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ABSTRACT

This document presents an overview of marine education in the United States for 1997. Marine education is defined as education regarding the ocean, coastal waters, and Great Lakes. This report describes the history of marine education, informal education, and discusses its place in elementary, secondary, and higher education. (Contains 16 references.) (YDS)

Year of the Ocean, 1998
Marine Education, U.S.A.: An Overview

National Oceanic and Atmospheric Administration

1998 Year of the Ocean

MARINE EDUCATION, U.S.A.:

AN OVERVIEW

Contents

This Year of the Ocean document was prepared as a background discussion paper and does not necessarily reflect the policies of the U.S. Government or the U.S. Government agencies that participated in its preparation.

INTRODUCTION

This document provides an overview of marine education in the United States in 1997. For the purposes of this report, marine education refers to the education related to the ocean, coastal waters, and the Great Lakes. Aquatic education is a broader term that includes all inland waters (rivers, lakes, and wetlands). Environmental education is another term broader than marine education. These are not directly covered by this report. Formal marine education is carried out at schools, colleges and universities. Informal marine education occurs in the media, at public aquaria, and by various public and private agencies and organizations.

The Advisory Committee on Protection of the Sea's May 1997 report of the Oceans and Security Conference, includes the "Potomac Declaration: Towards Enhanced Ocean Security into the Third Millennium." :

Recognizing that:

> Continuing intensification of human activity in coastal and marine areas will adversely affect marine and coastal ecosystems world-wide and threatens the well-being of the
>
> human population. The natural resource base of world fisheries is threatened by overexploitation, habitat degradation, introduction of alien species and loss of biological diversity. Human security is threatened by unsustainable food production, increased public health hazard and unemployment, which may contribute to escalating human conflicts. Humans themselves have entered into conflict with the very environment that supports them. It is vital to take immediate action to strengthen environmental security if global human security is to be sustained;
>
> Climate change threatens to affect ocean levels and temperature, the land and peoples living in low elevation coastal regions, and species dependent on ocean and land touched by oceans. The oceans play an essential role in the planet's climate, though the mechanisms are poorly understood; and
>
> Sustainable development, including conservation of the marine environment, can actually increase environmental, food and economic security and therefore provide a foundation for political security.

Recommendation 10 from the Oceans and Security Conference states:

"Concerted national and international efforts should be undertaken to introduce environmental studies into all levels of formal school curricula at a global level, in order to eliminate environmental illiteracy, increase environmental awareness, and promote deeper environmental ethics. Up-to-date scientific knowledge about the oceans should be popularized and disseminated to the public through both formal education and creative communication channels such as arts, music, and multi-media. In support of this effort, the year 2000 should be declared as the "Year of Environmental Awareness" by the UN General Assembly at its forthcoming Special Session."

HISTORICAL BACKGROUND

It is only fitting that any discussion of marine education in the United States begin with a recognition of the contribution that Benjamin Franklin made as the publisher of the first chart of the Gulf Stream in 1770. In order to speed up the delivery of mail and goods from America to Europe, he urged that ships stay in the Gulf Stream to take advantage of the current. Based on measurements of temperature he took in his Atlantic crossings in 1775, 1776 and 1785, he advocated using regular temperature readings to ensure that the ship remained in the relatively warmer waters of the Gulf Stream. Franklin's cousin, Captain Timothy Folger of Nantucket, Massachusetts, provided essential information about the Gulf Stream and assisted in making the first chart. Folger was an experienced whaling ship captain who was familiar with the North Atlantic Ocean.

In 1838, the first American scientific voyage of discovery was launched. The United States Exploring Expedition, under the leadership of U.S. Navy Lieutenant Charles Wilkes, was a four-year expedition which resulted in a final report of 19 volumes of maps, text, and illustrations, including 241 new maps and charts.

Earlier, on August 13, 1825, Midshipman Matthew Fontaine Maury had been assigned to the USN Frigate, Brandywine, whose first duty assignment was to return General Lafayette to France following the mourning of the simultaneous deaths of Thomas Jefferson and John Adams on July 4, 1825. Maury kept a diary of his observations at sea, and his recordkeeping expanded in 1831 when he became sailing master of the Falmouth. On October 17, 1839, Maury was thrown from a stagecoach in an accident and sustained multiple injuries that precluded his return to sea. Fortuitously, Maury was reassigned as Superintendent of the U.S. Navy Depot of Charts and Instruments, later to become Superintendent of the U.S. Naval Observatory. In these new positions, he assiduously collected information from ships' logs. His first oceanography book, *The Physical Geography of the Sea* , was published in 1854 and was followed by seven revisions. The book was both popular and influential and is an important milestone in the history of marine education in America.

Two other popular books written in the 19th century by Americans also contributed to the public's knowledge about the sea. *Two Years Before the Mast* , by Richard Henry Dana, documented his voyage around Cape Horn from New England to California. It provided the public with a true, first hand account of shipboard life and waves and weather across more than 100 degrees of latitude in two oceans. The other book, Herman Melville's *Moby Dick* , while a novel, described many aspects of the life of a whaler and much information about whales and other sea life. Both books were important early sources of information for the public about the sea.

Science teachers in New England began receiving the first summer training in marine biology in the late 1870s under the leadership of Harvard University's famous naturalist, Alexander Agassiz. In addition to having founded the Museum of Comparative Zoology at Harvard, he was also the founder of the first U.S. marine station, the Anderson School of Natural History on Penikase Island, Buzzard's Bay, Massachusetts. There, the teachers, who were all women, stayed in a dormitory at Woods Hole, Massachusetts, and studied local marine life while learning new techniques using microscopes and dissection instruments. This represented a new, hands-on approach for pre-college education. Indeed, the study of science was just being introduced in schools at this time.

Scripps Institution of Oceanography was founded in 1903 and became a part of the University of California, Los Angeles in 1912. During the first half of the 20th century, virtually all the U.S. oceanographers were trained at this institute . It remains a cornerstone of leadership and research in the oceanographic community and in higher education. Woods Hole Oceanographic Institution was originally a marine biological laboratory and did not offer graduate degrees until the post-World War II era. In fact, the other leading institutions of higher education in oceanography did not play a significant role until after World War II.

World War II was a major milestone in marine science and education. Of course, many people went to sea for the first time. Sea warfare, especially submarines and aircraft carriers, created new strategic ocean-related needs. In 1942, the last single volume (1,087 pages) was published containing everything known about oceanography, *The Oceans* , by H.U. Sverdrup, Martin W. Johnson, and Richard H. Fleming. The field of oceanography has grown geometrically since then.

The deep dives by Andreas Rechnitzer, Don Walsh (both U.S. Navy) and Jacques Piccard in the bathyscaph, Trieste, captured the American pride in 1959 and 1960 after the cultural shock of Sputnik in 1958. These dives, the first television shows by Jacques Cousteau, and the emerging theory of plate tectonics raised the awareness level of the American public. A new exploratory submarine, Alvin, was launched. Amidst the excitement, many new ideas emerged. Three had special significance for marine science and education. One was the theory of plate tectonics, which forced a rewriting of textbooks at all levels, and a new general understanding of why earthquakes occur and why they occur where they do. A second idea came from Dr. Carl Hubbs at Scripps Institution of Oceanography. He thought a facility that would bring people in proximity to whales could prove educational. Thus, the idea for Sea World came to fruition with private sector support. Third, Dr. Athelstan Spilhaus, an eminent scientist, thought that the United States should enact a Sea Grant Act patterned after the Land Grant Act but focused on the sea. With support from the new Dean of the School of Oceanography at the University of Rhode Island, John Knauss, Senator Claiborne Pell, and many others, the Sea Grant Act was enacted in 1966.

The period of 1969-1974 was a time for a call to action in the environmental arena.. It was during this time that the Environmental Science and Services Administration, later to become the National Oceanic and Atmospheric Administration (NOAA), was established. Notable legislation enacted included: the Endangered Species Act, the Marine Mammal Protection Act; the National Coastal Zone Management Act; the Marine Protection, Research and Sanctuaries Act; the Federal Water Pollution Control Act; and the Clean Air Act. It was also during this period that the U.S. Environmental Protection Administration (EPA) was created. President Richard M. Nixon supported the initiation of the UN Law of the Sea deliberations and set the agenda for them. He also supported the UN Resolution on Prevention and Control of Marine Pollution. From this brief summary of events during his administration, it is possible that history may come to view President Nixon as one of the greatest "environmental presidents." .

For marine education in the 1970s, the resonant call to action produced multiple responses. New aquaria were built and Sea World expanded. Ocean-related television programs proliferated, with those featuring the prominent oceanographic explorer, Jacques Cousteau, being among the most notable. The National Marine Educators Association was established in 1976. The National Sea Grant College Program funded many initiatives in K-12 curriculum development. Interest and excitement peaked in 1977 with the discovery of the Galapagos deep sea hot springs and their associated chemosynthesis-based food web.

The stage is now set for a look at the current state of marine education.

INFORMAL MARINE EDUCATION

SeaWeb

"SeaWeb" was established in 1996 by the Pew Charitable Trusts to provide information about the ocean and ocean-related issues to the public. It is a multi-media educational organization designed to make the public more aware of the ocean and ocean life. It does no lobbying. One of SeaWeb's first endeavors was to contract with The Mellman Group to carry out a national survey of public attitudes towards, and knowledge about, the ocean, ocean life, and ocean-related issues.

The results of the SeaWeb survey provide a promising picture on the level of awareness and importance of marine issues to the public. The most startling finding was that people (72 percent) believe that ocean exploration is a higher priority than space exploration. Many people (87 percent) consider the ocean to be important to them. Most people (67 percent) believe the ocean is in trouble. A majority (58 percent) believe the condition of the oceans has deteriorated in the past few years, and many (87 percent) see the destruction of the ocean as a threat to their quality of life. A large majority of the people in this survey (82 percent) attributed the deterioration and threats to the ocean to human activity. Although Americans generally want less government in their lives, 85 percent would like the federal government to do more to help protect the ocean. Finally, when asked the question, "Which messenger of information about the environment do you trust a great deal?", people chose *National Geographic Magazine* (68 percent), Jacques Cousteau (63 percent), zoos and aquaria (51 percent), and NOAA (49 percent). Prominent elected officials, regardless of party, were very low on this list.

The SeaWeb survey establishes the importance of the ocean to the American public and the readiness of the public to take action to remedy ocean-related issues. As one of its educational activities, SeaWeb has begun publishing a monthly, "Ocean Update," focusing on current issues and providing contacts for further information (website address: www.seaweb.org). SeaWeb also sponsors a 90- second "Ocean Report" on National Public Radio and Voice of America with Sylvia Earle.

Aquaria

Aquaria, maritime science centers, and museums are currently a major source of informal marine education for the public. At this time, there are twenty-seven aquaria around the country, some for-profit, some for nonprofit. Education is a fundamental goal for all of them. Most aquaria have extensive educational outreach programs for school children and children in other groups (Scouts, Boy/Girls Clubs, etc). The outreach programs include escorted tours at the aquarium, classroom visits by aquarium staff, books, tapes, and curriculum materials.

Some of the best known of these facilities are Sea World, Monterey Aquarium, Waikiki Aquarium, the National Aquarium at Baltimore, the New England Aquarium, the Miami Sea Aquarium, and the Chicago Aquarium. In 1998, a new Maritime Discovery Center will open in Seattle. In 1999, a new aquarium will open in Charleston, South Carolina, and another in Long Beach, California, in 2000. New facilities are in the planning stage in Erie, Pennsylvania, and Denver, Colorado. These facilities are extremely popular and annually host millions of people to whom they provide high quality marine education opportunities. This approach to providing marine education is highly successful. It could possibly be improved by cooperative input from federal agencies as is now being initiated through Coastal America, a federal, multi-agency consortium.

Media

As indicated by the SeaWeb survey, the national media have an excellent reputation with respect to informing the public about the ocean. Most notable is the National Geographic Society . This organization's magazine has a large public circulation, is relatively inexpensive, and is in most school libraries. A notable example is the *National Geographic* issue of November, 1995, whose theme is "Exploring the Ocean's Bounty: Diminishing Returns." Other efforts by the Society in partnership with IBM have produced state-of-the-art CD-ROMs on marine life. It is widely recognized that the Society's television specials are high quality and popular, which explains why they are often shown on PBS-TV pledge nights. The National Geographic Society plans a one hour special for the Year of the Ocean to be shown on NBC-TV in 1998.

Everyone will miss Jacques Cousteau and he can never be replaced. His role in providing marine education for the world public is unmatched and unique. He has left a legacy of books and television programs for the continued benefit of the public. Some other individuals have made important contributions to informal marine education. In the 1950s, Thor Heyerdahl captured the attention of the world with his ocean voyages, books, and films. Currently, Robert Ballard, through his JASON project, has reached many people* especially young people. He has collaborated with the National Geographic Society in producing television specials. Another prominent spokesperson is Sylvia Earle, who serves on the Board of Directors for SeaWeb and has served as Chief Scientist for NOAA.

A recent spokesperson for the ocean, Jane Lubchenko, has gained prominence as President of American Association for the Advancement of Science. As a marine biologist studying coastal, rocky-shore ecology, she has raised the knowledge and awareness of many about the vulnerability of the coastal zone to human impacts.

There have been many modern books that have made major contributions to the understanding of the sea by the public. Rachel Carson's books, *The Sea Around Us* and *Under the Sea Wind* , were both best sellers and have served to educate and heighten the awareness of the public about the sea since their publication thirty years ago. A recent best seller, *The Perfect Storm* , by Sebastian Junger, gives a riveting account of men and women at sea struggling against the sea and weather. This nonfiction account of three storms coalescing off New England in October, 1991, is an excellent source of information about the sea.

Newspapers and national magazines are increasing their coverage of environmental issues, including the ocean. Global warming is a high-profile international issue which now has frequent and comprehensive coverage. The predicted El Nino, 1997-98, has received similar coverage. Many scientists have been quoted and the media has made a significant effort to educate the public about the science involved. Many elements of the national media have increased their coverage of such ocean-related issues as global climate change, El Nino, and fisheries. Occasional disasters, such as Hurricane Andrew and the Exxon Valdez oil spill, have also led to expanded media coverage of the ocean and subsequent education of the public.

Federal Agencies

Identifying the federal agencies involved in informal marine education is not entirely straightforward. Determining how much these agencies spend on

informal education is an impossible task. The problem is that many agencies have a general responsibility for education with no specific staff educators or budget. To a large extent, responsibility lies in a public affairs office, as in the case of the U.S. Coast Guard. Then too, it also depends on the definition of informal marine education. For example, if one includes boater education, The U.S. Coast Guard plays a large role. For this report, agencies with a budget and legislative mandate for informal marine education will be highlighted.

In the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, programs in three offices have specific informal marine education responsibilities. Obviously, the National Weather Service is a major provider. With more than 50 percent of the nation's population living within 100 miles of the coast, information about weather, tides, and waves along the coast is of continuing interest to the public. The National Weather Service maintains local forecast offices, provides information on the Weather Channel and other broadcast outlets for television and radio, and has special severe storm watch centers. The National Weather Service does an outstanding job of meeting its informal marine education responsibilities.

The National Sea Grant College Program in NOAA's Oceanic and Atmospheric Research Division supports informal education through its local programs in 30 coastal and Great Lake states and Puerto Rico. In Fiscal Year 1997, Sea Grant funds six special informal education projects for $486,000. Most of its activities in this area are carried out by marine educators and marine advisors through local marine extension programs. The activities are diverse and range from teacher workshops to boater education and safe handling of seafood. Some of the activities are community-based efforts such as beach clean-ups. Others are national in scope such as MarinaNet, which provides information and education to marina owners and operators, and the Hazard Analysis and Critical Control Point system, which provides Food and Drug Administration-approved safe handling techniques to people in the seafood industry. Testimony in Congress at the recent Sea Grant reauthorization hearings and a recent study by the National Research Council endorse the success and high quality of these efforts.

The National Marine Sanctuaries Program and the National Estuarine Research Reserves System in NOAA's National Ocean Service also have informal marine education responsibilities. One of their mandates is "resource protection through enhanced public awareness, understanding, appreciation, and wise use of the coastal and marine environments." There are presently 12 sanctuaries and 22 estuarine reserves. Sanctuaries has been granted special authority to organize "friends" groups to help support local sanctuaries. Sanctuaries and Reserves both have education visitor centers for the public and school children. They provide supplemental school curricular activities, sponsor nature walks, and publish informative newsletters. These activities are limited in scope but highly successful and effective at their local sites.

Coastal America is a partnership of representatives of eleven federal agencies including NOAA, the Environmental Protection Agency, the U.S. Navy, the U.S. Army Corps of Engineers, and the Department of the Interior. Their activity in informal marine education is to designate Coastal Ecosystem Learning Centers at various aquaria and to provide appropriate enrichment materials from each participating agency at the Centers. This is a new effort and only five learning centers, such as at the New England Aquarium, are functioning. It shows great potential for disseminating materials from diverse agencies. Also, Coastal America offers an opportunity to coordinate informal marine education activities among the partnering agencies.

The Smithsonian Institution has a long record of high quality informal education. Each of the Smithsonian museums has its own education program. None of the museums is specifically marine oriented, although the Museum of Natural History has many marine exhibits including special displays, and a traveling exhibit and documentary movie for "1997, International Year of the Coral Reef." Their outreach effort on coral reefs has reached millions of Americans during the past year. Their magazine, *The Smithsonian* , sometimes carries marine-related articles and has substantial public circulation. The Smithsonian also has another traveling exhibit called "Project Ocean Planet Awareness."

The U.S. Coast Guard, as previously mentioned, has a significant and important role in informal marine education. The principal responsibility rests in the Office of Navigation, Safety and Waterway Services. The specific responsibilities include enforcement of federal laws and regulations (and dissemination of knowledge about them), supervision of local Coast Guard Auxiliary operations, establishment of pleasure craft safety standards, administration of public education and training programs (especially regarding handling of all vessels and pollution control), and liaison with other organizations and state and local agencies concerned with boating safety and water pollution. The Boating Education Branch administers an extensive public information program which includes distributing literature, offering courses, and making announcements for the media. Recreational boating represents a $20 billion dollar industry in the United States with a 10 percent annual growth rate. The main problem for the USCG is its multiple responsibilities. It does an outstanding job with limited resources.

The Department of the Interior's National Park Service, through some of its parks, monuments, and national seashores, maintains site specific programs in informal marine education. There are visitor centers at each of these sites with educational exhibits, special programs, nature hikes, and book stores. The National Park Service has a World Wide Web site called The Learning Place (http://www.nps.gov/interp/learn.htm) with many educational materials, especially for teachers.

The U.S. Environmental Protection Agency (EPA) provides and supports a wide array of marine education mechanisms that reach targeted technical audiences, children, the general public, and industry groups. EPA's Marine Debris Curriculum, available in both English and Spanish, provides lesson plans and activities to help teach grade school students about marine debris, where it comes from, how it can harm the environment, and what they can do to help reduce the amount of debris entering marine waters. The National Estuary Program contains a public outreach and education component, and all 28 estuary programs around the country include a Citizens Advisory Committee to educate citizens about threats to their estuaries and involve them in devising solutions to those threats. Numerous training courses are offered to EPA constituent groups on topics such as coastal resource protection at the local level, consensus-building for watershed planning, and volunteer monitoring in estuarine waters. Technology transfer is also emphasized in many of EPA's ocean and coastal programs such as an effort underway in the wider Caribbean to share low-cost methods for managing land-based sources of marine pollution, and EPA's support of the *Coastlines* newsletter to provide local communities with a source of applied coastal management techniques and contacts to protect their coastal watersheds.

K-12 MARINE EDUCATION

National Standards

The *National Science Education Standards* by the National Research Council (National Academy Press, Washington, DC, 1996) contain almost no mention of the ocean[1]. There is no mention of the oceans or life in the sea in the major sections on Physical Science, Life Science, Science and Technology, Science in Personal and Social Perspectives, or History and Nature of Science. The citations above are in Earth and Space Science. Inferred references can be found in the citations regarding water, although a knowledgeable person would need to point these out. In the references to fossils, evolution and biological diversity, the ocean connection is never explicit. The words "ocean," "sea," "marine," or even "water," do not appear in the index.

This omission is appalling. Of course, no oceanographers were on the consulting advisory panel. There is a crucial need for an addendum to the *National Science Education Standards* detailing how the ocean fits in with the cited standards.

Admiral (ret.) James Watkins, President of the Consortium for Ocean Research and Education (CORE), recognized this omission and pointed out that, in fact, the ocean sciences comprise "one perfect implementation mechanism to meet national standards." In his address to the National Marine Educators Association conference in Chicago, August 1997, he said, "The so-called content standards of the *National Science Education Standards* include categories, each of which I will discuss in conjunction with utilizing ocean sciences as the ideal implementing tool." To this end , Admiral Watkins remarked on the following categories:

Unifying Concepts and Processes in Science. "The science of biochemistry, which is one of the most interdisciplinary fields ever developed, was invented by marine scientists in order to understand the global carbon budget and its role in controlling climate."

Science as Inquiry. "Ocean science is still a science of untold discoveries. Each research cruise raises as many new questions as it answers old ones. Some refer to oceans as the last frontier here on earth."

Physical Science. "Study of the sea covers every aspect of physics, from the classical dynamics of wave theory, to the most fundamental aspects of high energy physics related to how sea water interacts with deep undersea muons and neutrinos. It is these studies which will feed into our understanding of such seemingly unrelated subjects as nuclear fusion as an energy source."

Life Science. "The ocean holds the key to the origins of life, as shown in the chemosynthetic behavior of deep-sea vent biota. How can life exist in the absence of sunlight,

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[1]Here are the only citations: (1) page 159, "ocean floors are the tops of thin oceanic plates," "...to change continuously earth's crust, oceans, atmosphere..."; (2) page 160, "Water evaporates...collects in lakes, oceans, soil...", "Oceans have a major effect on climate, because water in the oceans holds a large amount of heat." (3) page 189, "This energy transfer is influenced by...static conditions such as the position of mountain ranges and oceans."

and often in hostile environments prohibitive to their counterparts with which we are familiar in shallower waters?"

Earth and Space Science. "Even a subject as seemingly remote as the study of asteroids is now being addressed through analysis of deep-sea cores where sediments have revealed the clues to the extinction of dinosaurs 65 million years ago."

Science and Technology. "Every aspect of technology, including communications, advanced materials, information technology, and sensor design, is critical to ocean sciences, and made even more difficult by the forces of the operating environment. Arguably, in many aspects, deep ocean research is more technologically challenging than studying rocks on Mars."

History and Nature of Science. "The history of oceanography is one of basic research feeding immediately into societal needs -- defense and fisheries are the classic examples, but new issues such as coastal hazard mitigation and sustainable development of mineral resources will demand even stronger ties between the social sciences and ocean sciences."

Textbooks

None of the major publishers of public school textbooks publishes one on oceanography, marine science, or marine biology for the K-12 portion of formal education. Many publishers have sections of Earth Science textbooks that relate to the oceans. Most are compendia of facts or concepts about the ocean such as tides and plate tectonics, which tend to be complicated. The coverage of other topics in the ocean sciences is sparse. The authors and editors of these volumes appear to have little knowledge about the oceans except what they may have read in a college textbook. They also seem unaware that many children in the United States have been to the ocean often; after all, 50 percent live within 100 miles of the shore. Many children thus have an experiential base to build on. There is a major need for a national conference/workshop to educate the authors and editors of the major textbook publishing companies about the ocean and how this knowledge can be infused into the K-12 science and social science curriculum.

Curricula

While textbooks in marine education are scarce and inadequate for K-12 education, the same cannot be said for available curricula. The Consortium for Ocean Research and Education (CORE) is compiling an inventory of K-12 marine education programs. This is due to be published in 1998 and will provide much needed information on a national basis.

Federal agencies, especially Sea Grant and the National Science Foundation (NSF), have funded the development of marine science curricula for K-12 use. Some of these have been in use for several years by many teachers, and have been cited for excellence by various organizations such as the National Science Teachers Association (NSTA) and the U.S. Department of Education.

The Hawaii Marine Science Studies program was developed by the Curriculum Research and Development Group at the University of Hawaii. It is designed as a one or two year integrated science program for grades 9-14. It is a hands-on, multidisciplinary program with a marine theme that integrates science, technology, and environmental studies. The Fluid Earth portion has units on waves and beaches, physical oceanography, chemical oceanography, and transportation. The Living Ocean portion deals with fish, invertebrates, plants, and ecology. This is not a Hawaiian-only program. The program has been reviewed by at least 50 marine scientists and tested in the classroom by over 400 teachers to date. Clearly, this is a high quality program that fits a new niche in grades 9-12, namely, a two-year "integrated science" course for all students. This type of course is especially applicable in California where the State Science Framework calls for some physical, life, and earth sciences in each science course.

At the Lawrence Hall of Science, University of California, Berkeley, the Marine Activities Resources and Education program is a comprehensive ocean exploration program developed for K-8 (elementary and middle schools) . This program devotes the attention of an entire student body of a school to the ocean for a week. Students read books and stories about the ocean, create ocean-related art, listen to music about the sea, and study ocean-related

topics in mathematics, science, and social science. There are special programs for teachers, parents, and even the community. This program provides a short but intense and comprehensive approach to marine education, not just to marine science education.

A new international environmental curriculum is underway that has the endorsement of the Clinton/Gore Administration. Called "Global Learning and Observations to Benefit the Environment (GLOBE),". its focus was on making measurements and observations related to lakes, rivers, and weather. Recently, GLOBE is expanding to include coastal waters. Students make measurements and observations based on a GLOBE protocol and share data via the Internet. To date, more than 3,000 schools in 50 countries are participating.

Under an NSF grant, three curriculum projects spanning K-12 have been refined and enhanced. They will become available soon on two multimedia compact discs. The discs will contain all the text and graphics from the three projects. The three are the Marine Activities Resources and Education program, FOR SEA (developed by the Marine Science Center at Poulsbo, WA), and "Living in Water," an aquatic science curriculum for grades 5-7 developed at the National Aquarium, Baltimore.

"Oceanic Education Activities for Great Lake Schools " was developed at Ohio State University under the leadership of Dr. Rosanne Fortner. These are activities that are designed to take a concept or idea from the existing school curriculum and develop it into an oceanic and Great Lakes context using teaching approaches and materials appropriate for grades 5-9. Dr. Fortner has also developed "Great Lakes Instructional Materials for the Changing Earth System." The topics include fisheries, shipping, pollution, biodiversity, climate, and estuaries (wetlands). These were developed mainly with Sea Grant funding.

In 1998, CORE is sponsoring a national "Ocean Sciences Bowl" along with CORE member institutions and the National Marine Educators Association (NMEA). This will be the first time a national high school competition on the ocean is held. Awards will include scholarships, research cruise participation, visits to ocean research laboratories, computer hardware and software, and laboratory supplies and equipment. The grand prize will be a trip to the International Year of the Ocean celebration at EXPO '98 in Lisbon, Portugal. This bowl will be modeled after the National Science Bowl, now in its seventh year. There will be regional competitions (16) followed by a final competition in Washington, D.C., during Earth Week in April, 1998. It is expected that teams from up to 500 high schools will compete. Funding is provided by NSF, NASA, NOAA, U.S. Navy, and other agencies, and private sources. This competition should provide national visibility for the ocean sciences and be highly motivational for students. It is great to see such cooperation between ocean science-related agencies.

A "new kid on the block," the National Ocean Partnership Program (NOPP) has recently appeared on the marine science education scene. Following a very short notice and limited Internet announcement, this program has nonetheless already funded five K-12 ocean-related projects that may prove to have major national impact potential. These are as follows:

- "The Bridge: A Marine Education Clearinghouse" is a project to provide teachers access to the multiplicity of marine-related educational and curriculum materials or, at least, annotated reviews of commercial materials. This is an update and extension of a Sea Grant-funded project begun over 15 years ago at the Virginia Institute of Marine Sciences. "The Bridge" will be developed in consultation with the National Marine Educators Association and will be linked to NMEA on the Internet.
- "JASON IX" will continue under the leadership of Dr. Robert Ballard. This is an ocean exploration project which links Dr. Ballard in a submersible, usually Alvin, to students at remote, scattered sights via telecommunication/satellite. This is a real-time, live, exciting experience for students and teachers (and sometimes Dr. Ballard!).
- "COAST: Consortium for Oceanographic Activities for Students and Teachers" builds on the past five years experiences of "Operation Pathfinder," the Sea Grant initiated teacher training workshops. It also will extend Operation Pathfinder to high school teachers and pre-service teachers in training at the college level. As with Operation Pathfinder, a shipboard, at-sea experience for teachers is included.

- "Bringing the Ocean into the Pre-college Classroom Through Field Investigations at a National Underwater Laboratory" will be carried out through Rutgers University and NOAA. There is presently a shallow water laboratory located offshore of New Jersey doing comprehensive ocean data monitoring. The experimental project will be linked to classrooms enabling students not only to learn about the nearshore marine environment, but also to appreciate the technical problems inherent in real-time ocean monitoring in the environment.

- The University of South Florida will extend its "Project Oceanography" live via educational television to middle school science students. In Fall, 1997, seven weeks are devoted to coral reefs and seven weeks to plankton. NOPP is joined in supporting this project by National Geographic Society and five private sector corporations (Honeywell, K-Mart, Northern Trust Bank, TASA Graphic Arts, and Time-Warner Communications).

Sea Grant has funded fifteen K-12 education projects for 1996-97 at fifteen different educational institutions from Hawaii to Maine to Puerto Rico. These projects are for teacher training, curriculum development, and student field experiences. They include Operation Pathfinder, which will be publishing 50 activities of its "best of the best" designed for middle school students by the teacher participants.

The Environmental Protection Agency is funding a compilation of 50 coral reef education activities for middle school teachers. This effort will employ both English and Spanish editors. The activities are compiled by Dr. Sharon Walker, Gulf Coast Research Laboratory, Biloxi, Mississippi. Teacher workshops will be held in Humacao, Puerto Rico, in summer, 1998, in conjunction with the annual conference of the National Marine Educators Association.

In an innovative new program being developed currently with funding from NOAA's Oceanic and Atmospheric Research Division, real-time oceanographic data will be accompanied by lesson plans and instructions for using the data through OAR's home page on the WWW.

Teacher Training

The National Science Foundation has funded summer institutes and other programs to train teachers in marine education. In fact, the author directed the first summer institute in oceanography for teachers in 1972-73. NSF has recently been funding the "Maury Project" at the U.S. Naval Academy. This teacher training project was originally a partnership between the Naval Academy. and the American Meteorological Society. With its early success, sponsorship has grown and now includes the U.S. Naval Meteorology and Oceanography Command, the Office of Naval Research, and NOAA's National Environmental Satellite, Data, and Information Service, and NOAA's National Ocean Service. This project concentrates on physical oceanography in a two-week summer workshop including laboratory and ship-board experiences. To date, 76 teachers have been trained and each

summer 25 more are expected to be trained. After attending, teachers are expected to become "peer trainers" to conduct local workshops for teachers in physical oceanography. This has been a highly successful program that deals with a topic rarely or poorly covered in K-12 curricula.

Sea Grant initiated a teacher- training program called "Operation Pathfinder," now in its fifth year under the leadership of Dr. Sharon Walker at the Scott Marine Education Center and Aquarium in Biloxi, MS. The project name derives from the USN survey ship Pathfinder. Two week summer workshops are held regionally for elementary and middle school teachers. In 1997, six were held in Connecticut, North Carolina, Mississippi, California, Minnesota, and Ponape Island (Mariannas). The following agencies were co-sponsors with Sea Grant: NOAA's National Environmental Satellite, Data and Information Service, Office of Naval Research, U.S. Naval Meteorology and Oceanography Command, and the Department of the Interior. Teachers were trained in oceanography and coastal processes. They also had a shipboard at-sea experience. About 300 teachers have been trained to date. "Operation Pathfinder" was the basis for an expanded teacher training program called "COAST," which has been funded by the previously mentioned NOPP.

NOAA maintains a "Teacher-At-Sea" program. Teachers are invited to participate in fishery cruises under the research program of the National Marine Fisheries Service. As many as 40 teachers participate annually. The National Undersea Research Program in NOAA funds an "Aquanaut Program" which allows some teachers and students to go to sea to use remotely operated vehicles in research projects. The U.S. Navy and the National Geographic Society run Project Marco Polo which enables middle school teachers and students to go to sea on a Navy oceanographic ship.

Nationally, pre-service teaching and teacher credential programs rarely provide any special instruction in oceanography. Some universities offer oceanography or ocean-related courses as electives for those planning to teach. Teaching methods courses frequently provide information about water, but rarely about the ocean specifically. Some colleges that train teachers in dissection techniques do use fish as a vertebrate example; more generally however, teacher training at universities ignores areas that pertain to the ocean. One noteworthy exception is Oregon State University, which offers an MS degree in science education with marine emphasis for teachers. The teachers go to Newport, Oregon, and take courses every summer for three years at the Mark Hatfield Marine Science Center. This is the only degree program in marine education in the United States and it graduates about five students per year while maintaining enrollment at fifteen students.

CORE led an education workshop on ocean sciences and K-12 education in 1996 sponsored by NSF. The participants included ocean scientists, classroom and informal science education experts, and leaders in science education. The participants agreed on the following general conclusion:

> "...the workshop participants strongly support the theme that the ocean agencies present outstanding opportunities and untapped resources for K-12 education, and that oceanographic processes and features are ideally suited for constructing and demonstrating knowledge and science-based skills in the fundamental principles of science across all disciplines, including the social sciences, and over a wide range of levels of sophistication. The challenge is for the ocean sciences research community and K-12 educators to reach out and develop partnerships (both formal and informal) to, over the long term, mutually develop new ways to infuse the ocean sciences into K-12 education at all levels and throughout the curriculum."

The CORE report recommended urgent action in these priority areas:

1. Develop a formal umbrella partnership directed at ocean sciences and K-12 education reform with professional societies and associations which share similar goals and concerns. These include, but are not limited to: the American Association for the Advancement of Science (including Project 2061), the National Science Teachers Association, the National Marine Educators Association, the Association of Science-Technology Centers, the Association of Zoos and Aquariums, The American Geophysical Union, and The Oceanography Society. The basic purposes of these partnerships should be to:

    a. facilitate implementation of the recommendations in this report;

    b. ensure the highest standards of quality are met throughout this process;

    c. foster the development of standards for ocean science literacy;

    d. enhance visibility of ocean sciences in educational reform;

    e. explore new linkages between ocean sciences and education communities.

2. Develop, publish and disseminate "Standards for Oceans/Ocean Science Literacy." In other words, what are the basic knowledge components (by discipline, such as physics and by topic, such as ocean currents) that should be understood by students at different grade levels (K-4, 5-8, 9-12) and which can be explored and tested through grade appropriate inquiry-base study? At the adult level, what should a science literate person know about the oceans and their influence on global environment and impact (both now and likely in the future) on the global economy?

3. Issue a policy statement strongly endorsing the need for pre-college outreach on the part of ocean science researchers. Federal agencies concerned with the support of ocean sciences should advocate pre-college outreach by ocean science researchers and include outreach as an evaluation criterion in the review of research proposals by these agencies. Strong endorsement by funding agencies of the need and value of pre-college outreach is particularly necessary in order to change the reward system (tenure) for younger faculty at academic institutions.

4. Prepare a thorough inventory of existing K-12 ocean sciences programs and curricula. Initial focus should be placed on gathering information on pre-college outreach programs conducted by universities. The inventory should then be expanded to include other sites and locations through the assistance of the education societies including the AAAS, the National Marine Educators Association and the National Science Teachers Association. This inventory should be made available in readily usable format to classroom teachers and informal science educators. In addition, working with scientists and K-12 educators, standards or guidelines which could be used by teachers and educators to judge the quality, currency, and utility of existing K-12 ocean science education programs should be developed.

Another recommendation called for CORE to expand and enhance its current home page on the World Wide Web (http://core.cast.msstate.edu) to include information on K-12 programs and opportunities. This home page should also "point" to those other home pages in the ocean sciences research community which include K-12 information. The CORE Home Page will also be the site for the maintenance and display of an inventory of current K-12 programs, particularly those involving and impacting teachers.

Consistent with these urgent needs for action, the universities should encourage and provide incentives for faculty members to engage in K-12 outreach to teachers and students. These activities could include, but are certainly not limited to: working with teachers in nearby schools to help incorporate ocean sciences research into classrooms; designing and delivering outreach skills-training to faculty and scientists; providing opportunities for field trips and research internships for teachers and their students; mentoring and counseling both teachers and students, etc.

The CORE/NSF workshop participants also made general recommendations for the improvement of K-12 marine education:

1. Creation of a national program of summer research internships for K-12 teachers at oceanographic institution research sites.
2. Development of a model pre-service ocean sciences course for use in pre-service K-12 math/science teacher education.
3. Continued support for K-12 curriculum development.
4. Increased teacher and student participation through technology in ocean sciences data collection and analysis.

The National Marine Educators Association has provided leadership for some 20 years, and has kept marine education "alive and kicking" through a network of educators and a professional journal. The organization has a membership of just over 1,000 teachers and informal educators. It is not a grant receiving institution, nor does it have political clout in Washington, DC. CORE could provide the clout and grant attracting ability to expand and improve K-12 marine education.

Federal granting agencies such as Sea Grant, NSF, and the Department of Education need to maintain and expand where feasible their support for K-12 marine education.

HIGHER EDUCATION

Thirty- six universities or consortia offer a graduate degree (MS/Ph.D.) in a marine related field in the United States. Some of the consortia (e.g., Dauphin Island) consist of several universities. About 650 Ph.D. degrees are granted annually. These figures come from the Marine Technology Society (MTS) publication, "Education and Training Programs in Oceanography and Related Fields" (1995). NSF annually supports about 500 graduate students in ocean sciences research. Sea Grant supports another 250 graduate students (personal communications).

Again, based on figures from the MTS directory, about 200 BA/BS degrees are earned annually in marine-related areas and about 1,100 MA/MS degrees are earned. The purpose of the MTS directory was not to collect this data; however, there was a line for respondees to report "Number of Degrees Granted." Not all universities reported, so the numbers are less than the actual number of degrees granted. On the other hand, the reported degrees are in "Oceanography Related Fields," which would indicate that the numbers probably exceed the marine science or oceanography degrees earned at reporting universities. In any case, this provides a general sense of university output in the field. Some figures are startling: Coastal Carolina University has an undergraduate Marine Science major with 400 students! The University of Miami and the University of Rhode Island do not report degrees granted.

According to a survey by CORE of alumni of U.S. marine science and policy graduate institutions, there were only 157 MS degrees and 309 Ph.D. degrees granted in 1994. This represents a much narrower survey of marine science than the MTS Directory uses and is based on graduates of the major ocean research institutions.

The California Sea Grant College Program publishes a "Directory of Academic Marine Programs" (1993, 3rd edition). There are ten programs at two-year colleges. There are 38 four-year colleges with oceanography or marine-related programs. Most are, for example, biology (with marine emphasis). The University of Southern California offers both an MS and Ph.D. in ocean sciences. The University of San Diego and Humboldt State University offer a BS in marine science and oceanography, respectively. The U.S. Naval Postgraduate School offers a Ph.D. in oceanography. The University of California, Berkeley offers a Ph.D. in ocean engineering. The University of California at Santa Barbara offers both the MS and Ph.D. in ocean engineering. Scripps Institution of Oceanography offers both an MS and a Ph.D. in applied ocean sciences, biological oceanography, geological, sciences, geophysics, marine biology, geochemistry, marine chemistry, and physical oceanography.

In discussions with experts in these fields, a need exists for trained graduates in maritime law, marine affairs, seafood technology, recreation, and naval architecture that are not being met. Marine recreation, for example, is now a $17 billion industry in California. Based on the MTS Directory and additional personal communications, national needs are similar to those in California. In recognition of these needs, new graduate programs in marine affairs are emerging.

The strength of marine higher education in California and the nation lies in the research training area for the basic sciences. There is no question that the United States has the best marine research and training in the sciences available in the world. The number of graduating trained researchers certainly meets or exceeds the needs of the nation at this time. The main support comes from NSF, Sea Grant and the U.S. Navy.

In addition to grant support of graduate students in research, there are Fellows and Internship programs supported by NSF, Sea Grant, AAAS and the U.S. Navy. The Knauss Sea Grant Fellows program provides Washington, D.C.-based experience in both the executive and legislative branches of government for about 24 graduate students per year. This kind of practical training enhances the university experience. Sea Grant is beginning an Industrial Fellows program which will place graduate students in private industry. This program should be expanded.

One of findings made by Dr. Andreas Rechnitzer's in California in 1969 persists. That is, graduate students are mainly prepared to be research professors at graduate research institutions. The reality is that the majority of MS and Ph.D. graduates in ocean sciences will find employment in government agencies and private industry. University faculty and placement offices need to be more aware of this reality and help students prepare better for this eventuality.

There are eight maritime academies or institutes in the United States. The U.S. Merchant Marine Academy at King's Point, New York, is the only federal academy. Six are state-run (New York, California, Massachusetts, Maine, Texas, and Michigan). The Maritime Institute of Technology and Graduate Studies (MITGS) is the training arm of the International Organization of Masters, Mates and Pilots at Linthicum, Maryland. These are all high quality institutions that maintain a tradition of training U.S. merchant mariners. Most have from three to six hundred students. The MITGS trains about 1,400 working professionals annually in specialized courses for upgrading and modernization. With a relatively small fleet of non-military U.S. flag ships, these institutions meet the current U.S. need.

The U.S. government also supports the U.S. Naval Academy and the U.S. Coast Guard Academy, both of which maintain high quality undergraduate level programs in ocean-related studies. These institutions meet the current U.S. needs.

ETHNIC MINORITIES

The ocean sciences community continues to have extremely low numbers of people from ethnic minorities. This means that all universities, government agencies, and private industries dependent on graduating students are affected.

At NOAA, each line office (National Weather Service, Oceanic and Atmospheric Research, etc.) has a program to encourage participation and professional training of ethnic minorities. The Sea Grant program, for example, has granted $50,000 per year for three years to five "historically black colleges and universities" to develop and encourage undergraduate participation and studies in ocean sciences. NOAA's total annual investment is about $1.5 million. Unfortunately, there is no coordination of the program in NOAA.

The U.S. Navy probably has the best record for recruiting ethnic minorities into the ocean sciences by virtue of its overall record in this area.

NSF has funded projects to encourage ocean science study by ethnic minorities as well. An example is a summer program between Harbor Branch Oceanographic Institution and Savannah State University. This provides research and ship-board opportunities for both faculty and students from Savannah State.

NOAA is also supporting an Earth Systems Science curriculum at Clark Atlanta University which includes an agreement with Oklahoma University leading to a BS in Earth Systems Science and an MS in Meteorology. Students spend three years at Clark Atlanta and two years at Oklahoma.

There is no clear answer to the glaring problem of low numbers of people from ethnic minorities in the ocean sciences community. Surely more intra- and inter-agency coordination would help matters. Universities and K-12 educators also need to direct more attention to this matter and must shoulder some of the blame for the present condition. New ideas in this regard are urgently needed.

CAREER OPPORTUNITIES

Too often, ocean scientists advise students only about careers in research. High school students receive little information about ocean related careers. The best job opportunities today are in marine recreation and tourism. In California alone, it has already been noted that this is a $17 billion per year industry. There are a few good publications that provide information about marine careers. Sea Grant has a recent publication, *Marine Science Careers: A Sea Grant Guide to Ocean Opportunities* . This can be obtained from Woods Hole Oceanographic Institution Sea Grant Program, 193 Oyster Pond Road, Woods Hole, MA 02543-1525. A good source for information about ocean-related careers other than the sciences is *Opportunities in Marine and Maritime Careers* by William Ray Heitzmann (VGM Career Horizons, 4255 West Tonky Avenue, Lincolnwood, IL 60645). Additional resources include the organizations and publications listed below:

Publications:

Careers in Oceanography and Marine-Related Fields. The Oceanography Society, 4052 Timber Ridge Drive, Virginia Beach, VA 23455, (804)464-0131, fax: (804)464-1759, e-mail: jrhodes@ccpo.odu.edu.

Education and Training Programs in Oceanography and Related Fields. Available from the Marine Technology Society, 1828 L Street, NW, Suite 906, Washington, D.C. 20036-5104, (202)775-5966, fax: (202)429-9417.

Strategies for Pursuing a Career in Marine Mammal Science. Allen Press, P.O. Box 1897, Lawrence, KS 66044-8897, 800/627-0629.

Taking the Initiative: Report on a Leadership Conference for Women in Science and Technology. Available from the Association for Women in Science, 1522 K Street, NW, Suite 820, Washington, D.C., 20005, (202)408-0742, fax:(202)408-8321, e-mail:awis@digex.net.

Careers in Oceanography. Neritic Enterprises, PO Box 5485, Santa Barbara, CA 93108.

There is a need to communicate information about marine careers to high school guidance counselors. California Sea Grant sends its Directory of Marine Programs to every counselor in the state. NOAA, the U.S. Navy, and/or CORE should consider buying a booth at the national conference of career and guidance counselors.

CONCLUSIONS

Informal marine education is extensive and growing in the United States. The media has improved its coverage in both extent and quality over the past 25 years. There are many aquaria and similar institutions available for public viewing and education. These institutions have extensive and usually high quality education programs. SeaWeb has begun a worthy program of raising the awareness of the public about ocean issues. The U.S. Congress has also shown new interest about ocean issues and policy after a 25-year hiatus. Government agencies are extensively involved in a wide range of informal marine education endeavors and maintain a high level of quality.

K-12 marine education appears to lag other aspects of marine education. There are a few curricular programs and materials that are available from aquaria and government agencies. Science textbooks have little coverage of the ocean. Teacher training in marine education is almost non-existent in universities. Several government agencies have in-service teacher training programs. The new NRC *National Science Education Standards* ignore the ocean.

Higher education is a bright spot in marine education. Graduate programs are high quality and produce adequate members of scientists to meet national needs with the exception of marine affairs (social sciences). Marine affairs is of growing importance to the nation and there is a need to develop new graduate degree programs. Maritime academies meet the national needs at this time considering the low availability of jobs in the merchant sector. NSF

and Sea Grant are the main supporters of ocean science graduate students.

Ethnic minorities while under-represented in science are even more under-represented in the ocean sciences. Women are generally represented in oceanography similar to their representation in other sciences.

There are some publications available for career opportunities in the ocean sciences. Students at all levels are poorly informed about the range of careers available in the ocean sciences. The best job opportunities lie in the area of marine recreation and tourism.

OPTIONS FOR CONSIDERATION

- **Provide leadership and visibility for marine education;**
- **Seek new international/national advocates for marine education;**
- **Coordinate efforts and new ideas to promote diversity of people in marine education;**
- **Increase public awareness of ocean issues;**
- **Educate the public regarding the role of the ocean in global climate;**
- **Coordinate marine education support by federal agencies;**
- **Revise/amend the *National Science Education Standards* (National Research Council) to infuse ocean sciences;**
- **Fund and organize a national conference/workshop to educate K-12 textbook authors and editors about the oceans;**
- **Support CORE and National Ocean Partnership Program;**
- **Make real-time oceanography accessible and useful for teachers and students;**
- **Encourage more university programs in marine affairs, law, coastal engineering, and ports and harbor management and planning;**
- **Improve career education information about ocean-related employment at all levels of education;**
- **Provide marine career information to career and guidance counselors.**

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LIST OF ACRONYMS

COAST Consortium for Oceanographic Activities for Students and Teachers

CORE Consortium for Ocean Research and Education

GLOBE Global Learning and Observations to Benefit the Environment

MTS Marine Technology Society

NASA National Aeronautics and Space Administration

NMEA National Marine Educators Association

NOAA National Oceanic and Atmospheric Administration

NOPP National Ocean Partnership Program

NRC National Research Council

NSF National Science Foundation

UN United Nations

USCG United States Coast Guard

USN United States Navy

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

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