desired outcomes. While federal agencies, state governments, and nongovernmental groups do partner with communities on such programs, and should continue to promote participation of traditionally underrepresented and underserved groups, increasing populations and limited resources swamp the ability of these programs to reach all who would benefit from ocean-related information.

Information supplied to the public should be timely and accurate. It should also be supported by a system that allows for follow-up and the acquisition of additional information or guidance. The roles of, and relationships among, scientists, educators, and journalists in translating research results for the public are especially critical. Innovative partnerships with media outlets or industries that deal with the public may offer new means to broaden the visibility of ocean issues and increase public awareness. Informal education facilities and the academic community should work closely together to facilitate the rapid transfer and translation of the latest scientific discoveries into publicly accessible displays, materials, and programs.

Information delivered through informal education programs, displays, and activities is most effective when it is linked to the positive associations people have with the oceans. Information should be presented in terms of the ocean's role in the Earth system as a whole, including the physical, chemical, and geological aspects of the marine environment, and interactions with humans.

Recommendation 8–16. Ocean.ED, working with other appropriate entities, should enhance existing and establish new mechanisms for developing and delivering relevant, accessible information and outreach programs to enhance community education.

In addition, Ocean.ED should:

- *work with ocean-related informal education initiatives to better engage underrepresented and underserved populations and communities by using mechanisms, materials, and language familiar to and accepted by them.*
- *work with informal education facilities to develop the capacity to prepare and deliver new science-based materials and programs to the public and the media in a matter of weeks to capture immediate interest in noteworthy advances in ocean science.*

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- ¹ Belden, Russonello, & Stewart and American Viewpoint. *Communicating About Oceans: Results of a National Survey*. Washington, DC: The Ocean Project, 1999.
- ² Calsyn, C., P. Gonzales, and M. Frase. *Highlights from TIMSS* [Trends in International Mathematics and Science Study]. Washington, DC: National Center for Education Statistics, 1999.
- ³ National Science Board. *Science and Engineering Indicators—2002*. Arlington, VA: National Science Foundation, 2002.
- ⁴ McManus, D.A., et al. *Center for Ocean Science Education Excellence: Report of a Workshop Sponsored by the National Science Foundation*. Ocean Springs, MS: University of Southern Mississippi, 2000.
- ⁵ National Research Council. *Report of the Committee on Oceanography*. Washington, DC: National Academy Press, 1929.
- ⁶ Ocean Research Advisory Panel. *A National Strategy to Improve Ocean Literacy and Strengthen Science Education through an Improved Knowledge of the Oceans and Coasts*. Washington, DC, 2002.
- ⁷ National Oceanic and Atmospheric Administration. *New Priorities for the 21st Century: NOAA's Strategic Plan for FY 2003–FY 2008 and Beyond*. Washington, DC, 2003.
- ⁸ National Research Council. *The Role of Scientists in the Professional Development of Science Teachers*. Washington, DC: National Academy Press, 1996.
- ⁹ National Research Council. *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium*. Washington, DC: National Academy Press, 2000.
- ¹⁰ National Center for Education Statistics. *Out-of-Field Teaching and Educational Equality*. Statistical Analysis Report NCES 96-040. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, October 1996.
- ¹¹ Geoscience Education Working Group. *Geoscience Education: A Recommended Strategy*. Arlington, VA: National Science Foundation, 1997.
- ¹² National Research Council. *The Role of Scientists in the Professional Development of Science Teachers*. Washington, DC: National Academy Press, 1996.
- ¹³ Written comment from Wendy Allen. In U.S. Commission on Ocean Policy, *Appendix 2: Summary of Testimony Indexed by Presenter*. Washington, DC, 2004.
- ¹⁴ Kauffman, T., and S. Losey. "Work-Force Crisis Eased." *Federal Times*. 39, no. 15 (May 12, 2003).
- ¹⁵ *Ibid.*
- ¹⁶ *Ibid.*
- ¹⁷ *Ibid.*
- ¹⁸ *Ibid.*
- ¹⁹ *Ibid.*
- ²⁰ Cuker, B. E. "Steps to Increasing Minority Participation in the Aquatic Sciences: Catching up with Shifting Demographics." *ASLO Bulletin*. 10, no. 2 (June 2001).
- ²¹ Statement by Matthew R. Gilligan to the U.S. Commission on Ocean Policy, Appendix 2.
- ²² Belden, Russonello, & Stewart and American Viewpoint. *Communicating about Oceans: Results of a National Survey*. Washington, DC: The Ocean Project, 1999.
- ²³ *Ibid.*
- ²⁴ National Science Foundation. Informal Science Education (ISE) Program Solicitation NSF 03-511, 2003.
- ²⁵ American Zoo and Aquarium Association. 2003. The Collective Impact of America's Zoos and Aquariums. <<http://www.aza.org/AboutAZA/CollectiveImpact1/>> Accessed July 30, 2003.
- ²⁶ The Mellman Group. *Presentation of Findings from a Nationwide Survey and Focus Groups*. Washington, DC: SeaWeb, June 1996.