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Cover photos: Scientists launching a corer to collect sediment samples in the long tube they steady, a coastal cleanup, a fishing boat, and an aquarium scene represent a variety of marine careers. Photography by Jim Broda, WHOI; Tom Kleindinst, WHOI; U.S. Coast Guard; and Rick Browne, Monterey Bay Aquarium.

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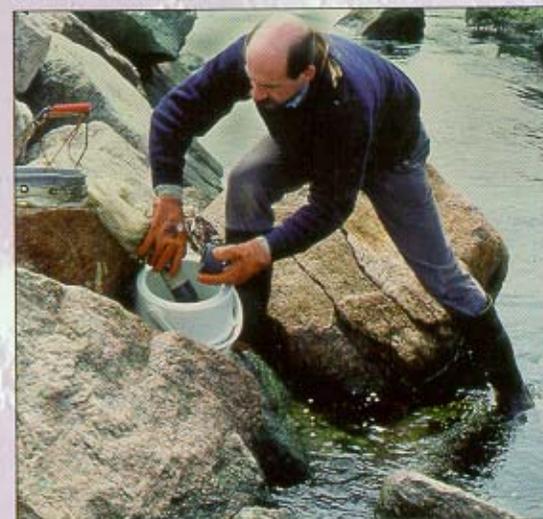
ROD CANAVAN, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Oceanographers work at sea...



DAL WHITE, UNIVERSITY OF ALASKA FAIRBANKS

in laboratories ashore and afloat...



TERRI CORBETT, WOODS HOLE OCEANOGRAPHIC INSTITUTION

and in coastal environments.

Oceanographers apply the basic sciences to studies of the sea, its contents, and the surrounding environment.

Often, they are chemists, physicists, biologists, or geologists who bring their special skills to ocean studies. They collaborate with one another and with engineers and social scientists on complex, challenging problems and issues as they expand our knowledge of the world ocean. They work in laboratories ashore, on ships and submersibles at sea, and in coastal environments.

Oceanography is a relatively young discipline. Work done during this century, ranging from the deepest seafloor to outer space, has brought the first global glimpse of how the oceans work. Our knowledge of the global ocean with its coastal and polar margins has expanded dramatically in recent years. Today we understand that the ocean, atmosphere, ice, solid earth, and living organisms are part of the global Earth system that regulates our climate. Through research and new technology, we are learning how the oceans affect life and the future of our planet.

Those in marine-related fields, including biologists, mathematicians, physi-

cists, geophysicists, computer scientists, meteorologists, chemists, geologists, engineers, and public policy experts, are working together to advance our knowledge of the ocean and its effects on society. Their efforts are leading to improvements in weather and climate prediction, transportation, waste disposal, the recovery of oil and minerals, and the discovery of new medicines and foods. The next century promises new technology that will substantially expand the frontiers of oceanography, and growing interest in environmental issues and the ocean sciences promises new job opportunities.

This booklet focuses on careers in marine-related scientific, technical, and public policy areas and on their educational requirements. Most of these careers require a college education and some require post-graduate work. There are also opportunities in other marine-related areas, including boat building and repair, sales, maritime operations, marine construction and maintenance, recreation, education, and ocean fishing. These occupations may involve some specialized training, but they do not necessarily require a college education.

Through research and new technology, we are learning how the oceans affect life and the future of our planet.

WHERE ARE THE JOBS?

More than 50 academic institutions have seagoing research programs, and some 500 institutions offer courses in oceanography and marine-related fields.

Jobs in oceanography can be found almost everywhere in the United States. The majority of opportunities are on the Pacific, Atlantic, and Gulf coasts and on the Great Lakes. The largest employers of oceanographers are the federal and state governments and academic institutions. Many departments of the federal government employ oceanographers, ocean engineers, marine technicians, and those interested in marine policy.

Federal agencies are concerned with the ocean environment, marine resources, and the ocean's strategic importance for national defense. There are strong marine components in the Department of Commerce, which houses the National Oceanic and Atmospheric Administration (NOAA); the Department of the Interior, which includes the U.S. Geological Survey (USGS), the Minerals Management Service (MMS), and the National Biological Survey; the Department of Defense (DoD) with the Navy and the Army Corps of Engineers; the Department of Energy (DOE); the Environmental Protection Agency (EPA); the National Science Foundation (NSF); the National Aeronautics and Space Administration (NASA); and the Department of Transportation (DOT) with the Coast Guard.

Oceanography and marine-related fields are strongly represented in academic institutions. More than 50 such institutions have seagoing research programs of some type, and some 500 institutions offer courses in oceanography and marine-related fields. University professors and researchers spend varying amounts of time in the classroom and the lab and often have a great deal of freedom to decide which projects and activities to pursue. As a consequence, university positions are appealing to many and the competition for openings can be intense.

Careers in private industry are also available, primarily in engineering, geology and geophysics, environmental quality activities, marine policy, resource economics, and fisheries. These jobs may offer higher salaries than university positions, but activities and projects are often dictated by the industry rather than the individual researcher. Consulting companies of various sizes offer diverse career opportunities. Individual consulting opportunities may arise for those with strong

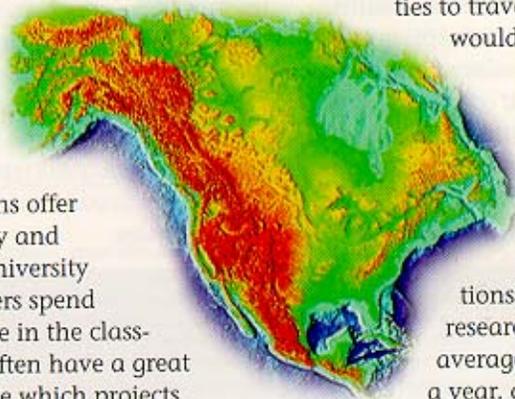
credentials and a good reputation. The competition for private industry jobs can also be stiff.

In universities, research institutions, and often in industry, a portion of a researcher's time is devoted to preparing requests for funding from government agencies. This funding is known as "soft money," because it supports a researcher's work for a limited time, usually one to three years, and then renewed funding must be sought through new proposals that compete for limited government funds with proposals from other scientists around the country. "Hard money" is provided by the employer, for example, to support the teaching portion of an academic position or for specific research a scientist may be hired to do for private industry.

If you are considering careers in oceanography or marine-related fields, it is important to remember that they may require rigorous scientific study, personal dedication, and demands on your time and energy that extend beyond normal workday hours. But there are rewards—most oceanographers share an enthusiasm for the work, love of discovery, and an appreciation for the environment. In addition, if you are involved in fieldwork or marine policy, you may have more opportunities to travel around the world than you would in many other fields.

If fieldwork appeals to you, then it would be advisable to obtain some at-sea experience during your education, perhaps through a summer internship at one of the oceanographic institutions. Oceanographers whose research involves field work may average two to eight weeks at sea in a year, and some marine technicians spend most of the year at sea. Life at sea is very appealing to some people, but it does not suit everyone. The earlier you find out whether you enjoy being at sea, the easier it will be to chart your own career options. But remember, you can be an oceanographer without ever going to sea. Opportunities are open to all.

There are many career options in marine-related fields outside the standard oceanographic disciplines. Various maritime industries ranging from shipping and marine operations to commercial fishing can provide jobs for those without scientific backgrounds.



Sources of Information on Marine-Related Careers

U.S. Government

National Energy Information Center
Energy Information Administration,
EI-231, 1000 Independence Avenue,
SW, Washington, DC 20585
(202) 586-8800, TDD: (202) 586-1181

U.S. Department of Health and Human Services
Public Health Service, Bureau of
Primary Care, 4350 East-West
Highway, 11th Floor, Bethesda,
MD 20814

U.S. Army Corps of Engineers
Career Program Operations, Build-
ing 159, Room 200, Washington
Navy Yard, Eighth & M Streets, SE,
Washington, DC 20374,
(202) 475-2978

U.S. Department of the Interior
Minerals Management Service,
Equal Employment Opportunities
Office, Park Atrium Building, Room
2321, 381 Eldon Street, Herndon, VA
22070, (703) 787-1313

U.S. Coast Guard
Department of Transportation,
400 7th Street, SW, Washington,
DC 20590

U.S. Environmental Protection Agency
Waterside Mall, 401 M Street, SW,
Washington, DC 20460

National Aeronautics and Space Administration
Two Independence Square Building,
300 E Street, SW,
Washington, DC 20546

National Oceanic and Atmospheric Administration (NOAA)
Office of Public Affairs, Herbert
Hoover Building, Washington,
DC 20230

NOAA Corps Recruiting Commissioned Personnel Center (CPC22)
1315 East-West Highway, Room
12100, Silver Spring, MD 20910

National Science Foundation
Ocean Sciences Division, Room 725,
4201 Wilson Boulevard, Arlington,
VA 22230

National Sea Grant College Program
NOAA/Sea Grant, R/OR1, SSMB-3,
11th Floor, 1315 East West Highway,
Silver Spring, MD 20910,
(301) 713-2431



U.S. COAST GUARD

Coast guard personnel operate boats, ships, and aircraft for maritime law enforcement and safety as well as marine environmental protection and national security.

U.S. Geological Survey
USGS National Center, 12201
Sunrise Valley Drive, Reston,
VA 22092

U.S. Naval Oceanographic Office
1002 Balch Boulevard, Stennis Space
Center, MS 39522-5001,
(601) 688-4367

Aquariums and Marine Science Museums

The Aquarium of the Americas
1 Canal Street, New Orleans, LA
70130, (504) 565-3029

Association of Science Technology Centers
1025 Vermont Avenue, NW,
Suite 500, Washington, DC 20005

Belle Isle Aquarium
Box 39, Royal Oak, MI 48068,
(313) 267-7159

Dallas Aquarium
P.O. Box 150113, Juanita Craft
Station, Dallas, TX 75315-0113,
(214) 670-8443

J.L. Scott Marine Education Center & Aquarium - Gulf Coast Research Laboratory
115 Beach Boulevard, Biloxi, MS
39530, (601) 374-5550

The University of Georgia Marine Extension Service
30 Ocean Science Circle, Savannah,
GA 31411

Marineland
Route 1, Box 122, St. Augustine, FL
32084, (904) 471-1111

Miami Seaquarium
4400 Rickenbacker Causeway,
Miami, FL 33149-1095,
(305) 361-5703

Monterey Bay Aquarium
886 Cannery Row, Monterey, CA
93940, (408) 648-4800

Mystic Marinelifelife Aquarium
55 Coogan Boulevard, Mystic, CT
06355, (203) 572-5955

National Aquarium
U.S. Department of Commerce,
Washington, DC 20230,
(202) 482-2825

National Aquarium in Baltimore
Pier 3, 501 E. Pratt St., Baltimore,
MD 21202, (301) 576-3800

New England Aquarium
Central Wharf, Boston, MA 02110,
(617) 973-5200

Aquarium for Wildlife Conservation
Boardwalk & West 8th Street,
Brooklyn, NY 11224,
(718) 266-8500

RESOURCES

Sources of Information on Marine-Related Careers

Continued from previous page.

North Carolina Aquarium at Roanoke Island
Manteo, NC 27954,
(919) 473-3493

North Carolina Aquarium at Fort Fisher
Kure Beach, NC 28449,
(910) 458-8259 (office),
(910) 458-7468 (programs)

North Carolina Aquarium at Pine Knoll Shores
Box 580, Atlantic Beach, NC 28512,
(919) 247-4003

Pittsburgh Aqua Zoo
1 Hill Road, Pittsburgh, PA 15206,
(412) 665-3768, (412) 665-3639

Stephen Birch Aquarium-Museum
Scripps Institution of Oceanography,
University of California, San Diego,
2300 Expedition Way, La Jolla, CA
92093-0207, (619) 534-FISH

Sea Life Park
41-202 Kalaniana'ole Highway #7,
Waimanalo, HI 96795,
(808) 259-7933

Sea World of Ohio
1100 Sea World Drive, Aurora, OH
44202, (216) 562-8101

Sea World of Florida
7007 Sea World Drive, Orlando, FL
32821, (407) 351-3600

Sea World of California
1720 South Shores Road, San Diego,
CA 92109-7995, (619) 222-6363,
Fax (619) 226-3996

Seattle Aquarium
Pier 59 Waterfront Park, Seattle, WA
98101, (206) 386-4300,
Fax (206) 386-4328

Shedd Aquarium
1200 S. Lake Shore Drive, Chicago,
IL 60605, (312) 939-2426

South Carolina Aquarium
57 Hasell Street, Charleston, SC
29401, (803) 720-1990

Steinhart Aquarium
Golden Gate Park, San Francisco, CA
94118, (415) 221-5100

Vancouver Aquarium
P.O. Box 3232, Vancouver, BC,
Canada V6B 3X,
(604) 685-3364, Fax (604) 631-2529

Virginia Marine Science Museum
717 General Booth Boulevard,
Virginia Beach, VA 23451,
(804) 425-3474

Waikiki Aquarium
2777 Kalakaua Avenue, Honolulu,
HI 96815, (808) 923-5335



Marine scientists and ships' crew members work together to gather data, here during operations in the Norwegian Sea.

Oceanographic and Marine Science Organizations

American Geophysical Union
2000 Florida Avenue, NW,
Washington, DC 20009,
(202) 462-6903

American Meteorological Society
45 Beacon Street, Boston, MA 02108

American Society of Limnology and Oceanography
Virginia Institute of Marine Science,
P.O. Box 1346, Gloucester Point, VA
23062, (804) 642-7000

National Sea Grant Depository
Pell Library Building, University of
Rhode Island, Bay Campus,
Narragansett, RI 02882

International Oceanographic Foundation
4600 Rickenbacker Causeway,
Miami, FL 33149-1098

Marine Technology Society
1828 L Street, NW, Suite 906, Wash-
ington, DC 20036, (202) 775-5966

National Marine Educators Association
P.O. Box 51215, Pacific Grove,
CA 93950

National Research Council
2101 Constitution Avenue, NW,
Washington, DC 20418, (All at the
same address: Marine Board, Naval
Studies Board, and Ocean Studies
Board)

The Oceanography Society
4052 Timber Ridge Drive, Virginia
Beach, VA 23455, (804) 464-0131

Society of Exploration Geophysicists
P.O. Box 702740, Tulsa, OK 74170

Water Environment Federation
601 Wythe Street, Alexandria, VA
22314, (703) 684-2400

EDUCATIONAL REQUIREMENTS

If you are interested in a marine-related career, you should enroll in as many chemistry, earth science, biology, physics, computer science, and mathematics classes as possible, both in high school and in college. It is important not to specialize too early, and many oceanographers are trained first in other disciplines. The better prepared you are in the general scientific disciplines, the more you will be able to contribute and the broader your career choices will be. English and speech courses are also important since a great deal of a professional's time is spent writing proposals, papers, and articles and giving oral presentations.

There are opportunities for those who do not continue their education beyond high school, but they are generally limited to technical support positions. Marine technicians use instruments and computers to collect and analyze data, but they do not usually interpret data, write reports, or give presentations. Some positions for technicians do require post-secondary school training, and it can often be obtained through two-year community colleges. About 30 U.S. schools offer specialized technical training in marine-related fields. A listing of the schools can be found in the book *University Curricula in Oceanography and Related Fields* (see resource listing on page 9).

Careers Requiring an Undergraduate Degree

An undergraduate degree in one of the basic sciences (including oceanography) is the minimum educational requirement for those wishing to work as marine scientists or oceanographers. For many technical jobs in oceanography, you need a bachelor's degree. As competition increases, you may need a master's degree or further work experience.

One of the best ways to obtain experience is through an internship. They are often available through cooperative education programs. Your university career services center can provide further information. If you think you might enjoy an internship, you should start investigating the options during your sophomore year of college. You might also wish to take courses at a marine science laboratory; such courses are offered by many schools around the country (see list on page 9).

Selecting a college that is right for you can be a difficult process. Many factors need to be considered such as course offerings, the faculty's reputation, the location, the research facilities, the cost, and the availability of financial aid. Support services for disabled persons can also be a critical factor. The more information you can get from counselors, classmates, graduates, and faculty, the easier it will be to decide where to apply. Visits to

The better prepared you are in the general scientific disciplines, the more you will be able to contribute and the broader your career choices will be.



A marine biologist works with a computer file and video images for studies of animals in Monterey Bay off the California coast.

EDUCATIONAL REQUIREMENTS



SCHIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA, SAN DIEGO

Researchers examine a dredge haul aboard an oceanographic vessel. A dredge is an open-mouthed chain bag that is dragged along the seafloor to collect samples for analysis aboard ship or ashore. The samples collected are archived for long-term use.

prospective institutions can also help you make your decision. General information about colleges and universities that offer marine courses and programs can be found in the book *University Curricula in Oceanography and Related Fields*.

Two options are available to undergraduates who wish to pursue a career in oceanography. If you want to become an oceanographic technician immediately after graduation, it would be appropriate to major in oceanography or ocean engineering. If you plan to do research, however, then a graduate degree will be required, and it may be better to choose an undergraduate major in one of the basic sciences as well as taking some optional courses or having a minor in ocean sciences or engineering.

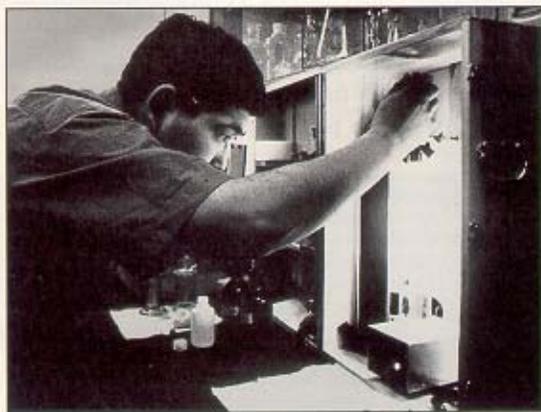
Careers Requiring a Graduate Degree

Although there are some very famous senior oceanographers who do not have graduate degrees, it is difficult to become a professional oceanographer today, whether in research, teaching, or policy studies, without either a master's or doctoral degree. Most oceanographers also engage in postdoctoral studies before beginning independent research careers. Since the focus of graduate studies is research, only the first two years or so are spent in a formal classroom setting. Most two- or three-year master's programs require one to one and one-half years of course work. A doctoral degree usually requires two years of courses, depending on the student's background. Researching

and writing a thesis usually takes an additional three years.

Graduate school admission to oceanography or ocean engineering programs generally requires an undergraduate degree in mathematics, biology, chemistry, geology, geophysics, engineering, physics, or oceanography. A grade point average of 3.00 or above may be required along with test scores from the Graduate Record Examination.

Suggested undergraduate science preparation for graduate work in oceanography and marine-related fields includes at least one year of mathematics including calculus, preferably through differential calculus, one year of physics (using calculus) with laboratory, one year of chemistry with laboratory, an additional year of either physics or chemistry, and a minimum of one year of both biology and geology. To these should be added computer science and technical writing courses. This list is only a framework for preparing you for oceanographic work. The marine-related area you wish to pursue in graduate school will further determine what courses you should take as an under-



TOM KLINE, UNIVERSITY OF ALASKA FAIRBANKS

A student conducts chemical analysis of seawater samples in a shipboard laboratory.

graduate. Your academic advisor can help you design a course load that meets your specific interests and goals.

Study at the graduate level allows you to specialize in a subfield of oceanography. Graduate school catalogs can provide more information, as can professors who are doing research in your area of interest. Once you are admitted to a graduate program, you will be assigned to an advisor who will help you select a research topic and guide you through all phases of the graduate program.

Marine Research and Educational Institutions

This is a partial listing. Students are encouraged to investigate whether institutions of interest to them but not listed here may have marine programs.

The Academy of Natural Sciences
Benedict Estuarine Research Center,
10545 Makall Road, St. Leonard,
MD 20685

**Bigelow Laboratory for
Ocean Sciences**
McKown Point, P.O. Box 475,
W. Boothbay Harbor, ME 04575

Brookhaven National Laboratory
Associated Universities, Inc., Upton,
NY 11973

**California State University,
Long Beach**
1250 Bellflower Boulevard, Long
Beach, CA 90840

College of William & Mary
School of Marine Science, Virginia
Institute of Marine Science,
Gloucester Pt., VA 23062

Curriculum Guides

► *Curricula in the Atmospheric, Oceanic, Hydrologic, and Related Sciences, 1994.* A joint publication of the American Meteorological Society and the University Corporation for Atmospheric Research. American Meteorological Society, 45 Beacon Street, Boston, MA 02108. (Published every 2 years)

► *University Curricula in Oceanography and Related Fields (1988).* Marine Technology Society, 1825 K Street, N.W., Suite 203, Washington, D.C. 20006.

► *Vocational Education and Occupations.* Department of Education, Federal Office Building 6, 400 Maryland Avenue, S.W., Washington, D.C. 20202.

► *Information on Undergraduate Programs in or Related to Oceanography and Marine Sciences, (1994).* (Council on Ocean Affairs, Joint Oceanographic Institutions, National Science Foundation) North Carolina State University, Department of Marine, Earth & Atmospheric Sciences, Raleigh, NC 27695-8208. (919) 515-3711.

Columbia University
Lamont-Doherty Earth Observatory,
Palisades, NY 10964

Dauphin Island Sea Lab
Marine Environmental Science
Consortium, P.O. Box 369, Dauphin
Island, AL 36528

**Duke University School of the
Environment, Marine Laboratory**
135 Duke Marine Lab Road, Beau-
fort, NC 28516-9721

Fairleigh Dickinson University
Department of Biological Science,
1000 River Road, Teaneck, NJ 07666

Florida Institute of Oceanography
830 First Street South, St. Petersburg,
FL 33701

Florida Institute of Technology
Melbourne Campus, 150 W. Univer-
sity Blvd., Melbourne, FL 32901-6996

Florida State University
Department of Oceanography, OSB
Building, Room 331A, Tallahassee,
FL 32306-3048

**Harbor Branch
Oceanographic Institution**
5600 U.S. 1 North, Ft. Pierce, FL 34946

**Louisiana Universities
Marine Consortium**
8124 Highway 56, Chauvin,
LA 70344

**Massachusetts Institute
of Technology**
MIT/WHOI Joint Program Office,
Building 54-912, Cambridge, MA
02139

**Monterey Bay Aquarium
Research Institute**
160 Central Avenue, Pacific Grove,
CA 93950

Mote Marine Laboratory
1600 Ken Thompson Parkway,
Sarasota, FL 34236

**New Jersey Marine Sciences
Consortium**
Building #22, Fort Hancock, NJ 07732

North Carolina State University
Department of Marine, Earth &
Atmospheric Science, P.O. Box 8208,
Raleigh, NC 27695-8209

**Nova Southeastern University
Oceanographic Center**
8000 North Ocean Drive, Dania, FL
33004

Old Dominion University
Department of Oceanography, 1054
West 47th Street, Norfolk, VA 23529

Oregon State University
College of Oceanic & Atmospheric
Sciences, Oceanography Admin.
Bldg. 104, Corvallis, OR 97331-5503

Roger Williams University
Dean, College of Arts & Sciences,
Bristol, RI 02809, (401) 254-3087

Rutgers University
Institute of Marine & Coastal
Sciences, P.O. Box 231, New
Brunswick, NJ 08903-0231

Sea Education Association, Inc.
P.O. Box 6, Woods Hole, MA 02543

**Skidaway Institute
of Oceanography**
10 Ocean Science Circle, Savannah,
GA 31411

**South Carolina Department of
Natural Resources**
P.O. Box 12559, Charleston, SC
29422-2559, Attn: Office of Human
Resources

**State University of New York,
Stony Brook**
Marine Sciences Research Center,
Stony Brook, NY 11794-5000

Texas A&M University
College of Geosciences, College
Station, TX 77843-3146

**Tiburon Center for
Environmental Studies**
Romberg-Tiburon Centers, P.O. Box
855, Paradise Drive, Tiburon, CA
94920

University of Alaska
Institute of Marine Science, Box
757220, Fairbanks, AK 99775-7220

University of California, San Diego
Scripps Institution of Oceanography,
0207, La Jolla, CA 92093

**University of California,
Santa Barbara**
Marine Science Institute, Trailor 342,
Santa Barbara, CA 93106

University of California, Santa Cruz
Institute of Marine Sciences, Santa
Cruz, CA 95064

University of Delaware
College of Marine Studies, Newark,
DE 19716

University of Georgia
Marine Institute, Sapelo Island, GA
31327

University of Hawaii
School of Ocean and Earth Science
and Technology, 1000 Pope Road,
MSB 205, Honolulu, HI 96822

RESOURCES

University of Maine

Center for Marine Studies,
14 Coburn Hall, Orono, ME 04469

University of Maryland System

Center for Environmental & Estuarine Studies, P.O. Box 775, Cambridge, MD 21613

University of Miami

Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149

University of Michigan

Center for Great Lakes & Aquatic Sciences, 2200 Bonisteel Boulevard, Ann Arbor, MI 48109-2099

University of New Hampshire

Ocean Process Analysis Laboratory, Morse Hall, 39 College Road, Durham, NH 03824-3525

University of New Orleans

Department of Geology & Geophysics, Room 1065, New Orleans, LA 70148

University of Puerto Rico

Department of Marine Sciences, P.O. Box 5000, Mayaguez, PR 00681-5000

University of Rhode Island

Graduate School of Oceanography, South Ferry Road, Narragansett, RI 02882-1197

University of San Diego

5998 Alcalá Park, San Diego, CA 92110

University of South Florida

Department of Marine Science, 140 Seventh Avenue, South, St. Petersburg, FL 33701

University of Southern California

Natural Sciences & Mathematics, University Park, Los Angeles, CA 90089-4012

University of Southern Mississippi

Center for Marine Sciences, John C. Stennis Space Center, MS 39529

The University of Texas at Austin

Institute for Geophysics, 8701 N. MoPac Expressway, Austin, TX 78759-8397

University of the Virgin Islands

Academic Affairs, St. Thomas, US Virgin Islands 00802

University of Washington

College of Ocean & Fishery Sciences, HN-15, Seattle, WA 98195

University of Wisconsin,

Milwaukee

Center for Great Lakes Studies, 600 East Greenfield Avenue, Milwaukee, WI 53204

Woods Hole

Oceanographic Institution

Information Office, Woods Hole, MA 02543-1050

Financial Aid Information

Various forms of financial aid are available to help cover the costs of a college education. These include grants or scholarships, which do not require repayment; loans, which must be repaid with interest after graduation; college work-study programs, which allow you to earn money for school; teaching or research assistantships; and fellowships, which allow for advanced study or research and provide a stipend.

A number of federal aid programs are currently available: Pell Grants, Supplemental Educational Opportunity Grants (SEOG), Perkins Loans, Stafford Loans, Parent Loans for Undergraduate Students (PLUS)/ Supplemental Loans for Students (SLS), and college work-study (CWS). Most federal student aid programs—with the exception of PLUS and SLS—are awarded on the basis of financial need. The student must be a U.S. citizen or eligible noncitizen, be enrolled in an eligible degree or certificate program, and demonstrate satisfactory academic progress. Financial aid awards are usually determined by college costs and the amount that parents can afford.

Fellowships for graduate students are available from the Office of Naval Research and the National Science Foundation, and McNair Grants are available for underrepresented groups. Most states also offer grants

for college expenses, and state vocational rehabilitation agencies are particularly important in providing educational funds for students with disabilities.

Financial aid may also be available through individual colleges, local and regional organizations, foundations, and corporations. Some of these programs are based solely on ability or academic standing without regard to family financial conditions. Additional information can be obtained from high school guidance counselors and college financial aid offices.

Scholarships from private sources are also available, but eligibility requirements are varied. Criteria may include academic standing, parents' place or type of work, ethnic background, career goals, religious affiliation, or a disability. The best source of information about private scholarships is usually college financial aid offices.

After deciding which colleges you like, you can ask each financial aid office to send you a financial aid package. Each package should provide details about the resources available to meet your financial aid needs. There is no guarantee that any one institution will be able to meet your total financial needs, but they will usually try to make it possible for you to attend the college of your choice.

Your career goals and how closely a

specific college's curriculum matches those goals should be the primary factors in choosing a college. You may need to consider a number of schools before you find the least expensive school that satisfies your needs.

Much of what has been said above applies to both undergraduate and graduate education. However, some forms of aid are not available either to graduate students or to those who wish to pursue a second bachelor's degree. The excluded forms of aid include the Pell Grants, Supplemental Grants, and college work-study. Other types of financial aid are often available from graduate schools.

Sources of funds for graduate training include fellowships and research or teaching assistantships, all of which normally include a tuition waiver. Fellowships are generally competitive positions and include a stipend to cover living expenses while you are doing graduate research. Research and teaching assistantships are available from individual institutions. Assistants are hired to support research activities or to teach lower division undergraduate courses, often with an emphasis on laboratory sections, and are paid a salary. The specific college departments of interest to you can provide details about fellowships and assistantships.



A. STANDBY, SEA EDUCATION ASSOCIATION, INC.

A student participating in a sail training-oceanography semester explains her research findings to shipmates.

Financial Aid Resources

► *Federal Student Aid Fact Sheet.* Office of Student Financial Assistance, U.S. Department of Education, Washington, DC 20202. (800) 333-4636.

► *Summary of Graduate Education Fellowships and Assistance Programs and Funded Institutions.* Office of Higher Education Program Services, U.S. Department of Education, Washington, DC 20202. (800) 333-4636.

► *Applying for Financial Aid.* Covers basic information for students and parents. Available from college financial aid offices or American College Testing Service, 2201 North Dodge Street, P.O. Box 168, Iowa City, IA 52243.

► *College Costs at Selected Colleges and Universities.* Available at no cost through New York Life Insurance Company, 51 Madison Avenue, Room 1107, New York, NY 10010 or any local New York Life agent.

► *The Federal Educational and Scholarship Funding Guide.* Reviews over 135 separate granting agencies and includes information contacts and addresses. Grayco Publishing, P.O. Box 1291, West Warwick, RI 02893.

► *Foundation Center.* Has a volume of listings called *Foundation Grants for Individuals* arranged in broad categories. To find the nearest cooperating Foundation Center call (800) 424-9836.

► *How to Obtain Maximum College Financial Aid.* Provides step-by-step instructions for getting grants, loans, and scholarships and includes application guidelines for over 120 funding agencies. Grayco Publishing, P.O. Box 1291, West Warwick, RI 02893.

► *Need a Lift?* An annual publication covering sources of financial aid and the financial aid process. Special emphasis given to programs for children of deceased or disabled veterans, but designed to be of service to all students. Available for \$3 (prepayment) from American Legion National Emblem Sales, P.O. Box 1050, Indianapolis, IN 46206

► *The Student Guide: Five Federal Financial Aid Programs.* A Department of Education publication that describes grants and loans available to college students. Available from college financial aid offices or Federal Student Aid Programs, Dept. DEA-86, Pueblo, CO 81009.

► *Department of Defense Graduate Fellowship Program.* Application materials are available from and completed applications should be returned to Battelle NDSEG Fellowship Program Administrator, P.O. Box 13444, Research Triangle Park, NC 27709-3444, Attn: Dr. George Outterson, (919) 549-8505

► *National Science Foundation.* Graduate Research Fellowships (including Graduate Fellowships, Minority Graduate Fellowships, Women in Engineering, Computer and Information Science Awards), NSF Graduate Research Fellowship Program, Oak Ridge Associated Universities, P.O. Box 3010, Oak Ridge, Tennessee 37831-3010

► *Office of Naval Research Graduate Fellowship Program.* Application materials may be obtained from the American Society for Engineering Education (ASEE), 11 Dupont Circle, Suite 200, Washington, DC 20036. (202) 745-3616, (202) 293-7080.



SUSAN GREEN, SCRIPPS

► Marine biologist Margo Haygood catches up with scientific journals...



SUSAN GREEN, SCRIPPS

works in the lab with a colleague...



SUSAN GREEN, SCRIPPS

teaches young children in an aquarium study group...

MARINE SCIENTISTS AT

Research scientists engage in a wide variety of activities as they pursue their careers. Their working environments are usually rather casual, though some of their time, such as when giving presentations at scientific meetings, may be spent more formally. The photos on these two pages provide glimpses of scientists in settings that range from office to classroom to research vessel to soccer field.

Maurice Tivey is a marine geologist at the Woods Hole Oceanographic Institution (WHOI). His particular interest is understanding Earth history from magnetic signals recorded by cooling volcanic material that erupts at the boundaries of our planet's great crustal plates. He often uses submersibles to carry his instruments, and he is on the dive records of the French submersible *Nautille*, Japan's *Shinkai 6500*, and the WHOI-operated US *Alvin*. He also uses research vessels to tow magnetometers and other instruments for his investigations. His wife Meg is also a seagoing WHOI scientist, and the couple must juggle their demanding



SUSAN GREEN, SCRIPPS

demonstrates the procedure for sampling symbiotic bioluminescent bacteria from an anesthetized flashlight fish...

schedules along with caring for their two young children.

Margo Haygood is a marine biologist at the Scripps Institution of Oceanography, University of California, San Diego. She studies many aspects of marine microbiology. One of her favorite subjects is bioluminescent bacteria that live in special organs beneath the eyes of a family

of fishes called *Anomalopidae*, commonly known as flashlight fishes. Though many luminous bacteria can be grown and studied in the laboratory, the flashlight-fish bacteria that Haygood and her research group work with have so far proven impossible to culture, so much of their work must be done at sea with freshly caught specimens. She conducts her research in the Caribbean, eastern tropical Atlantic, western Pacific ocean, and in the waters off California.

Like most scientists, these two spend a lot of their time at the



BRADLEY TEIKO, SCRIPPS

and draws a seawater sample aboard ship.



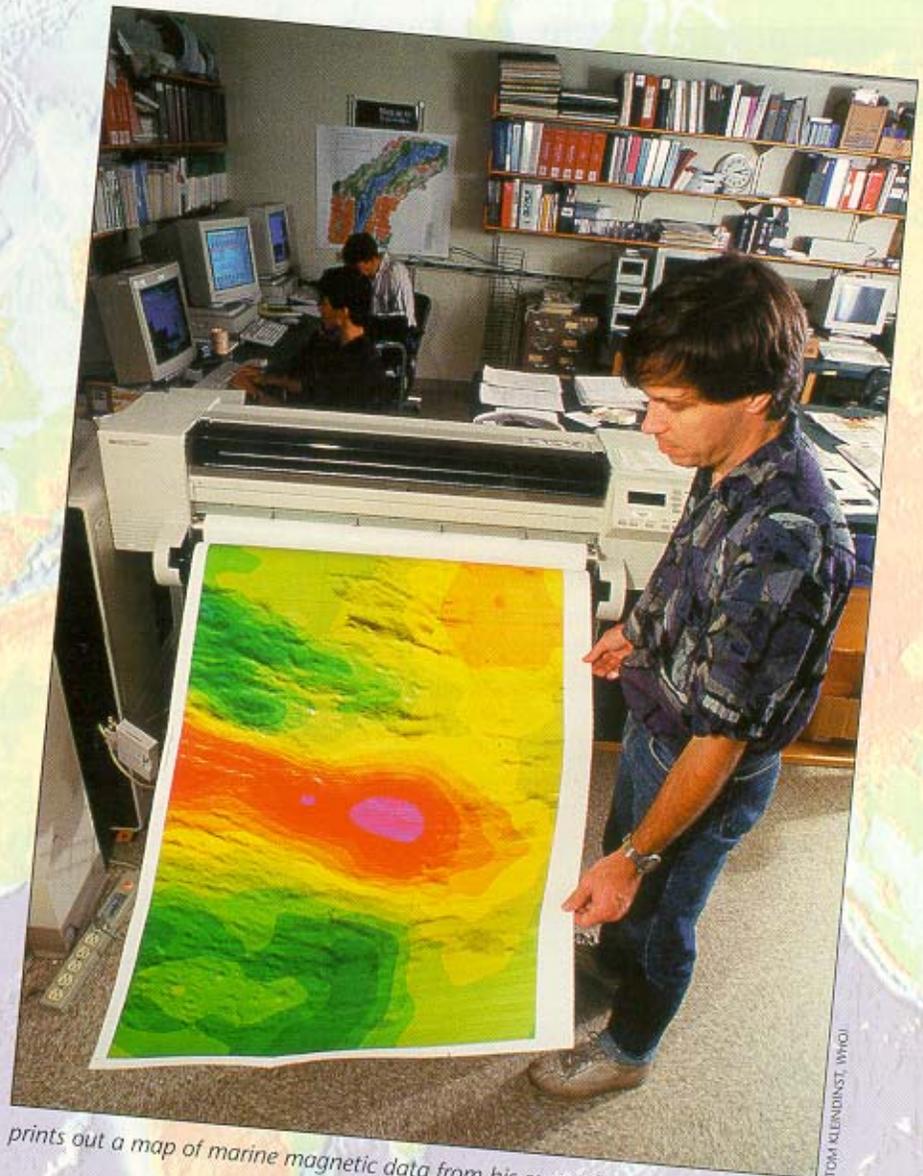
TOM KLINDINST, WHOI

► Marine geologist Maurice Tivey teaches a graduate class...

T WORK

computer, corresponding with other scientists in North America and abroad by electronic mail, writing proposals for funding of research they would like to do, composing reports on work they have completed, constructing laboratory or cruise research plans, and using computer modeling in their work. (Some marine scientists concentrate on computer modeling and can conduct most of their research at their home institutions.)

These scientists also teach classes, advise graduate students, supervise laboratory assistants and engineers who design and build their instruments, and serve on committees for their departments and institutions. They report on their work in discussions, lectures, and papers they write for research journals. Time must also be found to read the journals in their own and related fields in order to stay on the cutting edge of their science. They participate in the peer-review process by reviewing papers



TOM KLINDINST, WHOI

prints out a map of marine magnetic data from his research...

other scientists have submitted to journals and by writing recommendations for colleagues who are being considered for promotion at their own and other institutions.

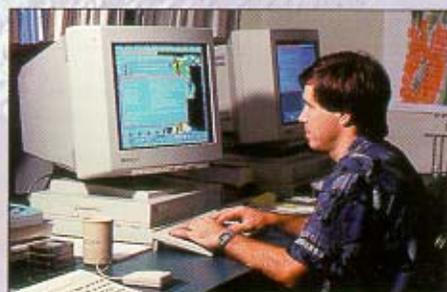
Though they have chosen very

demanding careers that often require time beyond the standard work day or week, most marine scientists are enthusiastic about the intellectual challenges they meet as they gain new knowledge about our planet.



WILFRED BRYAN, WHOI

emerges from a dive in Japan's Shinkai 6500 submersible...



TOM KLINDINST, WHOI

works with data and images at his computer terminal...



TOM KLINDINST, WHOI

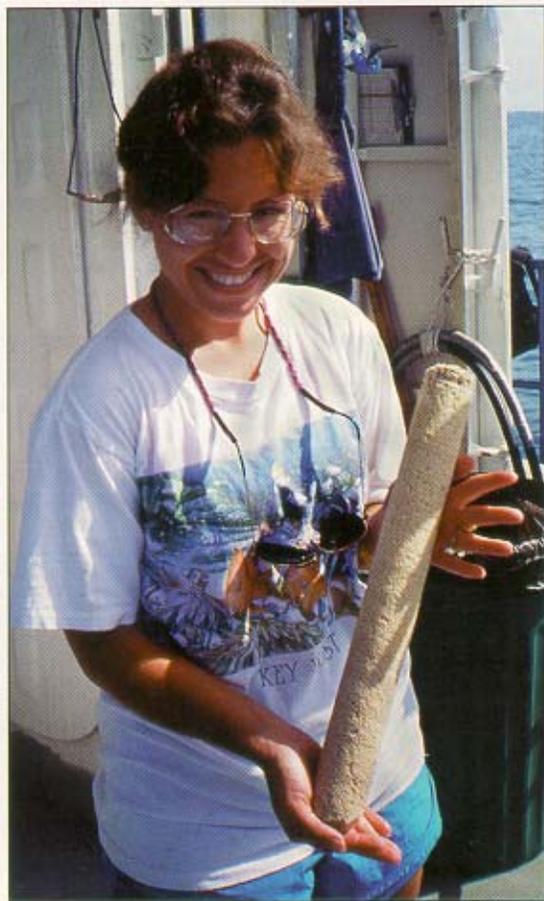
and takes a break with colleagues on the soccer field.

FINDING A JOB

Joining professional organizations while still a student is strongly recommended.

The best place to start looking for a job in oceanography and marine-related fields is your school or college career placement office. In addition, there are advertisements for jobs in major science periodicals such as *Science*, *Chemical and Engineering News*, *Nature*, and in such professional society publications as the American Geophysical Union bulletin *EOS*. You might also want to write to one or more of the institutions listed in the resources on page 9. There is no central employment clearinghouse for prospective oceanographers, but you can write to The Oceanography Society, the American Society of Limnology and Oceanography, or the American Geophysical Union who can provide you with some information. Jobs are often listed on electronic bulletin boards.

As in most fields, networking provides leads about available positions. Networks are groups of people with common interests and goals (such as promoting science careers for minorities and disabled individuals) who communicate with each other for their mutual benefit.



Study of cores drilled from coral provide information on seafloor geological history and on sea-level rise and fall.



DAVE GRAY, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Officers and crew members work aboard oceanographic research vessels like this one and on a variety of commercial and military ships.

A prospective oceanographer will benefit from membership in oceanographic organizations and societies. The publisher of this document, The Oceanography Society, offers low student membership rates so that students can become aware of what is happening in the field from *Oceanography Magazine* and other society publications. The American Geophysical Union, which has an Ocean Sciences Section, and the American Society of Limnology and Oceanography welcome students, as do many other groups noted in the resources on page 15. You might also contact the National Marine Educators Association, the Women's Maritime Association, the Association for Women Geoscientists (AWG), the Women's Aquatic Network, Inc., or the Association for Women in Science (AWIS). If you are interested in having a career in oceanography, you should consider joining one or more of these societies.

For the more engineering-oriented, the Marine Technology Society, the Ocean Engineering Section of the Institute of Electric and Electronic Engineers, and the American Society of Mechanical Engineers welcome students. The National Ocean Industries Association also has helpful information. These organizations provide information about job opportunities primarily through advertisements in their publications. Joining one or more of these professional organizations while still a student is strongly recommended because of the special rates.

Maritime Trade and Industry Associations

American Association of Port Authorities

1010 Duke Street, Alexandria, VA 22314

American Bureau of Shipping
65 Broadway, New York, NY 10006

American Institute of Merchant Shipping
1625 N Street, NW, Washington, DC 20006

American Maritime Association
17 Battery Place North, Room 944-52, New York, NY 10004

American Petroleum Institute
1220 L Street, NW, Washington, DC 20005

American Pilots Association
2000 H Street, NW, Washington, DC 20006

The American Waterways Operators
1600 Wilson Boulevard, Suite 1000, Arlington, VA 22209

Federation of American-Controlled Shipping
25 Broadway, New York, NY 10004

Institute of Electric and Electronic Engineers
Ocean Engineering Section, Institute of Navigation, 815 15th Street, NW, Suite 832, Washington, DC 20005

Lake Carriers' Association
915 Rockefeller Bldg., 614 Superior Avenue, West, Cleveland, OH 44113

Maritime Association of the Port of New York
17 Battery Place, New York, NY 10004

Maritime Service Committee
11 Broadway, Room 1712, New York, NY 10004

National Maritime Council
1748 N Street, NW, Washington, DC 20036-2997

National Ocean Industries Association
1050 17th Street, NW, Suite 700, Washington, DC 20036
(202) 785-5116

New York City Ports & Terminals
Battery Maritime Building, New York, NY 10004

New York Shipping Association, Inc.
80 Broad Street, New York, NY 10044

Pacific Maritime Association
635 Sacramento Street, San Francisco, CA 94111

Port Authority of New York and New Jersey
1 World Trade Center-34S, New York, NY 10048

Shipbuilders Council of America
Watergate 600, Washington, DC 20037

Society of Naval Architects & Marine Engineers
601 Pavonia Avenue, Jersey City, NJ 07306

Transportation Institute
5201 Auth Way, Camp Springs, MD 20746

U.S. Maritime Administration
400 7th Street, SW, Washington, DC 20590

Port Authority of New York and New Jersey
Mr. Paul Bea, Washington Representative, 1001 Connecticut Avenue, NW, Suite 610, Washington, DC 20036



Ship officers and crew work together to bring cargo, passengers, or scientific data to port safely.

SHELLEY LAUZON, WOODS HOLE OCEANOGRAPHIC INSTITUTION

INFORMATION FOR PEOPLE WITH DISABILITIES

If you are committed to exploring oceanography as a potential career, you should pursue it aggressively.

Success in oceanography or any marine-related field of science, technology, or policy requires rigorous and demanding study. This should not discourage anyone who truly wants to become a successful oceanographer. Individuals with disabilities can have rewarding careers in most areas of shipboard or laboratory work, data analysis, marine policy, and environmental protection.

There are almost certainly some jobs, particularly in shipboard fieldwork, that individuals with specific disabilities might not be able to perform, for example, diving. A physical or sensory disability might require you to delegate certain tasks to someone else, but need not prevent you from becoming an outstanding scientist or engineer. Career exploration can be a lengthy and challenging process for anyone. Many individuals with disabilities learn to manage their



CAL WHITE, UNIVERSITY OF ALASKA FAIRBANKS

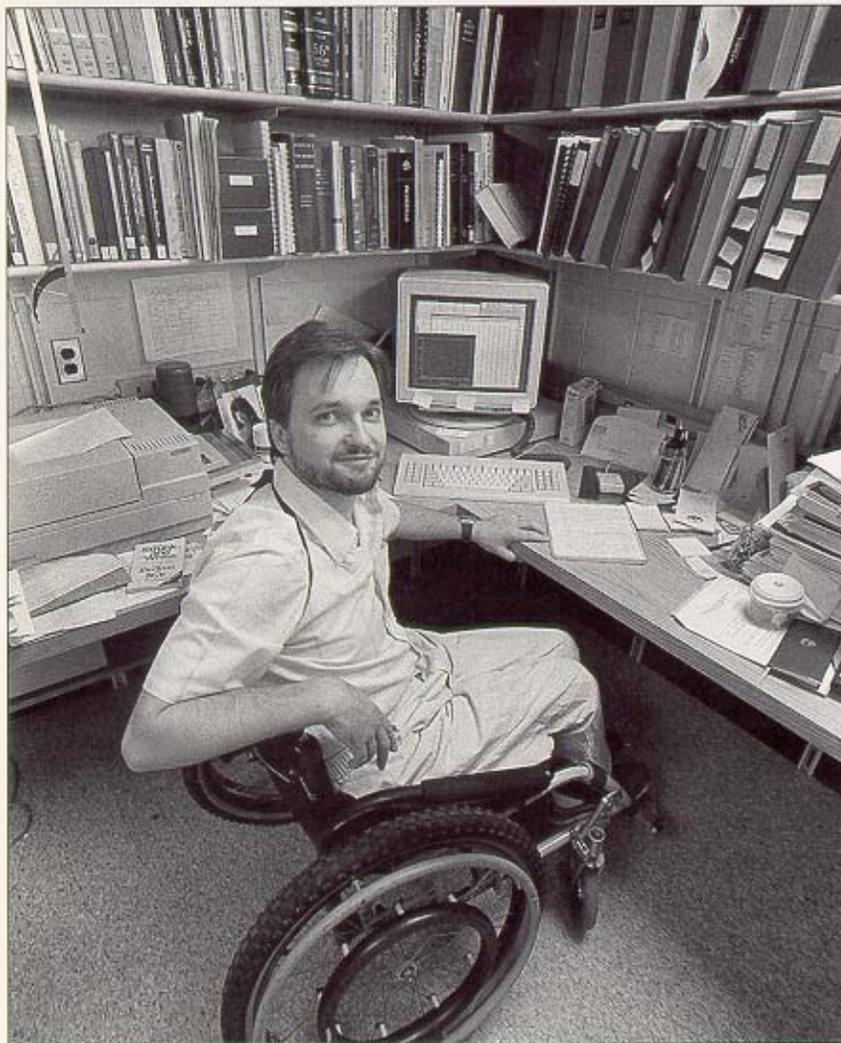
A technician examines the stomach contents of a juvenile pink salmon for studies of the animal's feeding habits.

disabilities so that they do not put unnecessary limits on their career decisions.

If you are committed to exploring oceanography as a potential career, you should pursue it aggressively. The Americans with Disabilities Act passed by Congress and signed by the President in 1990 ensures equal treatment under the law, and science funding agencies provide support for special equipment as well as appropriate personal assistance for scientists with disabilities.

Part of being a good candidate for the job of your choice is to have made contacts with people and organizations in oceanography, marine sciences, and engineering. You can begin by contacting the organizations listed in the references. Other scientists with disabilities can help you determine which careers might be open to you.

The book *Able Scientists—Disabled Persons: Careers in the Sciences* (see next page) gives profiles of 27 scientists and science students with disabilities, most of whom can be contacted through the Foundation for Science and the Handicapped. Two other organizations that can provide information about successful scientists with disabilities are the American Association for the Advancement of Science and the Association for Science and the Handicapped. All three of these organizations are good sources of information about science education and careers for persons with disabilities.



TOM KLEINDINIST, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Research laboratories and offices can comfortably accommodate scientists with disabilities such as this researcher who works from a wheelchair.

Sources of Information for People with Disabilities

Organizations

Advocates for Children of New York

24-16 Bridge Plaza South, Long Island City, NY 11101, (718) 729-8866

Alexander Graham Bell Association for the Deaf

3417 Volta Place, NW, Washington, DC 20007, (202) 337-5220 Voice/TTY

Association for Science and the Handicapped

c/o Ben Thompson, University of Wisconsin at Eau-Claire, Eau-Claire, WI 54701

Association on Higher Education & Disability

P.O. Box 21192, Columbus, OH 43221, (614) 488-4972

Easter Seal Society for Disabled Children and Adults, Inc.

2800 13th Street, NW, Washington, DC 20009, (202) 232-2342

Foundation for Science and Disability

236 Grand Street, Morgantown, WV 26505, (304) 292-4554 or (304) 293-5201

Higher Education and Adult Training for People with Disabilities Resource Center

National Clearinghouse on Postsecondary Education for Persons with Disabilities, 1 DuPont Circle, NW, Suite 670, Washington, DC 20036-1193, (202) 939-9320 or (800) 544-3284

National Association of Developmental Disability Councils

1234 Massachusetts Avenue, NW, Washington, DC 20005, (202) 347-1234

The National Easter Seal Society, Inc.

230 West Monroe Street, Suite 1800, Chicago, IL 60606-4802 (312) 726-6200 Fax (312) 726-1494, TDD (312) 726-4258

National Organization on Disability

2100 Pennsylvania Avenue, NW, Washington, DC 20037, (202) 293-5960

U.S. Naval Oceanographic Office Handicapped Employment Coordinator, Stennis Space Center, MS 39552-5001, (601) 688-4460

Paralyzed Veterans of America National Office, 801 18th Street, NW, Washington, DC 20006, (202) 872-1300

Special Services Branch, Division of Student Services Programs

Box 23772, L'Enfant Plaza Station, Washington, DC 20026-3772
For the location of the nearest Talent Search and Educational Opportunity Center call (202) 245-2165.

Reference Books, Articles and Financial Aid Information

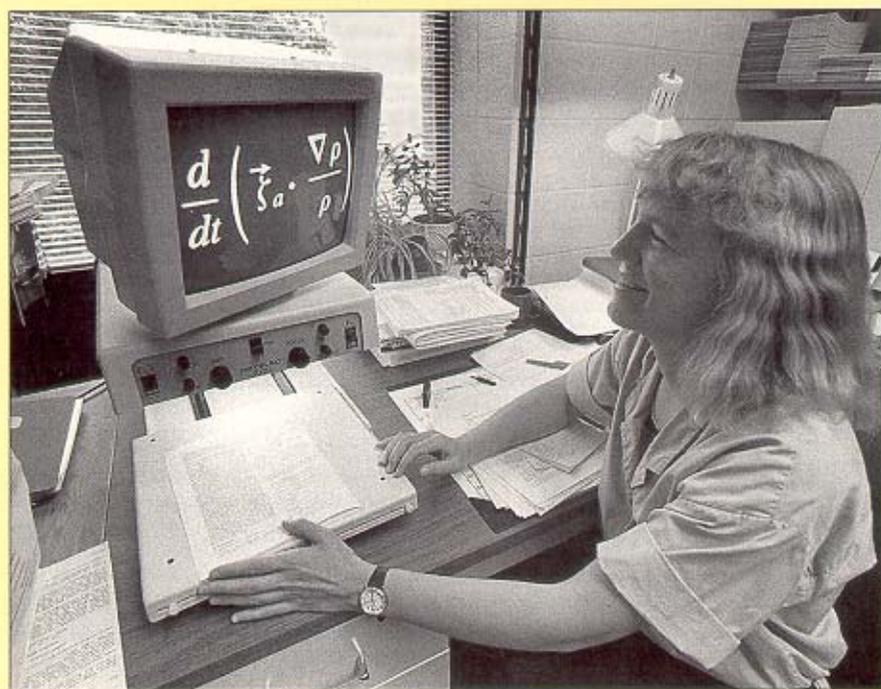
► *Resource Directory of Scientists and Engineers with Disabilities*. Contains 950 listings of individuals in all fields of science and is cross-referenced by scientific specialty, disability, geographical location, and gender. The directory is available for \$10.00 plus \$3.00 postage from the American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005. (202) 326-6671 (voice/TDD).

► *Able Scientists—Disabled Persons: Careers in the Sciences*, by S.P. Stearner, 1984. John Racila Associates, Inc., Oakbrook, IL. 65 p. Available for \$12.95 from: Dr. E.C. Keller, Jr., 236 Grand Street, Morgantown, WV 26505

► *Financial Aid for the Disabled and their Dependents*. A comprehensive listing of financial aid programs established primarily for disabled individuals and their dependents. Available for \$30 (pre-payment) from Reference Service Press, 3540 Wilshire Blvd., Suite 310, Los Angeles, CA 90010.

Each state has a vocational rehabilitation agency. These agencies are often the primary source of financial aid for disabled students going to college. Applicants for vocational rehabilitation aid must demonstrate financial need and have a reasonable chance of obtaining employment after graduation. Vocational rehabilitation offices can also provide career guidance and job placement assistance.

A list of organizations that provide scholarships for students with disabilities is available from the Higher Education and Handicapped Resource Center, One Dupont Circle, Washington, DC 20036. (800) 544-3284. This organization also serves as a clearinghouse for information about colleges for the disabled student.



Large type on a computer screen aids the work of a physical oceanographer.

WOMEN & MINORITIES IN THE OCEAN SCIENCES

Positions and education in the ocean sciences are open to all.

A scientist and a graduate student conduct a study of phytoplankton's response to iron-level changes in their ocean environment.



BROOKHAVEN NATIONAL LABORATORY

Positions and education in the ocean sciences are open to all. There is no single source of information about activities for women and girls or for minorities in science, engineering, and mathematics. The National Science Foundation, other government agencies, and professional societies provide funds for projects that encourage these groups in science, engineering, and mathematics. The projects are sponsored by such diverse organizations as schools, community groups, museums, science centers, colleges and universities, and partnerships among these, businesses, and others. Students interested in programs for minorities and women will need to contact such organizations in order to find appropriate programs. They may range from summer science camps for junior-high-age minority students, after-school activities for fourth-and-fifth-grade girls, and research assistantships for minority high-school students to undergraduate research experience programs and seminars that encourage undergraduates to proceed on to graduate education.

Resources

American Society of Limnology and Oceanography (ASLO)

Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA 23062, (804) 642-7000—Supports minority participation in the society.

Association For Women Geoscientists
4779 126th Street North, White Bear Lake, MN 55110-5910

Association for Women in Science
1522 K Street, NW, Suite 820, Washington, DC 20005, (202) 408-0742

Minority On-Line Information System (MOLIS)

Internet connection can be made directly or through the FEDIX system (800) 783-3349, login "fedix"

National Research Council
2101 Constitution Avenue, Washington, DC 20418. (Booklet, edited by Davidson and Skidmore provides contact information and national conference dates for more than 150 organizations and committees.)

Society of Environmental Toxicology and Chemistry (SETAC)
1010 N 12th Avenue, Pensicola, FL 32501, (904) 469-1500. Has a program to bring minority undergraduate students to national meetings.

The Environmental Careers Organization

(206) 625-1750. National nonprofit organization identifies internships for university undergraduates.

The Society of Women Engineers
120 Wall Street, 11th Floor, New York, NY 10005-3902

Women's Aquatic Network, Inc.
P.O. Box 4993, Washington, DC 20008

Women's Educational Equity Act Publishing Center
Education Development Center, 55 Chapel Street, Suite 200, Newton, MA 02160 (catalog of print resources on opportunities for girls in science and math)

Women's Fisheries Network
2442 NW Market Street, #243, Seattle, WA 98107

The Women in Engineering Program Advocates Network
1284 CIVL Building, G-296, Purdue University, West Lafayette, IN 47907-1284 (WEPAN maintains a comprehensive list of activities for young women sponsored by engineering schools throughout the U.S.)

Women's Maritime Association
P.O. Box 743, 1916 Pike Place #12, Seattle, WA 98101

New England Program Directory/ Biomedical Science Careers Project
Minority Faculty Development Program, Harvard Medical School, 164 Longwood Avenue, Room 310, Boston, MA 02115, (617) 432-2413

Society for the Advancement of Chicanos and Native Americans in Science

Sinsheimer Laboratories, University of California, Santa Cruz, CA 95064. (Internet bulletin board available.)

Summer Enrichment 1994—A Guide to Summer Programs
California State University, Sacramento Science Educational Equity Program, Sacramento, CA 95819-6077

Winds of Change Magazine
(Publication of the American Indian Science and Engineering Society)
AISES Publishing, Inc., 1630 30th St., Suite 301, Boulder, Co 80301-9547

Note: Marine education institutions in 17 states and Bermuda sponsored National Science Foundation funded minority programs in 1994. Geographically they ranged from Alaska to California and Massachusetts to Florida. Such programs are funded for varying lengths of time, and students are encouraged to contact institutions of interest to them to determine whether they may have a current program.

CURRENT MARKET OUTLOOK

As with any field, students should be realistic about employment possibilities in oceanography. You should be wary of exaggerated claims about career opportunities, recognizing that career opportunities depend on market demand and competition. Job opportunities are enhanced if you enter a field where demand is great and supply is low or if your credentials are outstanding.

Currently (in the early 1990s) the greatest demand in oceanography and marine-related fields is for physical and chemical oceanographers and for ocean engineers. The supply of such students has been low in these areas, so they now offer more opportunities. Conversely, biological oceanography attracts many people, hence the competition is strong. As a consequence, there is the possibility of an oversupply of graduates in this area. But demand and supply can change and are difficult to predict, especially in the rapidly changing post Cold War world. For example, the demand for geological and geophysical oceanographers may vary depending on the state of the offshore oil market. You should talk to your school counselor about the most recent situation.

Even though the number of openings within each job category may be small, there are many types of jobs available. Currently, job opportunities are good for marine technicians, but the competition is increasing and better trained or more experienced applicants have the advantage. Graduates who have experience in or have done research that covers more than one field of science usually have a better chance of obtaining employment than those with experience in just a single field of science.

Growth is expected in the market demand for oceanographers over the next 20 years. The great and growing interest in understanding and protecting the global environment will create new jobs. The full impact of the 1983 expansion of the U.S. Exclusive Economic Zone has not yet hit the marketplace. It is expected to create new employment opportunities, particularly in engineering and technical fields, as well as in fisheries. The long-term result will probably be an increase in exploratory geology beneath the ocean. Career opportunities related to fisheries resources, including basic research in biology and chemistry as well as mariculture



R. BROWNE, MONTEREY BAY AQUARIUM RESEARCH INSTITUTE

and sea ranching, will also increase.

Another area of oceanography that is expected to see an increase in job opportunities is remote sensing, gathering of data by a system that can be far away from what is being observed—aircraft and satellites are good platforms for remote sensing. Satellite data on ocean circulation patterns, currents, waves, ocean color, and sea ice are providing new ways of looking at the ocean. Sound waves can also be used to remotely sense changes in the ocean. Data obtained in this way is being used for making more precise weather and oceanic forecasts, and there are new demands for improved measurements. The data can also tell us about changes in climate and in the abundance and distribution of fish stocks and marine mammal populations. These new techniques offer new career opportunities.

The data systems for gathering, maintaining, and disseminating remotely sensed data must be continually improved and expanded. New products and services will be required. Oceanographic data collection and interpretation will become more dependent

A remotely operated vehicle is launched from a research vessel. People with a variety of job titles are involved with such a vehicle, including scientists, design engineers, marine technicians, and ship's crew.

CURRENT MARKET OUTLOOK

Research and public policy opportunities related to environmental and coastal issues will also increase.

on computers and mathematical modeling. Scientists with backgrounds in mathematical modeling will be among those most highly sought. Computer programming is also another important area for job opportunities.

Research and public policy opportunities related to environmental and coastal issues will also increase. Oceanographers will be needed to help forecast and solve the major problems of global change. Two other areas that are expected to grow and provide jobs in the near future are aquaculture (fish and shellfish farming and cultivation of other natural marine products) and marine biotechnology (see definition on page 2).

Future employment opportunities in the area of national defense are expected to be good. The Navy, for example, will continue with its global reach, but will also have a focus on coastal areas. Shipboard and shore-based computer support of the fleet includes systems for submarine detection and meteorological and ocean current forecasting. These allow the Navy to make rapid tactical decisions, and they will need to be expanded and improved. More information in this area can be found in the booklet *Oceanography and Your Career* (see resources on inside back cover).

There will be a growing demand for graduates who can investigate a problem involving more than one discipline (such as

biology, chemistry, and physics).

The following sections offer a fuller discussion of some areas of growing interest to society and to science that are likely to offer employment opportunities in coming years.

The Coast

From 1950 to 1984, the population in coastal counties of the U.S. grew by more than 80 percent. Forecasts suggest that within the next 50 years, more than three-quarters of the U.S. population will live within 50 miles of the coastline. Coastal waters and estuaries provide food and mineral resources for this growing population. They are the shelter and spawning grounds for almost two-thirds of the nation's commercial fisheries. Coastal waters and beaches are also an important recreational resource. But they can be threatened by waste products from urban, suburban, and rural areas. It is important that we conserve and protect this environment, and at the same time provide for the growing human population there. Because of the importance of properly understanding and managing our coastal waters, there are many opportunities for employment, ranging from research to environmental protection activities involving science, engineering, and policy and management.



Fisheries science students use a suction sampler to study blue crab densities in vegetated nursing habitats in Chesapeake Bay.

Coastal Warning and Prediction

Coastal areas provide a wealth of resources, but can be endangered by severe storms. Tropical storms, hurricanes, and their associated floods and other damage are frequent. In 1992, one of the strongest hurricanes of the century, Andrew, devastated the coast of Florida and the southeastern United States. Its effects emphasized the need to understand and prepare for coastal responses to major storm systems, including storm surges, floods, and changing sea levels.

Many of the most dangerous storm systems develop at sea and move inland, threatening coastal areas. In October 1987, Europe was suddenly engulfed by a severe storm that developed in just a few hours over the mid latitudes of the ocean. The role of the ocean in the origin and development of such "explosive" storms is not understood. Job opportunities here include research related to weather and storm prediction, floods, sea level changes, and storm surges; designing and constructing structures that can withstand severe storms; and assessing the environmental impacts.

The Exclusive Economic Zone

Coastal areas contain many resources and have many important effects on adjacent nations. To protect these resources, the U.S. and other nations have declared Exclusive Economic Zones (EEZ), defined as the seabed and subsoil up to 200 miles off the coast. The U.S. EEZ is one of the largest in the world, measuring more than 2.3 million square nautical miles and including 15 to 20 percent of the world's fisheries. The strategic importance of several EEZ minerals, including cobalt, chromium, manganese, and platinum, is a strong reason for the U.S. to continue scientific research and exploration of its EEZ. The U.S. will also continue to monitor and develop this new offshore public domain.

Oceans and Global Climate

The need to understand and cope with global environmental change has given new urgency to understanding the oceans, both regionally and globally. The possibilities of global warming and sea level rise have been highly publicized. We need to know how much and how fast Earth will warm with increasing concentrations of atmospheric gases such as carbon dioxide. We know that



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the concentrations of these gases are increasing, and today's climate models indicate that warming and sea level rise should occur. However, there are still large uncertainties in these predictions.

The ocean is an important part of Earth's climate system, but its role is not fully understood. Recent computer modeling shows that the ocean will probably delay global warming. How does this take place? What processes are involved? What role do living organisms, both on land and in the ocean, play in the uptake of carbon dioxide? The complexity of Earth's climate system makes these hard questions to answer, but it is important that we search for answers.

Earth's climate system includes the atmosphere, ocean, ice, solid earth, and all living organisms. The ocean is important in the cycling of elements between the different parts of the Earth system. Water from the ocean evaporates to form clouds and returns to the ocean as rainfall and runoff from the land, completing the hydrological cycle. Such cycles are important to the climate and life on Earth.

Since we cannot yet fully describe or predict ocean behavior, we are not yet able to adequately predict weather and climate change. To help improve our understanding, major new ocean research and observation programs are being planned and carried out. There are opportunities for research in physical, chemical, and biologi-

An aquarium staff member cares for orphaned sea otter pups. In addition to working with animals, aquarium staff assemble exhibits and programs that interpret marine subjects for their visitors.

CURRENT MARKET OUTLOOK

The fisheries industry offers career opportunities that include work aboard fishing boats.



TOM KLEINDINST, WOODS HOLE OCEANOGRAPHIC INSTITUTION

cal oceanography and in forecasting, engineering, and public policy related to global climate change.

Energy and Mineral Resources

The oil, gas, and mineral resources in our coastal waters are essential to our national economy and security. Since the first oil well was drilled off California's coast in 1896, a number of oil and gas reserves have been discovered in the oceans off many countries. The revenue derived from these resources is growing. The \$100 billion annual revenue from offshore oil in 1990 was double that of 1980.

A number of nonenergy marine minerals are now recognized to be commercially valuable. Sand and gravel account for about 40 percent of the total value of offshore mineral production; calcium carbonate, tin, and sulfur are also important. Metal sulphide deposits recently discovered at undersea hydrothermal vents may be another source of strategically important minerals in the future. But even today, little is known about the extent and grade of the minerals in coastal regions or about the potential environmental impacts of recovery.

On a global scale, the solid earth processes

that lead to the movements of continental plates determine the location of mineral and energy resources. Many of these processes occur at the mid-ocean ridges and continental margins. Oceanographers studying Earth's crust beneath the ocean are gaining a new understanding of the processes that generate volcanoes, earthquakes, and Earth motion in general; they hope to be able to more accurately determine the distribution of mineral and energy resources around the world. Some of the Earth's remaining unexplored giant oil fields may lie beneath the oceans. Understanding the processes that affect the evolution of continental margins is critical in deciding where to focus new exploratory efforts.

There are many career opportunities related to marine mineral resources, ranging from scientific research in marine geology and geophysics to oil exploration, minerals policy issues, and environmental protection and cleanup.

Fisheries and Marine Biotechnology

Fish are an important part of our national diet and of the U.S. economy, providing jobs in both production and the export industry.

CURRENT MARKET OUTLOOK

We need to understand more about how fish grow and are distributed and how they respond to changing climate and fishing patterns. Biological and chemical oceanographers help us understand the processes of oceanic food webs, including the roles of many plants and animals, from microplankton to whales.

The study of marine plants and animals may also help us understand other biological systems. For example, much of our knowledge about the human nervous system has come from the study of squid. Marine biotechnology, a field using technical advances to develop new drugs and other beneficial materials from the sea, offers a number of career opportunities.

Biological and chemical oceanography, marine biology, marine biotechnology, and study of fisheries can offer exciting, satisfying careers. Competition in these fields is high, but there are many related jobs dealing with fisheries that may include research, food production, and public policy.

Marine Pollution

The ocean is one of the major recipients of discharges from the land, water, and atmosphere. As waste disposal sites on land are filled, the ocean is increasingly being used for direct waste disposal. Pipeline discharges, sewage outfalls, and ocean dumping are of special concern. Pollution of estuarine and coastal waters has drawn increasing attention from the media and the public. Toxic and contaminated wastes are taking a growing toll on the ocean.

Continuing damage from pollution, development, and natural forces raises serious questions about the future health of coastal areas. We need to gain a better understanding of coastal systems and take action to reduce both the effects and causes of pollution. We must know how contaminants are transferred to marine plants and animals and what are their ultimate fates in the ocean. Today, permanent ocean waste disposal sites are being considered, but safe development and use will depend on a better understanding of ocean chemistry and biology as well as the geological processes at the seafloor.

Jobs dealing with marine pollution are available in a number of areas, including research, engineering to reduce pollution, impact studies, cleanup of polluted coastal

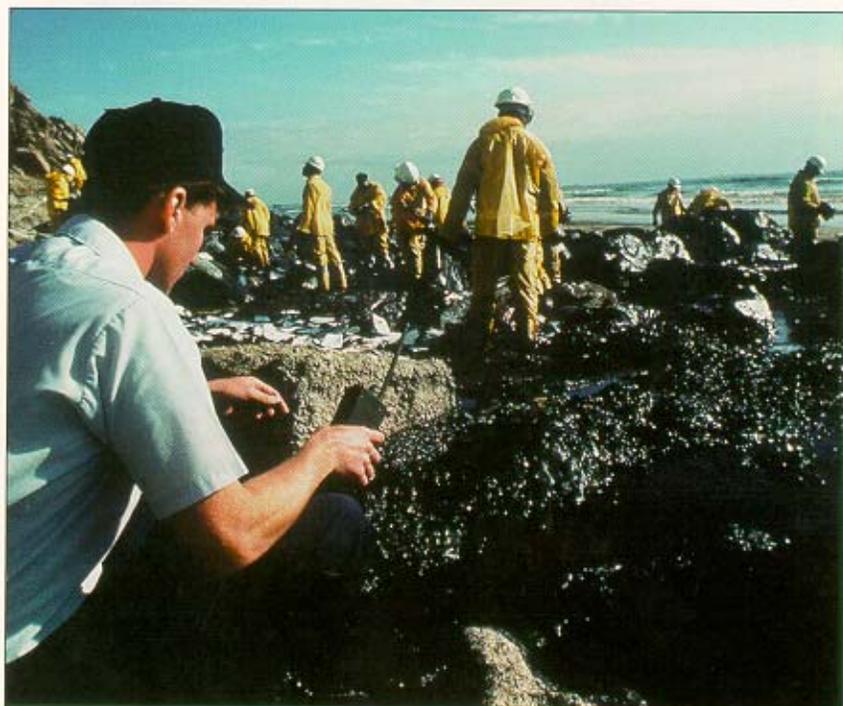
areas, and public policy. Pollution is both a national and an international problem, so related jobs will be available around the world.

Engineering and New Technology

The problems of studying a complex system like the ocean have long been recognized, but until relatively recently we have not had the technology required to adequately observe such a huge system, and we have lacked the computing capability to properly analyze the data and design mathematical models. However, recent engineering developments have led to new oceanographic tools. These include remotely-controlled vehicles, satellite-borne instruments, instruments for measuring trace chemicals, particle samplers, acoustic techniques, long-life buoys and floats, seafloor seismometers, and bottom stations. New computing techniques and computers facilitate the processing and analysis of data and the construction of models. These new techniques will greatly enhance our understanding of how the ocean works in the Earth system and will be used in all oceanographic disciplines.

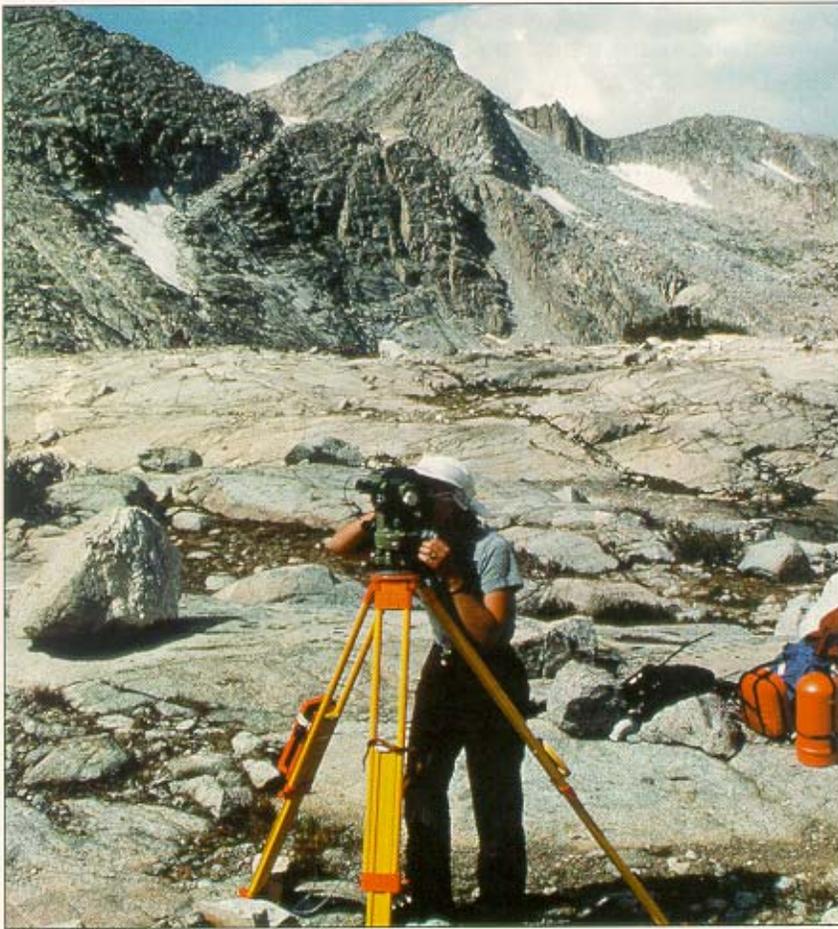
Many of these new techniques, for example, satellites, allow oceanographers to collect data without having to go to sea. Thus there are new marine-related career opportunities for those, including many disabled

Coast Guard career possibilities include jobs involved with cleaning up, investigating, and assessing penalties for marine pollution.



U.S. COAST GUARD

CURRENT MARKET OUTLOOK



Ocean scientists sometimes work on land in areas that once were oceans.

persons, who cannot undertake a physically demanding job. The development of new technology and finding of new applications for existing technology will continue to be areas of employment opportunity.

Exploration

Until recently, the major shipwrecks of the past have lain undetected beneath the sea. But now, using sound waves and television, it is possible to detect and explore these ships and their artifacts, even at great depths. After locating a ship, an unmanned remotely-controlled vehicle can be used to explore the wreck and recover the artifacts. The *Titanic* was found and explored in this way, as was the German battleship *Bismarck*. Wrecks of galleons, ships used in the slave trade, and other types of ships are being discovered and studied at an unprecedented rate.

Ocean salvage companies use a variety of new techniques, and their findings can yield information about ancient cultures. The coins, jewelry, iron tools, weapons, and pottery recovered from shipwrecks of ancient trading

vessels can tell us much about their original owners' cultures. There are opportunities for archaeologists, other scientists, and engineers, as well as entrepreneurs in this field.

National Defense

Defense at sea has become fully global with new political changes around the world and new technical developments. The coastal ocean provides a region of security for our country. The Coast Guard patrols this area and supports polar operations. The Navy's work environment is the ocean, and it depends on accurate knowledge of the ocean to deploy its ships, submarines, and amphibious craft most effectively. The seafloor promises to be an important source of strategic minerals, another aspect of national security. The Navy has a strong interest in oceanography and marine-related fields, including cartography and the astrometric activities of the Naval Observatory, and offers many career opportunities.

International Oceanography

Oceanography is a subject that lends itself to global studies. In the past decade, there has been a growing tendency toward international cooperation and funding of large programs. The birth of oceanography as a science is often traced back to the British *Challenger* expedition of 1872-1876. Those early global studies laid the foundation for today's description of the ocean, and they provided oceanographers with a mode of operation based largely on international cooperation.

The growing interest of coastal states and nations in their Exclusive Economic Zones is international. The U.S. has strong interests in protecting its EEZ, as do other countries. Oceanographers have found that international recognition of oceanographic programs is essential if the research involves coastal waters.

A number of jobs are available having to do with international marine policy issues. Those with skills in foreign languages and diplomacy who enjoy working with diverse cultures may find this to be a rewarding area. With the rapidly changing political situation around the world, there will undoubtedly be new arrangements and opportunities for international science and policy work.

Career Guides in Oceanography and Related Fields

Many of these resources may be available in the careers section of your local library. Single copies still in print are free from the sources noted unless otherwise stated.

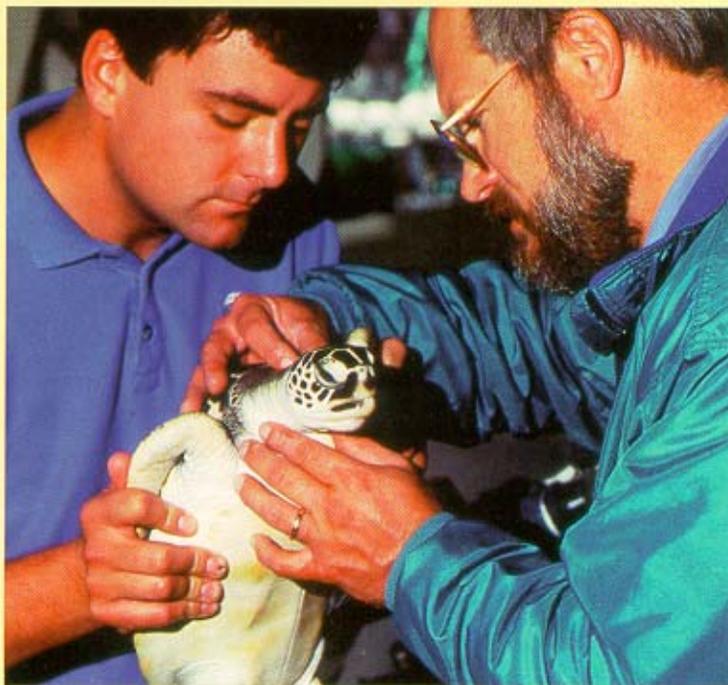
Guides

- ▶ *American Offshore Oil: Obstacles and Opportunities*. 1983. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. 8 pages. (202) 682-8000.
- ▶ *Careers in NOAA: A Career Development Aid for NOAA Employees*. 1984. National Oceanic and Atmospheric Administration, Silver Spring, MD 20910.
- ▶ *Geophysics in Petroleum Exploration*. 1984. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. 24 pages.
- ▶ *Marine Careers* (audiovisual program). Sea Grant Marine Advisory Service, College of Marine Studies, University of Delaware, Newark, DE 19716, (302) 451-8083 or (302) 645-4346. \$5 rental fee.
- ▶ *Marine Career Series: Marine-Related Occupations, A Primer for High School Students* by PAGESK. Stout. rev. 12/90. Rhode Island Sea Grant, University of Rhode Island, Narragansett, RI 02882. 20 pages
- ▶ *NOAA Careers and Challenges and the NOAA Corps: Careers in Science and Service*. National Oceanic and Atmospheric Administration, 11400 Rockville Pike, Rockville, MD 20852.
- ▶ *The Oceans and You*. Marine Technology Society, 1828 L St., NW, Suite 906, Washington, DC 20036.
- ▶ *Oil, Gas, and the Challenge of the Arctic*. 1984. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005, (202) 682-8000. 24 pages.
- ▶ *Opportunities in Oceanography*. Smithsonian Press, Smithsonian Institution, Washington, DC 20560. \$1.25.
- ▶ *Preparing for a Career in Oceanography*. Aquarium Bookshop, University of California, San Diego, Bookstore, 9500 Gilman Drive, La Jolla, CA 92093-0208. 4 pages. \$2.00 (incl. shipping & handling)
- ▶ *Science Centers...Places for the Imagination*. Association of Science-Technology Centers, 1025 Vermont Avenue, NW, Suite 500, Washington, DC 20005. 6 pages.

- ▶ *Training and Careers in Marine Science*. Information packet on current research, jobs, educational pathways, and other topics. International Oceanographic Foundation, 4600 Rickenbacker Causeway, Virginia Key, Miami, FL 33149. 16 pages. \$5.
- ▶ *Vocational-Technical Marine Career Opportunities in Texas* by D. Hollin. 1981, update 6/93. Sea Grant College Program, Texas A & M University, 4700 Avenue U, Bldg 306 2nd Floor, Galveston, TX 77551. 22 pages.

Reference Books

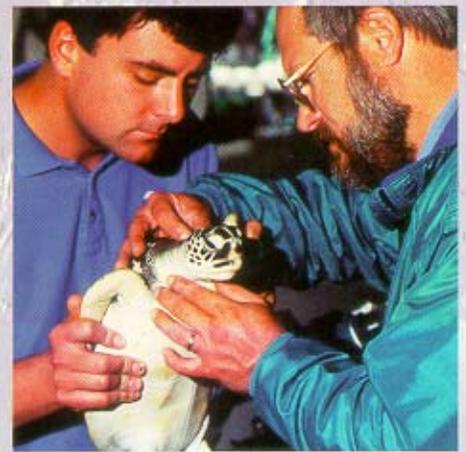
- ▶ *Current Aquatic Occupations* by A.B. Rechnitzer. Published quarterly by the National Marine Education Association, Box 666, Narragansett, RI 02882.
- ▶ *Dictionary of Occupational Titles*. Bureau of Employment Security-Manpower Administration, Washington, DC (updated annually).
- ▶ *Environmental Opportunities*. PAGESO. Box 788, Walpole, NH 03608. Sponsored by the Environmental Studies Department, Antioch New England Graduate School, Keene, NH 03431. 6 months/\$26, 1 year/\$47, (603) 756-4553.
- ▶ *Oceanography and Your Career*. Department of the Navy, Naval Oceanographic Office, 1002 Balch Blv., Stennis Space Center, MS 39522-5001. 3 pages.
- ▶ *Environmental Scientists and Conservation Occupations*. Reprinted from the *Occupational Outlook Handbook*. U.S. Dept. of Labor Statistics, Bureau of Labor Statistics, Washington, DC; Bulletin 2205.
- ▶ *Information Concerning Employment and Training Opportunities in the U.S. Merchant Marines*. Government Printing Office, Washington, DC.
- ▶ *Merchant Marine Occupations*. 1993. Chronicle Guidance Publications, Inc., P.O. Box 1190, Moravia, NY 13118-1190
- ▶ *Museum Careers and Training: A Professional Guide* by Victor J. Danilov. 1994. Greenwood Press.
- ▶ *Occupational Outlook Handbook*. U.S. Dept. of Labor, Bureau of Labor Statistics, Washington, DC (updated annually).
- ▶ *Oceanographic Institutions: Science Studies the Sea* by Peter Limburg. 1979. Elsevier/Nelson Books, New York, NY.
- ▶ *Opportunities in Marine and Maritime Careers* by W.R. Heitzman. 1988. VGM Career Horizons - A Division of NTC Publishing Group, 4255 W. Touhy Ave., Lincolnwood, IL 60646-1975 (800) 323-4900



An aquarist and a veterinarian check a green sea turtle before placing it in an aquarium exhibit.



Careers in
Oceanography



and
Marine-Related Fields



The ocean,

covering more than 70 percent of Earth's surface, touches our lives in many ways. The ocean and the seafloor provide resources for society including food, minerals, and energy. The ocean strongly influences weather and is part of the global climate system. Most international commerce is carried out by ships at sea, and the ocean can be used in many ways for national defense. Many scientific discoveries are yet to be made. The importance of the ocean in all of these areas means that there are many career and employment opportunities in oceanography and marine-related fields.



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