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Introduction to the Special Issue on Graduate Education in the Ocean Sciences

By Susan B. Cook and Nancy H. Marcus

The articles and sidebars in this special issue of *Oceanography* highlight the opportunities and challenges facing today's ocean sciences graduate student community in securing the knowledge, skills, and tools needed to be successful professionals in a wide variety of careers, most of which will not be in an academic setting. To date, dissemination of data and ideas related to graduate education in the ocean sciences has been largely via Web-based reports and talks and posters at professional society meetings. This special issue provides a more formalized framework that captures a selection of community ideas and viewpoints. We hope the compendium will serve as a foundation and catalyst for collaborative action by ocean sciences faculty, administrators, and policymakers—and in many cases graduate students themselves. We urge everyone involved to work together to update curricula, develop innovative programs, and provide additional mentoring pathways and opportunities that will more effectively prepare students for satisfying careers that address today's pressing issues such as climate change, ocean stressors (e.g., fisheries, pollution), and natural hazards, to name a few.

Building on publicly available resources (both print and electronic) and data collected by and archived at the Consortium for Ocean Leadership in Washington, DC, the special issue section begins with **Cook et al.'s** description of the current graduate education landscape in the ocean sciences, including degree

PHOTOS (from left to right)
(1) Optics students sampling water at the Darling Marine Center dock, and enjoying some time in the sun. *Photo credit: Mary Jane Perry (University of Maine)*
(2) University of South Florida graduate student Michelle Guitard samples a kasten core collected near Totten Glacier, East Antarctica. *Photo credit: Amelia Shevenell (University of South Florida)*
(3) MIT-WHOI graduate student filtering water at sea for chemical analyses. *Photo courtesy of Woods Hole Oceanographic Institution graphics*
(4) PhD student Arvind Shantharam evaluating the effect of the BP oil spill on benthic invertebrate communities of the Florida Panhandle Bight. *Photo courtesy of Florida State University*
(5) University of Delaware faculty, undergraduates, and graduate students conducting seafloor habitat mapping off Assateague Island National Seashore aboard R/V *Joanne Daiber. Photo courtesy of University of Delaware Team Habitat Mapping*

Box 1. Vision Statement: The "Sea Change" Report

The ocean science community will undertake research and pursue discoveries that advance our understanding of the oceans, seafloor, coasts, and their ecosystems; foster stewardship of the ocean; reduce society's vulnerability to ocean hazards; and nurture and exploit the integration of the disciplines. A diverse and talented community of researchers will develop new technologies to study the ocean in novel and cost-effective ways and create innovative educational programs that will engage and inspire the next generation. Partnerships will be fostered across funding agencies, national borders, and the private sector to provide the greatest value for the nation's investment in ocean science.

– National Research Council (2015)

completions and program size, the balance between master's and doctoral programs, and the demographic characteristics of ocean science degree recipients. **Briscoe et al.** then provide historical insights into the evolution of graduate training programs in the ocean sciences. They highlight the need for a new paradigm, one that acknowledges an academic research career is just one of many options for PhD graduates, and they suggest several steps for faculty and graduate students to take to prepare graduates for a range of satisfying careers. **Schaffner et al.** continue the theme of broader preparation and suggest that the ocean sciences community capitalize on the nurturing setting and unique opportunity for learning and training afforded by marine laboratories to incubate innovation in graduate education and training. **Johnson et al.** focus on ways the ocean sciences community can increase diversity in its ranks in order to be more reflective of the broader population; they provide examples of a variety of successful programs and strategies aimed at underrepresented minorities. The special issue section then switches gears to describing what programs professional societies and specialty networks and organizations offer graduate students to get them ready for careers beyond the academic setting (**Peach and Scowcroft** and **Duguay and Cook**). Then, **Lindstrom et al.** and **Cook** provide information about National Aeronautics and Space Administration (NASA) and National Science Foundation (NSF) graduate fellowship programs, respectively, geared toward graduate students in the Earth and ocean sciences. Examples of innovative programs and practices at various levels are presented throughout the issue in both invited articles and in sidebars.

To ensure that the work needed to effect change in graduate education in the ocean sciences occurs within a broad national context, we recommend that attention be given to three recent landmark reports in the ocean research and graduate education arenas. *Sea Change: 2015–2025 Decadal Survey of Ocean Sciences* from the National Research Council (2015) challenges the ocean community to draw on its diversity and talent to foster external partnerships and create innovative programs to educate and prepare the next generation (Box 1). *The Path Forward: The Future of Graduate Education in the United States* (2010) and *Pathways Through Graduate School Into Careers* (2012), published jointly by the Council of Graduate Schools and the Educational Testing Service, describe the vital relationship between graduate education and US prosperity; examine the perspectives of students, faculty, administrators, and employers regarding their needs and goals and career success; and recommend that graduate programs include more focus on career outcomes and job placement, broaden curricula to include development of professional skills, emphasize innovative master's degree programs, and enhance interactions with government and industry.

To effect more widespread change, individual faculty and administrators clearly need to come together within a community framework. We refer readers

Box 2. A Graduate School Dean's Perspective

Graduate education, the continued identification and development of human talent, is essential to our nation's future. The apprenticeship model for training graduate students has existed for decades in science, technology, engineering, and mathematics (STEM) fields, and it has worked well in the past for those students who sought careers in research-intensive institutions with graduate-only programs. But today many students have other career aspirations, and more and more programs are looking for faculty who are effective in the classroom, engaging with both undergraduates and graduate students, as well as in research. From my perspective as a graduate dean, the purpose of university graduate degree programs is to train the next generation of independent scholars, researchers, and critical thinkers. What may too often be missing in existing apprenticeship-style relationships is attention to the ultimate career goals of the student. Some faculty view time away from the laboratory or fieldwork as wasted, and they discourage students from gaining experience in teaching and strengthening other professional skills. Perhaps we shouldn't be surprised by this perspective, because the major research institutions reward faculty primarily for generating grant dollars and publishing papers. Furthermore, rankings of universities and programs are heavily based on these metrics and the placement of graduates in similar programs. It is time for the graduate education community to become more student-centered and focus on how we can better prepare our students for success in their chosen careers.

— Nancy H. Marcus

to TOS President Susan Lozier's column on pages 6–7 for thoughts on the importance of this issue and next steps. For our part, we would like to see future discussion and planning efforts cast a net that is as wide as possible to involve individuals from all aspects of ocean-related science as well as knowledgeable people from the broader graduate education community.

Finally, we wish to acknowledge and thank the 16 colleagues who served as peer reviewers, the trio of special issue advisors (Ashanti Johnson, Lee Karp-Boss, and Blanche Meeson) who provided an initial sounding board for our ideas, and NASA and NSF for supporting publication of this special issue.

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AUTHORS

Susan B. Cook (suecook1023@gmail.com) is Senior Associate, Ocean Research and Conservation Association (ORCA), Fort Pierce, FL, USA. She is currently the secretary for The Oceanography Society and a primary broader impacts coach for the Florida Center for Ocean Sciences Educational Excellence (COSEE Florida). Previously, she directed educational programs at Harbor Branch Oceanographic Institute and the Bermuda Institute for Ocean Sciences (previously the Bermuda Biological Station for Research). **Nancy H. Marcus** (nmarcus@admin.fsu.edu) is Dean, The Graduate School, Florida State University (FSU), Tallahassee, FL, USA, and a faculty member in the Department of Earth, Ocean, and Atmospheric Science at FSU. Prior to becoming dean, she served the university as director of the FSU Marine Laboratory and chair of the Department of Oceanography. She has served the broader ocean science community as president of the Association for the Sciences of Limnology and Oceanography (ASLO) and is currently the chair-elect of the board of directors of the Council of Graduate Schools.

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PAGE 14 PHOTOS (from left to right)
(1) Florida State University graduate student Kelsey Rogers conducts CTD sampling during a geomorphology/benthic ecology cruise. *Photo courtesy of Florida State University*
(2) Kara Vadman (USF) and Mark Rosenberg (CSIRO) prepare to deploy a sediment trap mooring near Totten Glacier, East Antarctica. *Photo credit: Amelia Shevenell (University of South Florida)*
(3) University of Delaware students Corie Charpentier and Adam Wickline and Professor Jonathan Cohen (off to the right, not shown) recovering a zooplankton net during sampling on Delaware Bay. The Delaware Sea Grant work is investigating seasonal zooplankton community dynamics for comparison with the last such study of this system conducted in the early 1950s. *Photo credit: Heather Cronin, University of Delaware*

PAGE 15 PHOTOS (from left to right)
(1) University of Hawaii graduate student Donn Viviani demonstrating on-deck incubators to local teachers during the Center for Microbial Oceanography: Research and Education (C-MORE) Science Teachers Aboard Research Ships program. *Photo Credit: James Foley (C-MORE, University of Hawaii, Manoa)*
(2) University of Delaware graduate students Megan Cimino and Danielle Haulsee prep an autonomous underwater vehicle for charging after a mission off of Southern California examining deep foraging whale prey. *Photo credit: Mark Moline, University of Delaware*