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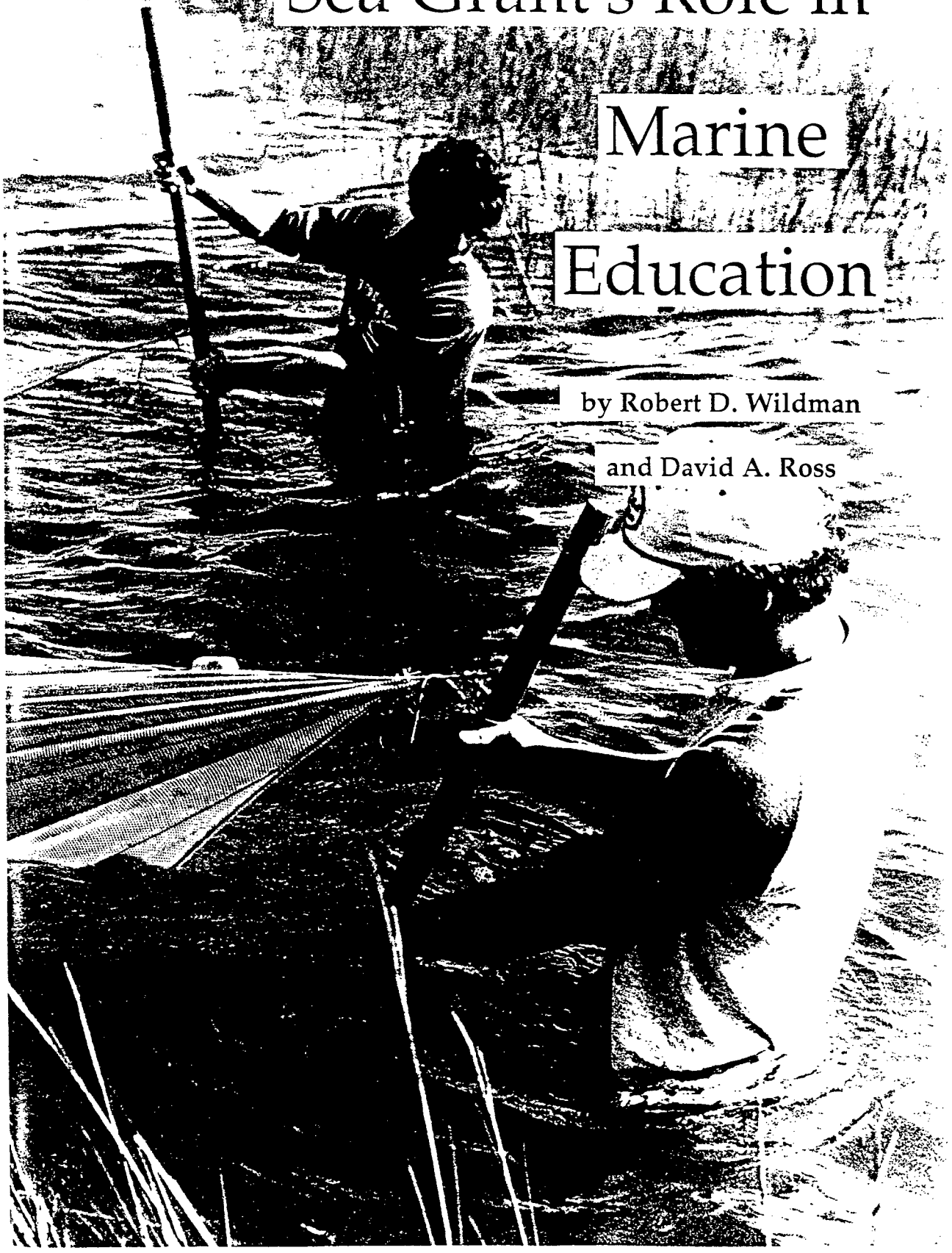

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Never before have scientific and environmental issues dominated the actions of countries and the concerns of individuals as they do today. Despite the fact that these issues are covered almost daily on the front pages of our newspapers and featured on the evening TV news, a major shortage of scientists and engineers is projected in the United States by the end of this decade. There are only a few programs in the United States that are striving to increase the numbers of marine scientists and engineers. One that is active in the marine area is the National Sea Grant College Program, which is part of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Department of Commerce.

*An NSF study concludes that the U.S. faces a shortfall of about 500,000 scientists and engineers by the end of the decade.*

In a 1989 study, the National Science Foundation (NSF) concluded that the United States faces a shortfall of about 500,000 scientists and engineers by the end of the 20th century and that the number could increase to 675,000 by the year 2006. One simple reason is that college-age students will number only 24 million in the mid-1990s, whereas they were 30 million strong in 1980. On top of this reduction in the available population, only a small portion, about 5 percent, of these students will actually earn a bachelor's degree in science.

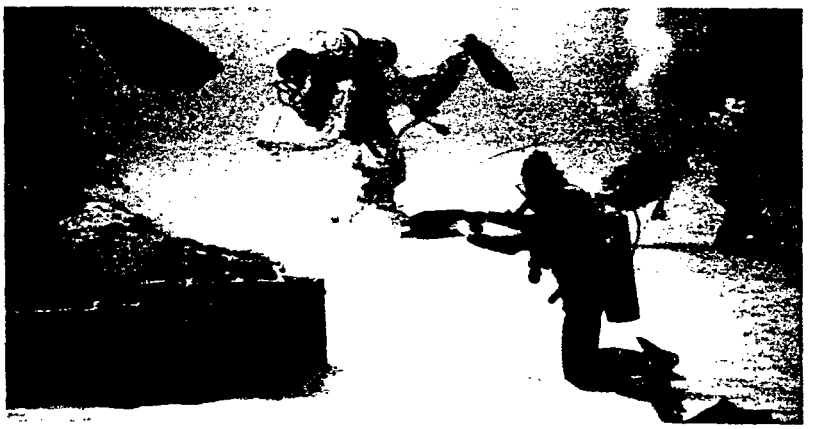
A number of reasons have been proposed for the decreased interest and enrollment in science fields. These include the above mentioned decline in the number of U.S. college-age students, which in turn leads to a reduction in the total number of students in all fields. Most of the science community's attention, however, has been directed toward the decreasing proportion of all students now entering science fields versus other careers. Possible causes for this range from the perceived difficulty of science education, to boring course materials, to uninspiring or poorly trained teachers. Of the few students who plan to major in science or engineering when they enter college, more than half fail to receive their degrees in these fields. This is attributed to students finding the course work too difficult, finding other fields more interesting, or believing the job prospects to be better in other fields.

One way to improve this situation is to attract larger numbers of women and minorities to science and engineering. Women at present earn about a third of the doctorates awarded in science, but most tend to be in the social sciences and psychology. For Blacks and Hispanics, the situation is even less favorable. While Blacks constitute 12 percent of the population, they only hold about 2 percent of the scientific and engineering positions. Hispanics constitute close to 9 percent of the population and they, too, only hold about 2 percent of the science and engineering positions.

In 1989, nearly 9,600 Americans received Ph.D.'s in the natural sciences and engineering. Only 133 of these were awarded to Blacks (of a total 811 in all fields), and this was the highest number yet

achieved. Of these 133, only three were in the Earth, marine, and atmospheric fields, or less than 0.5 percent of those awarded in 1989. Asians received 427 Ph.D.'s in science and engineering (out of a total of 624); for Hispanics, the numbers were 186 of 569, and for American Indians, 37 of 93.

On the other hand, a third of the earned Ph.D.'s went to foreigners studying in the United States. These small numbers of minorities in the sciences are a national shame: there are scientific opportunities for women and minorities in science, particularly in marine sciences, that should be tapped. Indeed, if the predicted shortfall is to be avoided, large numbers of women and minorities must be attracted to scientific or technical careers.



*In a subsea setting, students (above) map and survey marine archaeology during a University of Hawaii Sea Grant workshop at Oahu. They home in (below) on the remains of a light beacon.*

In the United States, the training of marine scientists at the Ph.D. or master's level has frequently been a controversial matter. One school of thought prefers that students be fully trained in the fundamentals of a basic science (for example, biology), and in their thesis research–and later in their careers apply this basic knowledge to the marine environment. The other position holds that students should be exposed in their training to all fields of marine science, but specialize in one specific subdiscipline – for example biological oceanography. Surprisingly, feelings often run strong concerning which of these two procedures should be used. At the risk of a pun, the argument may just be academic for the 21st century.

There are three major problems that the marine scientific community must solve in training the necessary talent needed for the coming century. These are 1) the general lack of national interest in science as a career among college-age and younger students; 2) the changing skills needed by oceanographers

in the 21st century; and 3) the impact of "big" science and advancing technology on the individual researcher and graduate student. These hurdles can be overcome, but it will take a national effort.

Marine science is undergoing some major changes. This includes the realization that the oceans play a critical role in the worldwide process of global change. To answer some of the questions related to global change, several new, large-scale research programs have been developed. These will be decade-long in duration and involve innovative ways of collecting data, such as by satellites. The oceanographer who will work in these programs will be different from the sea-going scientist of years past, as familiarity with computers may become more important than sea-going skills.

Real possibilities exist for making inroads on the three problems cited above through marine education and training programs. The National Sea Grant College Program sponsors work in marine research, marine education, and marine advisory services (see *Oceanus*, Vol. 31, No. 3). Through its network of participating academic institutions, Sea Grant has been actively involved in increasing the supply of well-trained, and educated specialists in marine science and marine affairs, and in making the public better informed about the wise use and protection of the marine environment and its resources.

Sea Grant's marine educational activities can be categorized as follows:

**Course Development and Student Projects:** Includes efforts to improve undergraduate and graduate level instructional programs in marine sciences and related fields. The projects help universities introduce new knowledge and methodologies into their instructional programs. Federal support is offered for a short period of time and only for development efforts that clearly exceed normal university resources available for this program.

**Research Assistantships:** The estimated numbers of graduate research assistants (GRA's) who have received at least partial support from Sea Grant in recent years are shown on page 43. Note that the table includes all the GRA's supported by Sea Grant, not just those in separate education projects.

**Elementary and Secondary Education and Teacher Training:** Investigators supported by these projects develop educational materials to be used in elementary and secondary classrooms, evaluate and disseminate the materials, and instruct teachers in their use. They also provide back-up support to teachers and administrators who are trying to introduce marine and aquatic education into their school systems.

**Non-Formal Education:** Includes marine and aquatic educational activities that occur outside formal classroom structures. The potential audience is the entire American public in all its diversity. Activities typically include lectures, conferences, 4-H and Scout projects, beach walks, and radio and television shows. These

*Numbers of Graduate Research Assistants (GRA's) Supported by Sea Grant in Past Decade*

| Fiscal Year | GRA's |
|---|---|
| 80 | 560 |
| 81 | 501 |
| 82 | 523 |
| 83 | 500 |
| 84 | 538 |
| 85 | 520 |
| 86 | 504 |
| 87 | 497 |
| 88 | 429 |
| 89 | 430 |

The numbers refer only to graduate research assistants, while graduate students who work in education, marine advisory service, and program administration are omitted.

activities often take place at science centers, museums, and aquaria.

**Technical and Vocational Education:** Includes projects to begin technical training, vocational training, and pre-baccalaureate technical training programs that typically are offered at junior or community colleges and technical institutes.

**Sea Grant Fellowship Program:** Includes projects intended to help stimulate interest in marine careers among those whose background or previous training might not have generated such interest.

**Sea Grant Fellows (John A. Knauss Marine Policy Fellowship):** This program supports highly qualified and motivated graduate students while they work on marine policy issues for one year in the legislative or executive branch of the federal government. The program is intended to round out a student's academic training and give him or her some experience at the federal policy-making level. The program has been in existence since 1979 and has supported 152 students to date. Public Law 100-200 renamed it the Dean John A. Knauss Marine Policy Fellowship Program after the former Dean of the Graduate School of Oceanography at the University of Rhode Island and current NOAA Administrator.

The total amount spent in these categories was $4,941,000 in Fiscal Year 89, of which $3,023,000 comes directly from NOAA Sea Grant, and $1,918,000 was matched or in-kind support from participating institutions.

Sea Grant-supported college graduates include not only some in the classical fields of oceanography, but also many trained as marine specialists in law, economics and social sciences, medicine and pharmacology, engineering, and transportation and energy.

The number of students supported by Sea Grant to date is approaching 10,000. Concurrently, hundreds of thousands of adults are reached through Sea Grant's Marine Advisory Service and Communications Programs with information on ocean and Great Lakes resource concerns.

**National Marine Educators Association:** In the 1960s and '70s, Sea Grant was one of the few organizations supporting marine education. Some of this support helped start the National Marine Educators Association (NMEA). NMEA was officially formed in 1976, although an "unofficial" group of individuals interested in marine education had been meeting since the mid-1960s. NMEA is now an independent organization with 15 regional chapters and more than 1,500 members. It holds annual and regional meetings and publishes a magazine: *Current —The Journal of Marine Education.*

Among the purposes of NMEA, many of which parallel Sea Grant's interests and help in developing marine scientists, are:

- *To provide a medium for the exchange of information and teaching materials;*
- *To stress the interrelationships of marine education to all disciplines and other educational experiences;*
- *To make available to educators information concerning the selection, organization, and presentation of marine materials at all levels; and*
- *To work for the improvement of the professional qualifications of marine educators.*

***Some 10,000 students to date have been supported by Sea Grant in various marine fields***

What then can marine science in general, and the Sea Grant Program in particular, do to contribute to solving the dilemma of reduced graduates in the sciences? Clearly, they cannot and should not attempt to reshape the entire U.S. science education field, an approach more appropriate for the National Science Foundation. Rather, Sea Grant should use its limited resources in complementary approaches that can make contributions for which the marine sciences have unique capabilities.

The oceans and the organisms that inhabit them still have a romantic allure for most people. Professionals involved in marine education in any capacity can take advantage of that fact to interest young people in science careers and the marine sciences in particular. During their educational development, students can be made aware of the wide variety of career fields open to them, many of which do not require a Ph.D. While a solid foundation in mathematics and natural sciences is a requirement for several career paths, it can be attained in a way that is much more appealing and less threatening to students.

In the realm of elementary and secondary educational programs, Sea Grant can enhance its efforts to make available stimulating instructional materials that can be infused into K-12 curricula in nonscience as well as science courses. This approach could lead to

more student awareness of and interest in science as a field and in marine science affairs specifically.

Communicating the many problems and opportunities involved in human interaction with the marine environment should be simplified and expanded to reach a wider public audience. Casting a larger net on marine issues to the public could increase interest in the pursuit of marine science careers.

Then enters the national priority of teaching the teachers. Improving curricula and enhancing out-of-classroom experiences for science teachers at the K-12 and post-secondary levels should translate back into increased career interest by the student population. At the graduate school level, assistantships and pre- and post-doctoral fellowships should be targeted toward specific job categories to fill identified needs, and toward minorities and women to take advantage of these increasingly important sources of marine careerists.

As with most problems facing us today, the balancing of supply and demand for marine science and marine affair specialists is not likely to yield to singular, simplistic solutions. Only carefully considered, multiple approaches are likely to lead to the desired results during this and the next decade.

*Teaching teachers is a national priority as is expanding public awareness of the opportunities and problems in the marine arena.*

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