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TECHNICAL COMMUNICATIONS

Training for the Next Generation of Coastal Management Practitioners

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ABSTRACT

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The complex and interconnected problems facing the world's coastal zones require solutions that bridge science and policy and integrate a range of stakeholder perspectives. The next generation of coastal practitioners will therefore need a wide-ranging set of problem-solving skills and the ability to collaborate across disciplines. As graduates of the Coastal Institute Integrative Graduate Education and Research Traineeship (IGERT) Project at the University of Rhode Island, we were participants in a multidisciplinary curriculum for students interested in the complex issues of coastal ecosystem management. Here we discuss aspects of the curriculum that were transformative from a graduate student perspective, as well as aspects that presented challenges. Fundamentally, the training provided us: (i) the opportunity to gain multidisciplinary knowledge working with a broad network of colleagues and mentors outside of our disciplinary backgrounds; (ii) communication and leadership training for coastal conflict management; and (iii) experiential learning opportunities that allowed us to apply these skills and knowledge at the science/policy interface. These three important features of our training could be implemented at any academic institution. While the training challenged us to balance the demands of our respective programs with additional work, it is our strong opinion that the benefits of such training considerably outweigh the costs.

ADDITIONAL INDEX WORDS: *University of Rhode Island, IGERT, graduate student education, multidisciplinary training, communication, experiential learning, network.*

INTRODUCTION

Coastal ecosystems at the interface of land and sea are subject to pressure from a broad range of environmental and social drivers (*e.g.,* land-based pollutants, sea level rise, overfishing, *etc.*) (Howarth *et al.*, 2000; IPCC, 2007; Pew Oceans Commission, 2003; U.S. Commission on Ocean Policy, 2004). In addition, the world's coastal areas are experiencing high rates of population growth and an increasing level and array of human activities. The dynamic nature of the coast, the diversity of stakeholder interests, and the discrepancy in scale between ecosystem processes and regulatory jurisdiction are just a few of the factors that contribute to the complexity of coastal management. Long-term management solutions, which have been elusive to date, will require an approach that integrates natural and social sciences, incorporates the humanities and history, bridges science and policy, involves stakeholders in a meaningful manner, and fosters implementation and adaptive management (Heinz Center, 2004; Pew Oceans Commission, 2003; United Nations, 1992; U.S. Commission on Ocean Policy, 2004). Initiatives such as Special Area Management Plans developed under the Coastal Zone Management Act (CRMC, 2010; Davis, 2004) and the West Coast Ecosystem Based Management Network (http://www.westcoastebm.org/) demonstrate the value of forming multidisciplinary teams to confront multifaceted coastal issues. Such integrative approaches, however, will require the next generation of coastal scientists and practitioners to have both a considerable breadth of knowledge to collaborate across disciplines and also a wide-ranging set of skills to draw upon (Ducrotoy, Shastri, and Williams, 2000; Muir and Schwartz, 2009; Sillitoe, 2004). This call for new approaches to coastal management is part of a broader shift across scientific disciplines that emphasizes multidisciplinary problem solving for research and management (Brewer, 1999; Metzger and Zare, 1999; Policansky, 1999; Sung *et al.*, 2003).

Recognizing the growing need for multidisciplinary scholars, the Integrative Graduate Education and Research Traineeship (IGERT) program was created by the National Science Foundation (NSF) to promote collaborative models for graduate education and training. In 2005, NSF funded the Coastal Institute IGERT Project (CIIP) at the University of Rhode

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Island (URI) to develop and deliver a new graduate curriculum to students tackling the complex, trans-boundary, and intractable issues affecting the coastal zone. Between 2005 and 2010, 23 Ph.D. students from a range of disciplinary backgrounds (including oceanography, fisheries science, marine policy, business, natural resources science, and economics) participated in the program as graduate trainees. The 2-year, supplemental curriculum was designed to examine multidisciplinary approaches to coastal science and policy issues, provide leadership and communication training to enhance understanding of coastal conflicts and values, and offer experiential learning opportunities designed to operationalize the skills, tools, and knowledge learned through CIIP coursework (Table 1).

The benefits and costs of multidisciplinary training for graduate students are widely discussed and debated (Campbell, Fuller, and Patrick, 2005; COSEPUP, 1995; Jacobs, 2009; Morse *et al.*, 2007; Newing, 2010; Nyquist, 2002; Rhoten and Parker, 2004; Sung *et al.*, 2003), yet the perspectives of the students themselves are often overlooked (Campbell, Fuller, and Patrick, 2005; Graybill *et al.*, 2006; Moslemi *et al.*, 2009). As graduates of the CIIP, we are in a unique position to identify aspects of our IGERT training that were transformative and aspects that presented challenges. Here we discuss specific features of the CIIP curriculum that we believe better prepared us to confront the complex and interconnected environmental challenges facing society. A survey of our co-trainees ($n = 23$) was used to help identify three broad themes—normally not a part of traditional Ph.D. programs—which we consider critical for the next generation of coastal management practitioners.

DISCUSSION

Multidisciplinary Knowledge and Appreciation

Building effective relationships within a team of coastal researchers requires trust, receptiveness, and a willingness to learn (Ascher, 1999; Bracken and Oughton, 2006; Bruce *et al.*, 2004; Marzano, Carss, and Bell, 2006). This requires team members that can communicate to colleagues from different disciplines the substance and the strengths and weaknesses of their own disciplines, coupled with an awareness and appreciation for diverse disciplinary perspectives (Daily and Ehrlich, 1999; Lele and Norgaard, 2005; Marzano, Carss, and Bell, 2006). A major strength of our CIIP training was the opportunity to regularly work with and learn from colleagues outside of our disciplines. In each curricular component we were challenged to broaden the way in which we viewed coastal issues. This began in our first class with an exploration of various coastal themes (*e.g.,* urban waterfronts, coastal hazards, fisheries) from an ecological, socioeconomic, policy, and management perspective, drawing upon each other's disciplinary knowledge and on the experiences of experts in relevant fields. As an example, our lobster fishery module included collaborative discussions with a lobster biologist, a fisheries outreach specialist, a lobster fisherman, and an economist whose work focuses on Individual Transferable Quotas as a method for lobster fishery management. The diverse range of perspectives helped us to better understand how both natural and social science informs coastal policy and how policy in turn affects the livelihoods and well being of lobstermen. Similarly, a module on urban waterfronts illustrated the competing interests of developers, environmental advocacy groups, and marine industries in zoning of the waterfront. The example demonstrated how the unequal distribution of power and financial resources among coastal stakeholders may influence the degree to which these interests are considered in the political arena.

Material from the humanities and the arts was used to further broaden the range of perspectives that were brought to bear on coastal issues. For example, examining the impact and recovery of New Orleans following Hurricane Katrina demonstrated to us the importance of historical context, environmental justice, sense of place, and intercultural perspectives in the decision-making process. Our training included discussions with a diverse group of experts involved in various aspects of the reconstruction of New Orleans. They introduced us to the human and scientific dimensions of coastal disasters. A community organizer from the Broadmoor district provided social and historical context, a public policy expert at Harvard's Kennedy School of Government explained the political and financial challenges of rebuilding, and a Louisiana-based hurricane researcher discussed the inadequacies of the design of the New Orleans levee system. Salt marsh migration attributable to sea level rise and sediment transport dynamics resulting from the channelization of the Mississippi River (Anthony *et al.*, 2009) was also discussed. This multidisciplinary approach to a specific coastal management topic improved our ability to frame coastal issues from multiple viewpoints and to recognize our lens of bias, that is, the way one views aspects of a complex multidisciplinary problem as a result of one's disciplinary expertise and past experiences.

In a field practicum we were introduced to some of the research methods employed in natural and social sciences, many of which were different from our own disciplinary approaches. For example, economists assisted with fish sampling in Narragansett Bay, and biologists participated in an economic experiment in URI's Policy Simulation Laboratory. Through this practicum we gained an appreciation and understanding of how each discipline develops research questions; the methods, data gathering, and statistical analysis techniques used; and how each discipline addresses scientific uncertainty. Our co-trainees identified these experiences as a significant advantage of participating in the CIIP because it afforded them a greater appreciation and understanding of other disciplinary perspectives when compared to their department colleagues.

Communication and Leadership Training

Despite a growing emphasis on science communication (Hartz and Chappell, 1997; Heemskerk, Wilson, and Pavao-Zuckerman, 2003; Kennedy, 2007; Reddy, 2011), programs that train graduate students in the coastal sciences to communicate effectively are uncommon. With this in mind, many elements of the CIIP curriculum were designed to focus on the skills needed to overcome challenges in communicating across disciplines and between scientists and members of the public, decision

Table 1. *Curricular elements of the Coastal Institute IGERT Program.*

Timeline	Programmatic Element	Description	Skills Gained	Tangible Outputs
Fall semester (years 1 and 2)	Coursework: *Multi-disciplinary problem solving in coastal ecosystems*	A trainee-led class to examine and develop multidisciplinary approaches to issues of coastal science and policy. Supported by lectures and case studies from visiting scholars and practitioners.	• Interdisciplinary approaches to problem solving • Developing a shared language • Presenting ideas across disciplines • Mentoring and teaching • Organization and logistical planning (course content) • Training in obtaining external funding • Working as part of a collaborative research team	Campus-wide seminars given by invited speakers; student/faculty-authored publications; website development; professional workshops
Winter intersession (year 1)	Coursework: *Leadership and communication in coastal ecosystem science and management*	A weeklong intensive introduction to issues from the arts and humanities that enhance understanding of coastal conflicts and values.	• Critical reasoning: logic, argument analysis, debate • Communication across divides (cross-disciplinary, cross-cultural, nonverbal communication) • Public speaking • Professional ethics and environmental justice • Social etiquette • Leadership awareness • Negotiation and conflict management • Work–life balance	Student-authored op-ed pieces
Spring semester (year 1)	White papers on contemporary policy issues in integrated coastal science	Trainees work with nonacademic partners to produce a collaborative assessment of a current issue in coastal ecosystem management that argues a specific position or solution to a problem.	• Multidisciplinary team work • Hands-on experience in science-based policy development and implementation • Writing for nontechnical audiences • Practical experience in regulatory agencies, NGOs, and legislative government • Professional networking in nonacademic setting	Student-authored white paper for host organization; conference presentations; popular (nonrefereed) articles
Summer session (year 1)	Coursework: *Field practicum in coastal science*	Intensive month-long science practicum consisting of 6–8 thematic field investigations that emerge from common research themes.	• Training/practical experience in coastal science • Communication to diverse audiences • Identifying collaborative research roles • Different approaches to describe uncertainty	Lab reports, presentations
Spring semester (year 2)	Internship in coastal ecosystem management	Hands-on experience with scientists, policy makers, and other stakeholders in the field of coastal ecosystem management. Trainees are in residence at a laboratory, office, or field research site of a nonacademic partner institution or Congressional representative.	• Integrating science and policy in a professional setting • Working as part of a collaborative research team • Interpersonal communication • Entrepreneurial training • Communication to diverse audiences	Technical reports, discussion papers, and fact sheets for host; refereed articles; newsletters; conference presentations

makers, and the media. Cohort diversity underscored the necessity for cross-disciplinary communication from the beginning of the program. We learned the importance of establishing a common vocabulary to clearly define terms and identify disciplinary biases as we worked throughout the coursework and on a collaborative publication (Anthony *et al.*, 2009).

A weeklong intensive course in leadership and communication led by humanities scholars was also recognized by our cotrainees as a significant advantage of their CIIP training. In contrast to "typical" graduate student seminars that focus on public speaking techniques, the course emphasized the differences in communication needs among audiences and across cultural divides and helped us to recognize the ethical and cultural complexities in coastal science and management (Figueroa and Mills, 2001; Rolston, 1991). A logic component was included to teach trainees how to dissect an argument, analyze its components, and then to draw upon these skills when trying to diffuse conflict between coastal stakeholder groups that might be attributable to fallacies or misconceptions. Emphasis was also placed on the importance of interpersonal skills such as active listening, nonverbal communication, conflict resolution through principled nego-

Table 2. *CIIP white paper and internship host organizations.*

International Organizations	Federal Agencies	State Agencies	Nongovernmental Organizations	Private
Institute for Marine Resources: Bremerhaven, Germany	Minerals Management Service	RI Coastal Resources Management Council	Bernice P. Bishop Museum	Caribbean Mariculture
Institute for Marine Sciences, Zanzibar	NOAA, Apalachicola National Estuarine Research Reserve	Rhode Island Economic Policy Council	Coastal Resources Center	EcoAssets Market, Inc.
Inter-American Tropical Tuna Commission's Achotines Laboratory	NOAA, Narragansett Bay National Estuarine Research Reserve	RI Department of Environmental Management, Division of Fish and Wildlife	Center for Ocean Solutions	Moonstone Oysters
Tanzania Coastal Management Partnership	NOAA, National Marine Fisheries Service	RI Sea Grant Program	Ceres	
	U.S. Embassy, Tajikistan	Northwest Florida Water Management District	Conanicut Island Land Trust	
	U.S. EPA, NHEERL Atlantic Ecology Division		Conservation Law Foundation	
	U.S. Forest Service, International Institute of Tropical Forestry		Environment Northeast	
	U.S. Geological Survey		Massachusetts Audubon Society: Coastal Waterbird Program	
	U.S. National Park Service		The Nature Conservancy	
	U.S. Senator Sheldon Whitehouse (D-RI)		The Nature Conservancy Office of Global Marine Programs	
	U.S. Senator Lincoln Chafee (R-RI)		Reef Ball Foundation	
	U.S. State Department: Baku, Azerbaijan		Regional Planning Association: CT, NJ, NY	
			Save the Bay	

tiation, and leadership in fostering communication and cooperation across disciplines. Active student participation was a significant part of the leadership course, and activities such as role-playing, active sharing, and debate presented us with valuable opportunities to practice these skills in a realistic setting that required us to think on our feet.

The CIIP also partnered with URI's Metcalf Institute for Environmental Journalism to give trainees and journalists a forum to exchange ideas on how to bridge the communication gap between scientists and the media (Hartz and Chappell, 1997; Reddy, 2011). These lessons were put into practice when each trainee wrote and published an op-ed column on a coastal issue. This exercise challenged us to write for readers in a different way from the usual technical, scientific audience and to take calculated risks by making persuasive, scientifically grounded arguments on sometimes highly controversial topics. It required consideration of appropriate tone and language, as well as finding a suitable window of opportunity and publication venue to communicate effectively with respective target audiences.

Applying Knowledge and Skills at the Science/Policy Interface

For most Ph.D. students the learning-through-doing aspect of their doctorate education occurs within their dissertation research. However, in the CIIP program, we had at least two different opportunities to partake in experiential learning prior to our dissertation research. The first entailed a semester preparing a white paper for a nonacademic partner organization, allowing us to gain hands-on experience at the science/policy interface. The second, a full semester internship, immersed us in the work and culture of our partner organizations and presented an opportunity to further apply the knowledge and skills attained throughout the CIIP.

To gain experience in settings and with topics beyond their disciplinary focus, trainees arranged their white paper and internship placements with a wide array of organizations (Table 2). Some of the trainees ventured far outside of their comfort zones by opting to live and work internationally in Azerbaijan, the Dominican Republic, Grand Cayman, Germany, Panama, Tajikistan, and Tanzania. Others expanded their boundaries by working in domestic settings focusing on coastal issues distinct from their traditional disciplines. Examples include natural scientists working on national policy issues for Rhode Island's U.S. Senators and an economist working with Rhode Island's Coalition for Water Security. In many instances the topics became the basis for dissertation research. In addition to the opportunity to put into action the skills and knowledge acquired throughout the CIIP, these experiential learning opportunities led to other outputs and publications that were of great value to the host organizations as well as the trainees (a list of trainee publications is available from the Coastal Institute IGERT Project [2011]).

Working in these different settings gave us the opportunity to view our topics through multiple lenses and to consider the many implications of coastal management decisions. The overwhelmingly positive response from our hosts also demonstrated that CIIP trainees were well prepared to deal with challenges and constraints. As one of our co-trainees noted, "I learned how to find answers, how to better anticipate questions that would arise, and how best to deliver results so that they were easily understood/digestible to a layperson."

Tradeoffs, Reflections, and Recommendations

While there are numerous benefits to augmenting a traditional Ph.D. program with coursework and experiential learning opportunities, tradeoffs exist. As students, we know first-hand how participation in a program such as CIIP requires a greater investment of time, imparts challenges in balancing the demands of concurrent programs, and at times, presents a struggle with our professional identity, as compared to departmental peers following the more traditional, discipline-based Ph.D. path. As a group, we discovered that while many individuals in a room can enrich the discussion, it can also be a liability if it precludes the meaningful involvement of all participants, so measures are needed to ensure active involvement by everyone. Despite these challenges, we feel the benefits greatly outweigh the costs and believe that the creative university could find ways to restructure traditional curricula to incorporate these valuable experiences in a synergetic manner. For example, a graduate program could consider developing a white paper course as a degree requirement or find outside partners that would be willing to provide paid internships. Also, students might find ways to dovetail the experiential learning opportunities with their Ph.D. requirements by incorporating work from those experiences into their dissertations.

Participation in the CIIP also allowed us to create a unique and proliferating network of colleagues and mentors from numerous academic institutions and other professional settings. The development of these multidisciplinary professional networks early in our careers is an invaluable asset. Because the CIIP drew students from multiple departments, each of us had the opportunity to interact with and learn from peers with different disciplinary training and backgrounds. This interaction created working relationships that will extend well beyond graduate school. In addition to peer learning, the wide array of experiences and expertise brought to the table by the CIIP faculty members provided access to many more mentors than one would have in a traditional Ph.D. program. Additionally, working alongside Ph.D.s outside academia gave us a more comprehensive overview of postgraduate opportunities, the challenges and rewards in each line of work, and an understanding of our mentors' career paths. Some of our co-trainees continued to work extensively with their host organizations far beyond the formal completion of their internships, while others secured postgraduate employment with host organizations.

Last, a significant and unexpected consequence of our CIIP training was courage. In many instances we were placed in uncharted waters, far outside our disciplinary comfort zones. Although intimidating and disconcerting at first, it was in these settings that we learned and grew the most. We learned that it was acceptable to admit in front of our peers and professors that we did not know something, and that in doing so we could become better scientists by learning from one another. We learned that while it can be frustrating to try and master things that we are not inherently good at, doing so makes us more comfortable over time at crossing disciplinary interfaces and taking some risks.

We strongly believe that our CIIP experience made us more adaptive and creative in problem solving. Furthermore, NSF's IGERT model as manifest in CIIP provided us with a greater capacity to confront the continuing challenges facing the coast, and we highly recommend similar initiatives in other graduate curricula.

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