

Building a Diverse and Innovative Ocean Workforce through Collaboration and Partnerships that Integrate Research and Education: HBCUs and Marine Laboratories

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ABSTRACT

Historically Black Colleges and Universities (HBCUs) attract, retain and award science degrees to African Americans at a higher rate than majority institutions. Because they offer life-changing and career-orienting experiences for students, field stations and marine laboratories are well positioned to help increase the number of students opting for science, technology, engineering and mathematics (STEM) careers and ocean science and education careers, in particular. Two kinds of partnerships have developed between Savannah State University (SSU), an HBCU, and marine laboratories as a result of federal funding: a Research Experiences for Undergraduates (REU) program between SSU and the Harbor Branch Oceanographic Institution, and an internship/graduate program between SSU and the Skidaway Institute of Oceanography. These collaborations and other funded projects since 1998 have resulted in an increase in the percent of graduates from SSU's Bachelor of Science in Marine Science degree who had a significant research experience from 25% before 1999 to 66% percent afterwards and an increase in the number graduating with honors from 30% prior to 1999 to 41% after 1999. The growth and productivity of marine science degree and research experience programs at Savannah State University illustrates how collaboration and partnerships can be an effective way to increase access and eventually pay big dividends by increasing diversity in geoscience professions.

INTRODUCTION

Underrepresented minorities (African Americans, Hispanics, and American Indians/Alaska Natives) do not participate in higher education in the same proportion as non-Hispanic whites. But among those who complete bachelor's degrees, similar percentages of underrepresented minorities and whites earn their degrees in science and engineering (S&E) fields, and underrepresented minorities are obtaining an increasing percentage of S&E degrees at all levels (National Science Board 2006). The share of degrees earned by underrepresented minorities is much lower in geosciences than all other science fields, and the number of doctorates earned in geosciences from 1994-2003 was 2.8%, 2.2%, 1.3%, and 0.4%, by Hispanics, Asian/Pacific Islanders, African Americans, and American Indians & Alaskan Natives, respectively. Women now earn half of bachelor's degrees in science and engineering (although they earn much lower shares in some specific fields), and new women and underrepresented minority doctorate

holders were more likely to enter academia than white males.

There is a growing body of recent data, reports, papers, strategies, plans and commentaries addressing demographic shifts in the population, particularly among Hispanic and African Americans, and the need for strategies to ensure a diverse and innovative future ocean science workforce in the USA (Bingham, et al., 2003; Cuker, 2001; Cuker, 2005; Gilligan, 1994; 1996; unpub.; Testimony; IOOS-COOS Report; Klug, et al., 2002; National Science Board, 2006; ORAP Education Report, 2002; Pew, 2003; SAML Report; USCOP, 2004) and Science Technology Engineering and Mathematics (STEM) workforce, generally (Anderson and Kim, 2006; Staples, 2006).

Among Minority-Serving Institutions (MSIs), Historically Black Colleges and Universities (HBCUs) are disproportionately effective in science education. HBCUs enroll only 13% of African American college students, yet they award 40% of the science degrees earned by African Americans (President's Board of Advisors on HBCUs, 1999; NCES). A variety of factors are responsible (Culotta, 1992; Gilligan, 1996). Few of the more than 100 HBCUs have marine science programs or marine laboratories however, field courses and field research experiences offered at field stations and marine laboratories are often life-changing for many students because they provide a highly-focused venue for actually doing science, and for experiencing inquiry-based learning (Klug, et al., 2002).

The development and productivity of marine science programs at Savannah State University is an example of the importance of HBCUs in this regard. In this paper we examine how linkages between colleges and universities where groups underrepresented in the ocean sciences are the majority, and research centers such as marine laboratories and oceanographic institutions, can be an important element of strategies to ensure an innovative and diverse future ocean workforce.

THE DEVELOPMENT OF MARINE SCIENCE PROGRAMS AT SAVANNAH STATE UNIVERSITY

History - Savannah State University was created by an act of the Georgia Legislature in response to the U.S. Land Grant Act of 1890. Today, the 135-acre campus is unique among the 35 instructional units of the University System of Georgia, in that it contains elements of two biologically diverse and important coastal ecosystems: the maritime live oak forest and the salt marsh estuary. This has provided an inspirational setting for intellectual and spiritual growth at "The University by the Sea" for

Marine Science Degrees Awarded

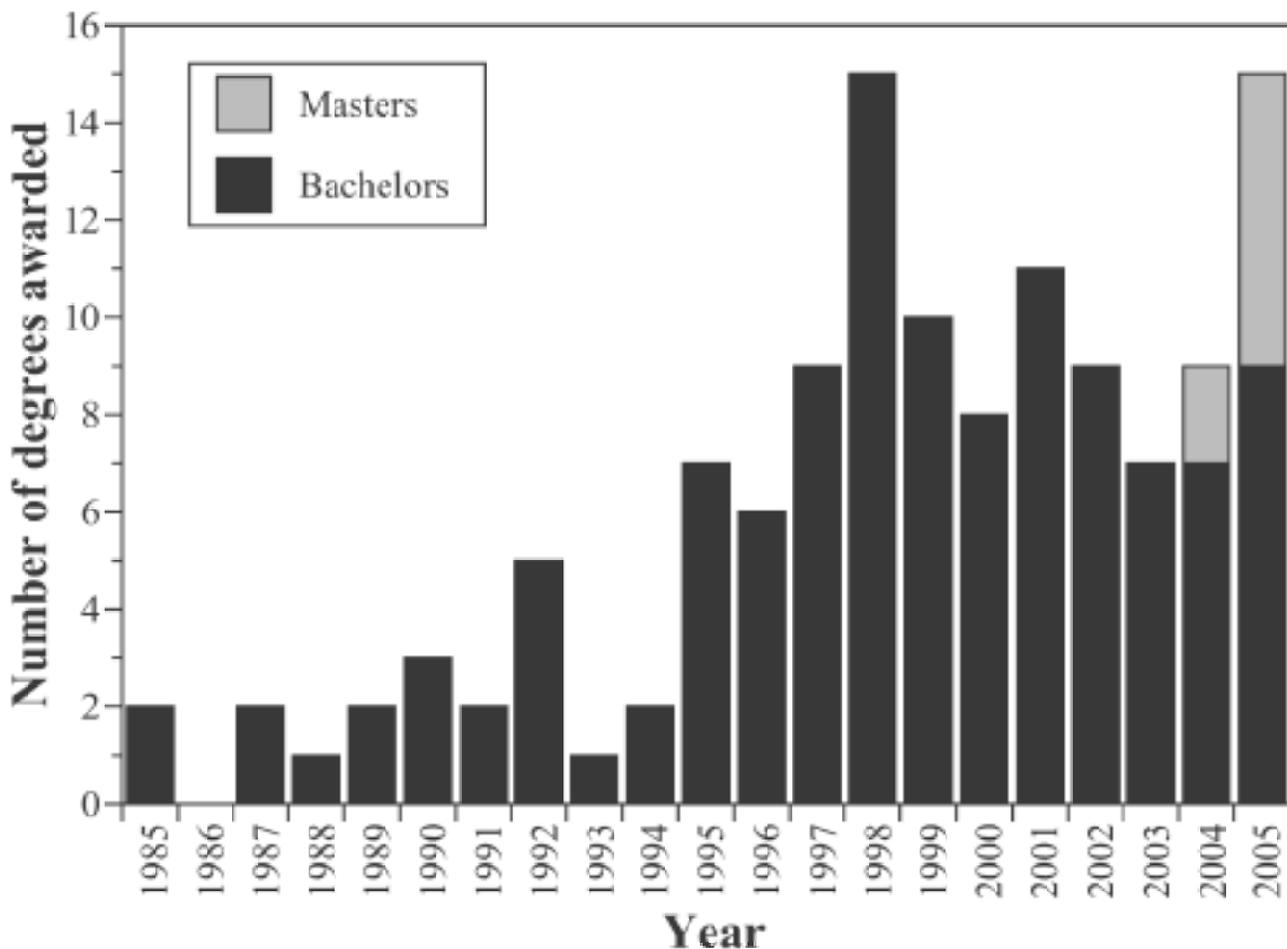


Figure 1 The number of bachelor of science and master of science in marine sciences degrees awarded by Savannah State University from 1985 to 2005.

over 115 years (Gilligan, 1994). The current enrollment is over 3,000 students, 90% of whom are African American. Despite its favorable location adjacent to a navigable tidal creek and salt marsh, it was not until a desegregation challenge by the U.S. Department of Justice in Georgia and other states in the late 1970s that it was possible to develop proposals for marine and environmental programs at SSU. At that time, spearheaded by Dr. Margaret C. Robinson, Chair of the Department of Biology, successful efforts in this direction were initiated. Degree programs for the Bachelor of Science in marine biology and environmental studies were approved in 1979, ostensibly to increase minority white enrollment at SSU as part of a federally mandated University System of Georgia desegregation plan. These programs attracted both African American and non-Hispanic white students, but enrollment was low until appropriate facilities and equipment were obtained (classroom, laboratory, wet-laboratory with seawater system, and dock and boats) through a combination of state and federal funding. With these facilities, enrollment grew at nearly 30% per year during the 1990s (Figure 1), with enrollment diversity fluctuating between 60:40 and 50:50 African American:non-Hispanic white. From May 1985 to May 2006 Savannah State University has awarded 134 degrees in the marine sciences. 49% of these degrees have been awarded to African Americans, 47% to non-Hispanic whites, and 4% to others (Asian, multi-ethnic). The degree total includes 123 B.S. degrees since May 1985 and 11 M.S. degrees since December 2004.

Student Outcomes - Students earning marine science degrees from SSU have been notably successful in pursuing professional careers. We have information on postgraduate pursuits and employment from 72% of the 134 graduates (Gilligan, unpub.). As of June 2006, 23% have either been accepted to, enrolled in, or have completed additional degree programs (e.g. M.S., Ph.D. DVM, MPA). Seventeen have completed advanced degrees and are now physician assistants, biologists, veterinarians, lawyers, film-makers, and research professors. Three students, all African American, have completed doctoral degrees, and seven are currently enrolled in advanced degree programs at SSU and elsewhere. Of the three who are in doctoral degree programs, two are African American. Those not pursuing additional degrees have been employed as aqua culturalists, biologists, fishery biologists, commissioned naval and Coast Guard officers, dolphin trainers, coastal zone managers, clinical technicians, environmental chemists, environmental consultants, environmental laboratory analysts, environmental protection specialists, fisheries observers, forensic pathology assistants, international fisheries observers, marine biologists, marine/outdoor educators, research assistants, research officers, research technicians, safety managers, science teachers, and youth activities coordinators.

Effectiveness of Externally Funded Programs - Prior to 1998, funded projects that provided assistance to

SSU/HBOI Summer REU Program Participants 1994 - 2002

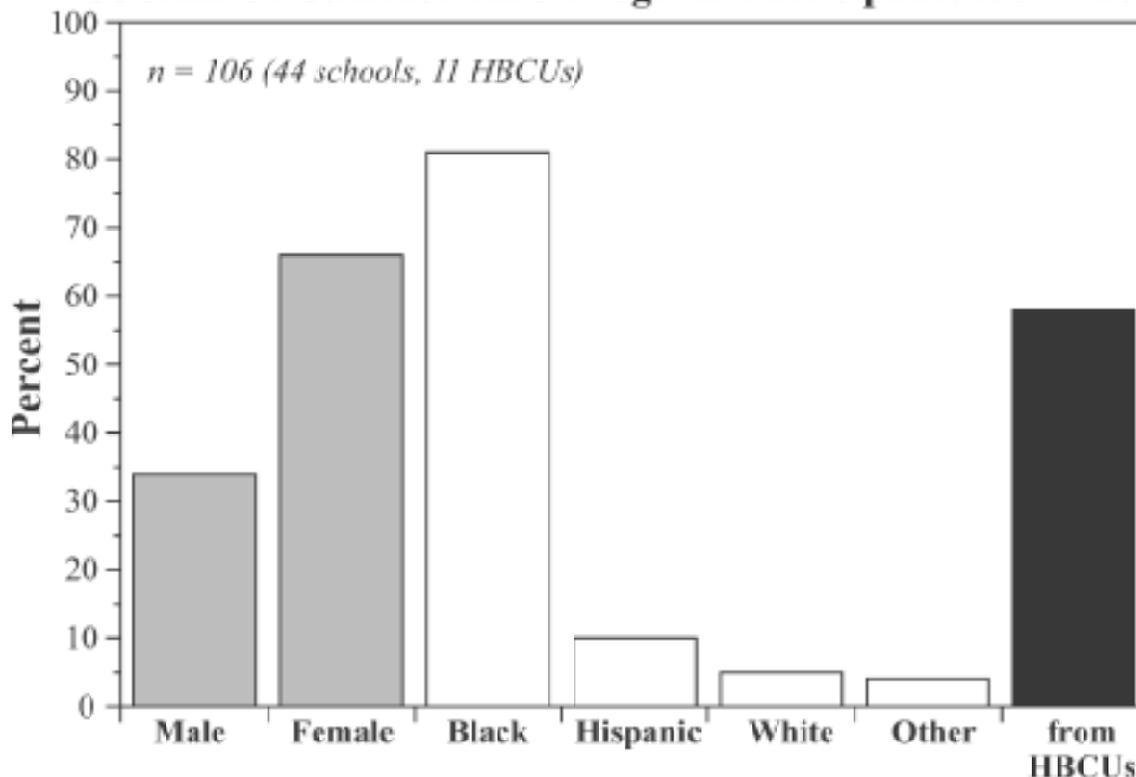


Figure 2 Percent of participants in the SSU/HBOI Bridge to Research Program 1998-2004 (n=106) who were male/female, non-Hispanic white/African American/Hispanic/other, and from HBCUs.

undergraduate students as research assistants or interns at SSU included small research grants and contracts with NOAA Sanctuaries, NOAA Fisheries Southeast Fisheries Science Center and Center laboratories (e.g. Panama City Laboratory), the National Park Service, and, significantly, a three-year, \$1.2 million Sea Grant award in the 1996 entitled 'Increasing Diversity in Marine Research and Education'. The latter grant provided funds to support research projects by SSU faculty on the SSU campus, research internships to undergraduate students, the purchase of research equipment, and allowed SSU to purchase and refit the R/V Sea Otter, a 31-foot twin diesel workboat that was acquired as surplus from NOAA Marine Sanctuaries. Two kinds of partnerships have developed between SSU and marine laboratories as a result of federal funding: a Research Experiences for Undergraduates (REU) program between SSU and the Harbor Branch Oceanographic Institution, and an internship / graduate program between SSU and the Skidaway Institute of Oceanography.

COLLABORATION WITH HARBOR BRANCH OCEANOGRAPHIC INSTITUTION: THE BRIDGE PROGRAM

In 1994, SSU and Harbor Branch (HBOI) received the first of three collaborative 3-year awards from the Division of Ocean Sciences of the National Science Foundation for the "Bridge Program". This unique undergraduate program ("Savannah State University-Harbor Branch Oceanographic Institution (HBOI) Summer Undergraduate Program: A Bridge to Research in the Marine Sciences") was a non-traditional REU program designed to provide research training, exposure and experiences to undergraduate students from groups underrepresented in marine sciences. These grants provided financial assistance for travel, room and board, some research support, and stipends to the participants.

Co-PIs of the project were authors Gilligan, and S. and C. Cook. It was non-traditional in the sense that it put a premium on attracting undergraduates at all levels who had not had any exposure or experience in the ocean sciences. Traditional REU programs focus on juniors and seniors judged to have a high probability of success in research environments based on coursework, course grade point average and advisor letters. The Bridge program was designed to attract students at earlier stages of professional development (particularly targeting underclassmen), who had little prior research experience. This selection process was effective in pre-screening individuals from underrepresented groups at a 'critical time' in their academic careers, when they are choosing a major and need exposure to non-traditional professional/academic areas of interest. As such, the program did not have to consider large numbers of applications from traditional non-underrepresented groups who are more likely to have had exposure and experiences in the marine sciences who typically dominate marine and ocean science undergraduate research experience programs. Two additional benefits of the 'early' strategy are that the experience could contribute to solidifying choice of a STEM discipline, and made students more competitive in intern / REU programs, as they typically apply for these programs as juniors and seniors.

Over its nine summers (1994-2002), 106 REU internships were awarded to 97 different individuals. The difference in these figures resulted from the returning peer mentor program, in which one or two alumni from previous years were invited to participate in the program again. Sixty-six percent of the participants were female, 81% African Americans, 10% Hispanic Americans, 5% non-Hispanic White, 3% multiracial Americans, and 1% American Indian and other (Figure 2). Students came from more than 30 different colleges and universities 11 of which were HBCUs and in all 58% of the students who participated were from HBCUs.

Achieving success in recruiting from HBCUs was a direct result of assistance by faculty in science departments at those institutions with whom the senior author had established friendships established over several years of hosting faculty and students on field trips to SSU and the Florida Keys during spring breaks. The spring break trips program, which was partially funded through the Southern Association of Marine Laboratories, involved stopping for tours of marine laboratories from Savannah, Georgia to the Keys Marine Laboratory, and included the Harbor Branch Oceanographic Institution.

Harbor Branch Oceanographic Institution - HBOI, an independent institution for marine research and education located on the east coast of Florida (a six-hour drive from Savannah), is perhaps best-known for the development and use of research submersibles (the *Johnson-Sea-Links*). The institution has strong programs in aquaculture, marine biomedical research as well as a variety of areas of marine biology. HBOI scientists direct graduate students through appointments with the Florida Institute of Technology in Melbourne and Florida Atlantic University in Boca Raton. This core of research scientists, post-doctoral associates and graduate students provided research advisors to students in the Bridge program. The education program at HBOI received major impetus with the construction of the J. Seward Johnson Education Center in 1989 and the subsequent appointment of Susan Cook as Education Director.

Programmatic Elements - The Bridge Program was conducted during the summer, and consisted of four weeks at SSU followed by five weeks at HBOI. The four weeks at an HBCU provided the opportunity for group coherency and 'bonding' in formal and informal learning settings, in preparation for the more intense research experience at HBOI. The SSU component of the program included an informal introduction to research environments and local marine habitats, followed by formal sessions on experimental design and analysis, how to identify research interests, the use of computers, statistics and web database literature searches. Technical writing components included the elements of a research report; how to write a resume and how to apply for a summer internship. There were also research presentations by, and informal discussions with, visiting mentors. Introduction to research "thinking" and techniques was facilitated by student group research projects involving SSU faculty and staff. Shipboard and field experiences included day cruises on the R/V *Sea Otter* (SSU) and R/V *Blue Fin* (Skidaway Institute of Oceanography, SKIO).

In order to expose Bridge participants to a variety of marine laboratory settings and research fields, an important component of the program was visits to local marine facilities. Some of these were accessible from Savannah (e.g. SKIO, The Georgia Department of Natural Resources in Brunswick, NOAA Lab / Grice Marine Laboratory / SCDNR Marine Laboratory in Charleston, SC), some were visited during the trip between Savannah and Fort Pierce (e.g., the Whitney Marine Laboratory in St. Augustine), and some during the HBOI segment (e.g., RSMAS / University of Miami, Keys Marine Laboratory).

The HBOI portion of the program had two major objectives: prepare students for the week-long independent research projects that comprised the capstone of the experience, and provide a true oceanographic experience with multi-day cruises aboard a major research vessel. As with the SSU segment, minority mentor scientists were invited to give presentations and hold informal discussion with students. Two other components of the HBOI segment were career panels and the opportunity for outreach with local minority high school students. The career panels

consisted of 3 or 4 scientists and teachers who shared frank experiences with the participants about careers in marine science. The outreach program was conducted in conjunction with Indian River Community College, and provided Bridge participants the opportunity to serve as role models for local students.

As discussed below, the cruises, funded by the NSF UNOLS program, were one of the most valuable portions of the Bridge experience. For 8 of the 9 years we used one of HBOI's vessels, (the R/V's *Edwin Link*, *Seward Johnson* or *Sea Diver*); for the last year we used the University of Miami's R/V *Walton Smith*. The crew of each vessel played important roles in providing participants with real shipboard experiences. During the cruises, students participated in a variety of oceanographic techniques including CTD deployment, nutrient analyses, plankton sampling, and the operation of an ROV [remotely operated vehicle]. Each cruise had a slightly different focus, with a research theme designed by an HBOI scientist. Students were required to prepare reports following each cruise. These reports generally involved the analysis of CTD, nutrient or plankton data in the context of the overall research theme. In addition to the benefits these cruises had for the students, this program resulted in the preparation of an *HBOI Oceanographic Cruise Guide*, which has been used by a variety of other HBOI educational groups.

The rest of the HBOI program was designed to prepare students for their research projects. Field trips to local marine habitats (seagrass beds, mangroves, rocky intertidal, *Sabellaria* reefs) were augmented by a trip to the Florida Keys and exposure to coral reefs. Many students learned snorkeling skills in the process. Lectures by HBOI scientists, augmented by relevant laboratories, introduced students to relevant research topics. The students were required to develop project proposals, and then carried out their projects under the direction of HBOI (sometimes SSU) scientists. Topics included, but were not restricted to: aquaculture, marine natural product chemistry, symbiosis, marine ecology and marine mammal biology. Each student, or occasionally a student pair, had to prepare a Power Point presentation in addition to a final written report. The schedule of talks was advertised to the general HBOI community.

Assessments and Surveys - We used several methods to assess how well the Bridge program achieved its goals. In the first of these, we employed a form developed by Dr. Clarice Yentsch and the Education Development Center in Newton, Massachusetts that was designed to collect standardized information from all Ocean Science REU programs. This form was used to evaluate how the students rated the program and how the program affected their skills and attitude toward science. Using data from 1999 as an example, on a scale of 1-7 (7 being highest), the overall rating of the program was 6.5 ± 1.0 (mean \pm sd; N = 31). Participants were generally positive about the learning environments, the helpfulness of research mentors and about their future interest in research (mean ratings > 6 for all). Negative comments focused primarily on timing and the balance between various components (more fieldwork needed, more lab work needed, too much lecture, too little time for research). The facilities and staff support have been ranked as good to excellent throughout the program, results that are typical of all years surveyed.

In 2002, we commissioned a retrospective survey by the SSU Survey Research Center to census participants from all years on a variety of issues (Appendix 1). One problem with this survey was the small sample size; only 13 of 67 questionnaires were returned. The results that we did receive were similar to those of the Yentsch surveys. Using a similar scale of 1 to 7, most indicated that the program had increased their confidence in research (6.0), increased their useful skills (6.0), increased

Activity	Overall Rank (sci. dev.)	Overall Rank (pers. dev.)
Shipboard Research Cruise	1	1
Field Trips	2	2
Visits to Other Labs/Organizations	3	4
Research Mentors	4	5
Workshops	5	3
Visiting lecturer/mentors	6	6
Lectures	7	7

Table 1 Retrospective survey of participants in the SSU/HBOI Bridge to Research Program ranking activities that contributed to scientific (left column) and personal (right column) development.

their confidence in giving presentations (5.8) and influenced their choice of career (4.9). One notable result of this survey (Table 1) is that when asked to rank learning activities in terms of scientific and personal development, the shipboard cruises were clearly the most important, while lectures were considered the least important. This confirms the near-unanimous praise throughout the nine years of this program for the shipboard experience, seasickness notwithstanding. As noted above, the cruises involved both operations and data gathering e.g. oceanographic stations including CTD casts, plankton sampling, benthic sampling, ROV work, and water chemistry were done by rotating student teams.

Outcomes - One notable outcome of the Bridge program was the percentage of participants who went on to other research or educational experiences. 77% of those responding (n = 13) went on to other intern programs, including 46% who went on other NSF / REU programs. Over half (54%) went on to graduate programs, and a similar percentage held paid positions in a research lab. Thus, it seems that our policy of encouraging underclassmen with little research experience was a successful approach.

COLLABORATION WITH THE SKIDAWAY INSTITUTE OF OCEANOGRAPHY: THE CIRE, BI-OMP, AND MSMS PROGRAMS

In 1993, Dr. Walter Massey, Director of the National Science Foundation, drew upon his experience as an undergraduate at Morehouse College, an HBCU, to help design two new programs at NSF: the MIE (Model Institutions for Excellence) and CIRE (Collaboratives to Integrate Research and Education) programs (Albert Bridgewater, pers. comm.). The MIE program resulted in implementation grants to six institutions in 1995, to improve the quality of and access to science, engineering and mathematics (SEM) education for all Americans, including women, minorities and persons with disabilities. In 1997, CIRE was established to build on the MIE institutions' experience by testing the ability of long-term research and education relationships between minority-serving institutions and NSF-supported centers and facilities to enhance diversity in the science and engineering research and education enterprise.

In 1998, SSU and the Skidaway Institute of Oceanography, a non-degree granting unit of the University System of Georgia in Savannah (see below), established an inter-institutional agreement, and developed a successful collaborative proposal to secure one of the five CIRE Program awards. At roughly the same time, a focused research program proposal involving similar integration and collaboration was funded by the Department of Energy through its Biotechnological Investigations - Ocean Margins Program (the BI-OMP program). Together with assistance from the Title III Program at SSU to help establish a Center for Marine, Environmental, and Biotechnology Research and a new partnership

associated with the Living Marine Resources Cooperative Sciences Center (NOAA EPP), these programs contributed infrastructure, thesis projects, and student research experiences. Success at these levels initiated a successful, collaboratively developed proposal to the University System of Georgia for a Master of Science in Marine Sciences (MSMS) degree program at SSU.

The Skidaway Institute of Oceanography, a non-degree-granting research institution, is also a part of the University System of Georgia whose activities and research focus on many different coastal and oceanographic research topics. The institute maintains approximately 15-18 full-time Ph.D.-holding faculty and a 60-70 member supporting staff. Since being founded in 1968, the Institute has been involved in education primarily through the support of graduate student research. Increasingly, however, the SkIO faculty has recognized the need and opportunity to expand their involvement in formal educational programs within the University System of Georgia. By doing so, its faculty is able to enhance their research capabilities, and to reduce their dependence on federal and state fixed-term research funding.

Administrative involvement in planning, development, and implementation of the program was essential to successful collaboration. An important planning element was the formal Inter-institutional Collaborative Agreement signed by the President of SSU and Director of SkIO to develop a long-term, mutually beneficial relationship. This document was included in the formal proposal to NSF. Direct involvement by the administration at SSU included membership by the Vice President for Academic Affairs (VPAA) and others on an advisory council and trips by the VPAA and Co-PIs to NSF to report on results and discuss continuation.

SSU and SkIO have a history of cooperation, largely developed on an ad-hoc basis. The agreement and subsequent proposals required the partners to clearly define their respective missions, needs and goals, and then to identify elements common to both institutions. The CIRE program from the National Science Foundation (NSF), with additional support from the Office of Naval Research (ONR), provided major capital for some of the formal elements. The Biotechnological Investigations-Ocean Margins Program (BI-OMP) from the U.S. Department of Energy (DOE), whose overall goal is to further knowledge of the oceans' roles in global carbon and nitrogen cycling, particularly through application of novel molecular approaches, provided additional resources to make it happen. Overall, student support through undergraduate research internships and graduate research fellowships has been the biggest cost at SSU, while faculty/staff support to engage in teaching and mentoring the biggest cost at SkIO. The two projects aimed at integrating education and research were motivated by the desire of the faculty and administration at both institutions to stimulate interest and increased participation by underrepresented groups in the marine and environmental sciences.

Programmatic elements included a post-doctoral research mentor (PDRM) at SSU, curriculum

enhancement, and research internships and graduate fellowships for SSU students in labs at SkIO, and research cruises. The DOE-funded BI-OMP grant provided for a post-doctoral fellow at SSU, a position which initiated a formal link between SSU and SkIO. At SSU, the PDRM was responsible for establishing and teaching an upper-division/graduate course (MSCI 4501/6501 Current Issues in Oceanography), developing a lecture series for SSU students with SkIO faculty and other scientists, and mentoring and assisting research interns. The course's primary objective is to provide students with a perspective of the ocean as a global system (with special emphasis placed on carbon and nitrogen cycling), and to expose them to the world of primary scientific literature. The course was an elective designed to stimulate critical, independent thinking without a heavy outside-of-class workload (fewer than 3 hours). Using text excerpts, internet resources, and peer-reviewed journal articles topics include climate change, global carbon cycling, biological responses, coastal issues, microbial processes, new methodologies, and paleo-oceanography. Typically, each topic receives four class periods, and for each, an appropriate guest lecturer was invited to speak to the class, providing real-world information about the subject matter and answers to questions about career development in marine science. In many cases, this lecturer was a faculty member from SkIO. The two PDRMs to date, Drs. Melissa Booth and Jennifer Brofft, were also required to spend 50% to 75% of their time conducting primary research, including experimental lab- and fieldwork at SkIO. The advantages of the dual duties were that these individuals were able to enhance their research skills and productivity and gain valuable teaching experience (credentials for eventual faculty employment) at both the undergraduate and graduate level. Their employment and central duty station at SkIO meant that they were more engaged at the SkIO campus with research than on the SSU campus with teaching and advising. However, this was balanced by the mentoring effort with SSU students who were awarded research internships on the SkIO campus.

There are two necessary components for such individual mentoring to work. First, the faculties involved have to be internally motivated, preferably passionate about their roles. Mentoring of professionally naïve students is time-consuming and does not typically offer immediate rewards to the research operation at hand. Second, there has to be administrative support for either the individual faculty's participation or for the system to accommodate the faculty's time commitment. This can take the form of buy-out from other activities, i.e. research, or acknowledgement in merit review that value is added to the system from such mentoring.

The participation of SkIO faculty in teaching at SSU has been a key feature of the collaboration, though SkIO faculty members who are involved in extensive, long-term research programs generally cannot commit to teaching entire courses. As a result, team teaching of a core graduate course MSCI 5202 Introduction to Coastal Oceanography (4 semester credit hours), and the development of SkIO-directed modules involving lectures, laboratory demonstrations, and fieldwork in existing courses, have been a useful alternatives. The modules are generally a few lectures combined with laboratories or trips to research facilities on and off campus. They provide viable opportunities for SkIO researchers to engage in instruction and are valuable co-curricular supplements in undergraduate courses.

It important to recognize that, like the Bridge Program, the CIRE and BI-OMP programs have been sustained efforts: both have been multi-year projects, have been renewed through new proposal competition, and are in their 7th year of support. The Bridge Program was offered for nine consecutive summers. All of these efforts had significant 'ramp up' periods that established

the linkages necessary for effective student recruitment both within and beyond SSU and establishing the best practices for progress and productivity. The success of these programs is directly linked to the nature of sustained institutional and agency commitments to the growth of effective inter-institutional collaboration.

In the early years of the Bridge program most applications and nearly 50% of the participants were from SSU. In later years the number of applications from other schools increased as well as the GPA of applicants from both SSU and elsewhere. This represents in part the lag time needed to develop and to "get the word out" about a national program. The first three-year CIRE award/program did not experience ramp up issues but certain aspects of the subsequent five-year award/program (especially development of the collaborative masters of science degree in marine science), were delayed for nearly one year as the infrastructure and administrative process were developed and approved and graduate students recruited. Similarly, the BI-OMP program had difficulty initially recruiting a graduate student to fill the microbial molecular methods focus of that program.

Research Internships - The BI-OMP program provided funds to support three student interns for three years. The NSF CIRE project provided funds for five, ten, and fourteen interns in each of its first three years of operation, and fewer in subsequent years in order to support as many as two graduate research fellows each year. SkIO faculty members interested in mentoring an intern were solicited, while internship candidates at SSU were identified on the basis of merit (interest, experience, and GPA), and were drawn from all marine and environmental science classes. During the first year of collaboration, students were paired with a faculty member by a selection committee based on interests they stated on their applications. This system was improved in following years, allowing students and faculty the opportunity to evaluate one another before the committee made assignments. After applications were submitted, the applicants were asked to attend a five-hour workshop at SkIO, where they rotated in small groups through the labs of participating faculty members. Technicians and graduate students guided the applicants through simple experiments, and SkIO faculty also held discussions with the student groups. These activities provided an opportunity for students to meet and interact with working scientists and exposed them to real skills needed to perform research in various areas in oceanography and marine sciences (e.g. microscopy, data processing, chlorophyll and DNA extraction). For many of these students this was the first opportunity to experience first hand a working research laboratory. After the workshop, the faculty compared observations of the various applicants and noted their preferences. Likewise, applicants were encouraged to submit information about which projects they had enjoyed and which they had not. The selection committee took input from both faculty and students under consideration when matching applicants with mentors. This workshop evaluation, which proved highly effective as a selection tool, had the added benefit of giving a "hands-on" learning experience even to those students not selected for an internship. The workshops were designed to assess aptitude, interest, and fit of individual intern applicants (undergraduate students) with the set of research labs willing to host undergraduate interns, though mentors (faculty and technicians at SkIO) learned and benefited from them, as well.

The BI-OMP interns focused on the application of molecular approaches to improving understanding of the nitrogen cycle in pelagic ecosystems. The CIRE interns worked on various projects alongside their respective faculty mentors at SkIO, ranging from

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Table 2 Selected abstracts and manuscripts resulting from SSU-SkIO research internships.

CIRE Cruise Participants 2002-2005

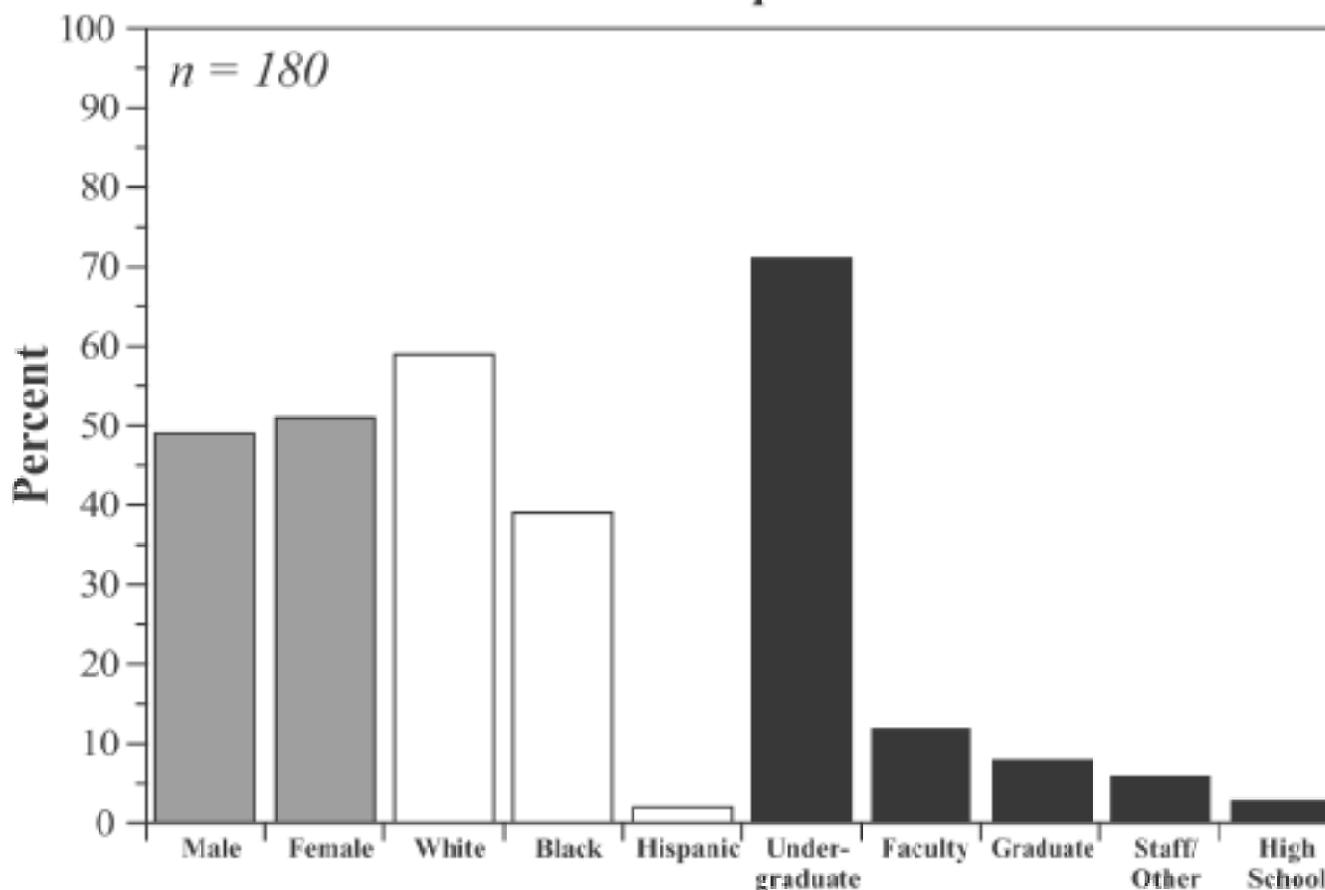


Figure 3. Percent of participants on CIRE cruises 2002-2005 (n=180) who were male/female, non-Hispanic white/African American/Hispanic, undergraduate/graduate/faculty/high school/staff or other.

toxicology, to molecular biology, to organic chemistry, to plankton ecology. Internships were flexible, allowing students to choose from several amounts of contact-time throughout the year of their award. The projects were designed so that each student had specific achievable goals. All of the students were required to prepare summaries of their work in the form of a typical science manuscript and to present their work to peer groups or, ideally, at regional or national scientific meetings. Successful interns were encouraged to continue beyond their initial year, and were allowed to work with either the same faculty mentor or with another one. The option of changing their faculty mentor provided students with the possibility of learning about different fields of marine and environmental science.

Mentoring of students was virtually always a key ingredient to successful internships, whether defined as retention or post-internship evaluation. Internship stipends were fundamentally important in initially drawing applicants, but success was largely predicated upon the quality of the mentoring received by the students. Faculty not experienced with students from a variety of backgrounds and who have had little exposure and experience in research environments received informal advice through direct discussions prior to accepting the role of mentorship. Mentors were encouraged but not required to attend initial contact sessions with a group of new interns, so as to both find proper matches between student and faculty interests, and to begin the process of bonding that leads to a successful relationship. The new interns received initial exposure to the basic aspects of research, the kinds of

equipment that might well be expected to use, and benefited from a question and answer session.

Laboratory supervisors are essential in a research environment. They provide the knowledge base and mentoring support mechanism in the critical early stages as a new intern grapples with the invariably intimidating aspects of working in an expensive setting and knowing the least of everyone. The professor mentor functions as the "big picture" provider between the day-to-day realities of learning, performing, testing, and growing intellectually, and knowing why it is that you (the intern and the rest of the research team) are doing what you do. From 1998 to 2005, 44 of 76 graduates of the marine science (58%) were able to participate in internships. Besides faculty at SSU, approximately 75% of the SkIO faculty has participated in the internship program, providing students with experience in microbial ecology, marine organic chemistry, shellfish histology, aquatic pathology, and molecular techniques for analyzing marine samples. Over 60 students are currently pursuing or have completed internships. Establishing these internships, however, required overcoming two hurdles. First, although SkIO is only 13 miles from SSU, public transportation does not reach its location on Skidaway Island. To resolve these transportation issues, grant funds were used to purchase a 15-passenger van, which acted as a student shuttle, and provided transportation for interns and mentors to regional scientific meetings. Second, student schedules had to be coordinated to a) overcome "stop-and-start" research problems, b) prevent lab disruptions, c) accommodate class schedules, and d) account for and compensate students and SkIO faculty members for contact time. These scheduling issues were

resolved by asking students to choose from four "level-of-effort" options. They were given the choice to participate 1/4-effort (10 hours/week), 1/3-effort (13 hours/week), or 1/2-effort (20 hours/week) during the fall and spring semesters. Full effort (40 hours/week) was also an option during the summer-and it has proven very popular. A system of checks was installed to monitor the students' progress. Students were asked to provide regular progress reports to their faculty mentors and to fill out periodic questionnaires to evaluate themselves and their experiences.

Faculty mentors were allowed to assign interns to particular members of their labs, such as research technicians or graduate students. These supervisors trained the students to work in a laboratory setting and to perform tasks related to their projects. A key element to the success of internships is a coordination role at SkIO by someone with experience as a student in such programs themselves. In the CIRE and BI-OMP programs, it has been a former SSU student and research intern and now full-time research employee, Mrs. Victoria Baylor. Mrs. Baylor's roles have included, participating in the student recruitment and selection process; developing, distributing and explaining the CIRE Program Student Handbook and reference materials (Baylor Unpub.; National Academy Press, 1995); coordinating semester-by-semester efforts; and organizing student research presentations and preparation for presentations at national meetings, e.g. minority student programs at ASLO meetings (Cuker, 2005)

Research intern presentations at regional, national, and international scientific meetings have included numerous American Society of Microbiology and American Society of Limnology and Oceanography (ASLO) national and international meetings. While she was an undergraduate intern, Mrs. Baylor received "Best Student Poster" award at the 2000 ASLO meeting in Copenhagen, Denmark. Recently, Ms. LaGina Frazier won third place for her student platform presentation at the Ocean Science 2006 meeting in Honolulu, Hawaii, at which six undergraduate interns and one graduate research fellow from SSU presented. That the students are presenting their work at national and international scientific meetings, and being included as authors in peer-reviewed publications, is itself an excellent indicator of the quality of their work (Table 2). Thus far, students have been involved in approximately 50 scientific abstracts for regional, national, or international meetings, with over a dozen papers that are published, submitted, or in preparation. The interns greatly value their interaction with real-world scientists in many sorts of career positions, including research technicians, graduate students, faculty members, post-docs, and fellow science majors. This experience allows them to clearly see some of the many career options available in the field of marine science.

Ship Time - Commissioned in 2001, the 91-foot research vessel 'Savannah,' a UNOLS fleet vessel operated by SkIO, has space for 18 scientists/students and hence provides an ideal platform for research exposure and experiences for SSU undergraduate and graduate students. The CIRE program provides seven days of ship time annually comprised of three two-day cross-shelf transect cruises and a one daylong cruise in coastal waters. The cruises typically include six or more oceanographic stations up to 60 nmi offshore along with opportunities for SkIO and SSU researchers to collect samples and information for their studies and classes. From 2002 to 2005, 180 students, faculty, staff, and others including from other HBCUs, colleges, universities, high schools, and foreign student research interns at SkIO have participated (Figure 3). Interestingly, males have participated at a higher rate than females, though females have historically comprised the higher percent

of students and graduates of the marine science programs at SSU. In contrast, the CIRE and BI-OMP program undergraduate interns (34) were 56% female and 62% African American. Similar to the access strategy of selection for first time research experience participants in the Bridge program, highest priority is given to students who had never participated in a multi-day research cruise, ensuring that even students not involved as research interns or with projects based on research cruise data had equal access to participation in shipboard research.

CONTRIBUTION OF RESEARCH EXPERIENCES TO STUDENT OUTCOMES

As a result of enhanced opportunities for research participation by these and other marine science funded projects at SSU there was an increase in the percent of marine science degree graduates who participated in significant research experiences while in school from 25% before 1999 to 66% percent afterwards. Also, 65% (13/20) of all graduates who had a significant research experience as undergraduates were accepted in to graduate degree programs. A significant research experience is defined here as one in which the student participates in a summer Research Experience for Undergraduates (REU) program (NSF Program) or at least 120 hours of research instruction/experience during a semester. We also noted an increase in the number graduating with honors from 30% prior to 1999 to 41% after 1999. These increases, particularly the number participating in research, is due in large part to expanded funding and opportunities for undergraduate research internships and graduate fellowships from externally-funded, collaborative research programs at SSU and its partners since 1998. Prior to 1998, students who were awarded research internships either attended other NSF REU sites or had internships at SSU through small funded projects. After 1998 several large collaborative projects that supported research internships and fellowships were in place.

CONCLUSIONS

Undergraduate research internships are a good predictor of future success in the marine science program at SSU, both in choosing and keeping a science major and in pursuing advanced degrees. Formal collaborations with research centers have significantly increased the number of internships available to students and has enhanced the growth of marine sciences at SSU which is now a Center of Excellence. The growth is directly linked to external support for collaborative research and education programs. For example, the number of faculty employed in marine sciences at SSU doubled from two to four after the Master of Science in marine sciences degree program was approved. It was the CIRE program and other collaborative projects that established the degree inter-institutional faculty collaboration which set the stage for the co-development of the new degree proposal. Collaboration also helped equip research laboratories and classrooms, provided teaching and research opportunities that were not available otherwise at both SkIO and SSU and transformed both institutions to some degree.

Our policy of encouraging underclassmen with little research experience to apply for the SSU/HBOI Bridge program was a successful approach. 77% of those surveyed went on to additional intern programs, while more than half (54%) went on to graduate work. The effective inter-institutional collaboration and partnership between SSU, an HBCU, and research centers (e.g. marine laboratories and oceanographic institutions) required a gestation period over which

mutually beneficial goals, objectives, roles, responsibilities, and commitments were developed.

Mutual respect of institutional missions, merits, and accomplishments, and strengths; acknowledgment that collaboration requires changes and has costs which were recognized by each institution. A formal inter-institutional agreement was important to demonstrate institutional commitment and to add legitimacy and recognition to faculty participation.

There are more than 100 HBCUs (NAFEO; NCES) and more than 100 marine laboratories (NAML) in the U.S. Thus, there should be ample opportunity for similar partnerships to develop. The diverse growth and productivity of marine science degree and research experience programs at Savannah State University illustrates how collaboration and partnerships can be an effective way to increase access and eventually pay big dividends by increasing diversity in the ocean science workforce.

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