

## **National Ocean Sciences Bowl Longitudinal Study 1999-2011**

The National Ocean Sciences Bowl (NOSB), sponsored by the Consortium for Ocean Leadership (Ocean Leadership, formerly the Consortium for Oceanographic Research and Education) and the National Ocean Partnership Program (NOPP), has been a highly successful competition for high ability secondary students implemented nationally. The NOSB is supported by U.S. federal agencies through NOPP, as well as by corporations, foundations and other non-governmental organizations, and is a collaborative effort between Ocean Leadership and the NOSB host institutions—primarily research universities. More than 2,000 students and 400 schools now actively take part in the competition each year, with more than 24,000 students having participated in NOSB during the past 14 years. The competition has grown from 16 to 25 regional competitions throughout the United States. Each regional bowl and the final competition is staffed and implemented by volunteers (primarily scientists, graduate and undergraduate students, and educators), who serve as moderators, science judges, rules judges, timers and scorekeepers.

As typical of other academic “quiz bowl-type” programs, the National Ocean Sciences Bowl consists of a round-robin/double-elimination format for teams of high school students. Teams consist of four students, one alternate, and a coach. It is a timed competition between two teams, with multiple-choice or short-answer questions from within the broad category of the oceans. Questions are drawn from the scientific and technical disciplines used in studying the oceans (for example, physics, chemistry, geology, atmospheric science, and biology) as well as from topics on the contributions of the ocean to national and international economics, history and culture. Each match consists of a series of toss-up questions that individual team members must answer without collaboration. A team that correctly responds to a toss-up question is given a bonus question to answer as a team. Additionally two "team challenge" questions are provided in written form and require teamwork and extra time to complete.

### **Methodology**

Dr. Howard Walters and Dr. Tina Bishop have been contracted to study the NOSB since 1999 (three times, this contract has gone through competitive, peer-review), and in the first two years of research addressed the content learning of students, the role of classroom teachers serving as coaches, and the organizational efficacy of the program. In 2002, the research expanded, at the request of the sponsoring agency, to examine the program from a systems theory perspective, to ascertain its impact as a system on the broader community of constituents, with a particular focus on how this competition impacts students’ career decisions.

Over the thirteen year effort to study the impact of the participants and stakeholders in the NOSB, the guiding research questions have included:

1. Does participation in the National Ocean Sciences Bowl influence the manner in which secondary student participants view careers in the ocean sciences community, and does participation provide an environment conducive to career decision-making?
2. Does participation in the National Ocean Sciences Bowl impact secondary students in affective, academic, developmental, and social ways which are durable and important in later college, career, and/or life settings?
3. Do participants develop meaningful and durable social relationships with key individuals or mentors who contribute to academic and vocational decision-making?

4. Do partnering organizations and individuals realize professional and systemic benefits from association with and support of the NOSB?
5. Is the NOSB, in short, more than a short-burst weekend program or academic competition; does it make a systemic difference in the social environment of ocean and marine science in the United States?

### Study Participants

A key task in this study has been the exploration and documentation of the link between NOSB participation and the education and career pathways of participating students as they migrated from secondary school into college and from college into graduate school or the STEM workforce. Working with Ocean Leadership and the regional university sponsors, the researchers identified and registered a sample of 440 student participants from 2006 through fall of 2011. This sample size was not concurrent, i.e. over time, different sets of active respondents have completed surveys, with select past participants remaining active with the study throughout their educational pipeline and into either graduate school or employment. Some study participants disengaged due to normal morality issues, i.e. moving, losing communications contact through changing email addresses or schools, or loss of interest. The number of active study participants for the most recent two years of the study (2009-2011) was estimated at 250 past participants, of whom 147 or 59% provided complete survey responses. Additionally, during two separate survey administrations (2003 and 2010) NOSB volunteers were surveyed extensively, with groups of 250 respondents (in 2003) and 288 respondents (in 2010). In 2003 and again in summer of 2011, the classroom teachers/coaches were also surveyed extensively, with 109 high school teachers, from 109 different high schools providing responses in 2011.

Finally, beginning in 2010, a sufficient pool of past-participants had been identified who were by then employed in the STEM career pool. These 49 individuals are now providing additional information regarding their current STEM careers and their past NOSB experiences. Relevant, current data include links from NOSB participation in high school, through the college and/or graduate school pipeline (to include curriculum/coursework included in these former students' education experiences), institutions from which they matriculated, and their current employers in the STEM field. These individuals have indicated willingness to participate in further, in-depth data collection with the research team, which will begin seeking fiscal support for this case analysis in spring 2012.

The key methods, instruments, audiences, and data types, with participation numbers by year, are included in Table 1 below.

### Key Methods

Phase	Year(s)	Study Participants	Number of Participants	Method	Product
1	1999-2001	<ul style="list-style-type: none"> <li>• Current Students</li> <li>• Coaches</li> </ul>	1,000 students and 200 coaches	Pre- and Post-criterion tests, Surveys, and Site visits	Written Report
2	2002-2004	<ul style="list-style-type: none"> <li>• Current students</li> <li>• Past Participants</li> </ul>	500 individuals representing each of the study	Surveys, Interviews, and Site Visits	An extensive written report which included a

		<ul style="list-style-type: none"> <li>• Coaches</li> <li>• Volunteers</li> <li>• Parents</li> <li>• Regional Coordinator</li> </ul>	subgroups		literature review
2a	2004			Updated Literature and Bibliography	Brief literature review and bibliography
2a	2005-2006			Updated Literature and Bibliography	Written abstract summaries
3a	2006-2010	Past participants	440	Registration Database linked to Alumni Web Site	
3	2006	Past Participants	215	Survey	Written report
3	2006-2007	Past participants	5 past participants	Case study and interviews	Written case studies Videos
3	2007			Updated Literature Review	Written report
3	2008	Coaches	66 coaches from 19 regions	Online Survey	Report
3	Annually	Past participants	Various levels of participation, but approximately 150 each season	Emails surveys-fall and spring	Summary of college majors and courses taken
3	2009	Past participants (diversity)	Indirect study of diversity site reports	Literature review Interview Survey	Written report
3	2010	Volunteers, scientists, and graduate students	288 respondents	Survey	Written report
3	2010	Past Participants in Workforce	54 respondents	Survey	Written report
3	2011	Coaches	109 respondents	Survey of second tier impact	Written report
3	2011-2012	Past participants in careers	49	Survey	Written report

## Findings To Date

Through the years, the findings have clearly indicated that the NOSB is more than an academic competition. It is a rich and complex interaction of a variety of stakeholders who benefit from their involvement in the program in positive ways.

For some in the group of past participants, connections to the field have led to interest both in science courses and careers. For others, it is awareness of important ocean and environmental topics that leads to hobbies and community service in related areas. For a number of participants the collegial environment engendered by team participation has been important, with a substantial number of respondents noting ongoing contact with their NOSB fellow participants and their coaches many years after high school (nearly 80% at the end of post-secondary education). Many of the students report the development of leadership, teamwork, presentation, self-confidence and organizational skills as a result of their participation. These qualities will be useful no matter what field of endeavor that they pursue. The excitement of competition and love of learning motivate some students to compete in NOSB.

From results of the second phase of the study in which students reported on NOSB's influence on career and college, 41% of the past participants *Strongly Agree or Agree* that NOSB participation influenced career choice. 50% were in *Strong Agreement or Agreement* that students' perceptions of their own abilities were the strongest influence on career selection. 39% indicated that NOSB influenced their choice of college major. Finally, a smaller 29% of students *Strongly Agreed or Agreed* that NOSB participation influenced college selection. This relatively lower response was expected, as economic, geographic, and family history factors seem to be much stronger impacts on college choice—which contains a greater diversity of options—than career choice.

Other factors identified by the students as motivators included extracurricular activities that introduced them to science and the natural world, particularly field-based or research based programs. Respondents also noted courses or classes, mentors or key adults, such as teachers or coaches, and personal interest or passion for a career. The opportunities for participants to interact with graduate students, faculty researchers and scientists through the competition seemed related to why students selected a career path, as reported by many past participants who have made these choices and are now enrolled in higher education. Many of these high school and college-aged young people—having demonstrated high academic ability already—have selected to pursue careers and/or college degrees in science, medicine, engineering, mathematics, teaching, and a host of other STEM areas, and provided responses indicating enhanced environmental stewardship.

Significantly, and moving beyond attitudinal or perception surveys, students who have participated in data collection have also provided specific information in the form of class schedules, courses taken, and degrees earned—and with the 2010 Workforce Survey, are now providing employer information to demonstrate that some of them truly are entering the ocean-related workforce or the STEM workforce more broadly. The research team is considering seeking additional grant funding to facilitate a case study of a selection of these, now, employed young adults in the STEM field to cross-validate the emergent recruitment factors related to the STEM pipeline that have been identified in earlier years of this study.

Volunteers, coaches, and regional coordinators report the satisfaction of working with young people and fostering interest in science fields, while conversely, the past participants reported

great reciprocal value for these relationships. Mentoring was highly valued by these past participants, with many reporting an appreciation of interactions with scientists, graduate students, and coaches in supporting their academic and personal development. Many volunteers return year after year, and numerous alumni return to volunteer and continue their interaction with NOSB. And finally, scientists clearly recognize the importance of an academic science competition on facilitating the career pipelines and connectivity of secondary students as they move toward post-secondary education.

## **Benefits**

The many thousands of young adults, classroom teachers, scientists and volunteers associated to the NOSB over the years have—certainly—benefitted from this involvement. These benefits are multifaceted, and some of these can be easily overlooked without the written reports immediately on hand. Summarizing these reports from over the years suggests a set of clear benefits for each of the involved stakeholders, to include:

- For past participants who entered STEM careers: the research and evaluations have indicated that these individuals were provided meaningful support, mentoring, and career guidance by the coaches who oversaw their years of competition. There is also evidence that through interactions with graduate students and faculty at the Ocean Leadership member institutions where many of the programs were held, the students had the opportunity to not only participate in the NOSB, but also to visit key universities where many of these students eventually matriculated. This clear support for career and education scaffolding is an important contribution of NOSB to the students.
- For past participants in general: The research has been clear that all of the students who participated benefitted from leadership development, team development, and study skills support for detailed and deep science content learning. Further, large proportions of past participants who responded to the survey indicated that they remained involved in a social network of science-minded peers and former teachers who were associated with the NOSB. And finally, many of these students demonstrated that they had been supported in making life-related stewardship decisions, had selected science-related hobbies and interests, and many, regardless of college major, eventually took additional college coursework that included ocean and marine content—thereby increasing their understanding of the oceans as citizens.
- For Coaches: Many of the classroom teachers who worked as team coaches reported that working with these high ability students required them to engage in a high degree of self-directed learning in the ocean science fields, in order to prepare to engage with the students at the high content level required by the NOSB. This preparatory work proved to be a highly effective professional development (PD) program for these teachers—and one could argue that many more teachers, through intense self-study, benefitted from enhanced content knowledge of ocean sciences as a result of NOSB (and without direct funding for this PD) than in many federally funded professional development programs in the ocean science community over this same period of time. These teachers reported consistently over the decade of study that they regularly infused ocean sciences content into other classroom instruction with the non-NOSB participating student body. This observation suggests that the NOSB contributed significantly, albeit indirectly, to the

federal STEM education goals associated to ocean sciences as a secondary, leveraged impact—and without the expenditure of federal funds to do so. This aspect of the program is little understood and remains a fertile area for a learning sciences research study, as the nation continues to need effective mechanisms to transfer science content from its laboratories to the teachers in its classrooms. Many coaches expressed a renewed energy for teaching by their interactions with these highly motivated students.

- For Scientist Volunteers: the federal agencies have long encouraged its funded scientists to seek a broader impact for the results of their scientific research, by seeking creative, leveraged opportunities to infuse this new content into public education and outreach efforts. The NOSB program, from its very beginning, sought out scientists and high level graduate students to create the questions used in the competition, to facilitate the quiz-bowl sessions, to judge the accuracy of student science responses, and to serve as both advisors to the program, but also as active volunteers in a number of capacities to actually implement the program. Over the years, these relationships have grown to also include recruitment of new graduate and undergraduate students out of the ranks of NOSB participants into the student bodies of the hosting institutions, and scientists hosting laboratory tours, field trips and experiences, and supporting teachers and students in the secondary classrooms through speaking and class visits. In this vein, the NOSB program has successfully modeled a rich and complex social community of scientists from the most elite laboratories and universities, working in partnership with federal agency personnel, secondary school teachers, graduate and undergraduate science majors, and secondary students—to see a rapid transfer of emergent science knowledge into education programs. Consequently, the NOSB has substantively benefitted all of these communities by functioning as the nexus of this social network.
- For Second Tier Students: consistently over the research period, the coaches—those high school teachers that were responsible for advising and guiding the individual NOSB team from a school—reported that the regularly infused ocean sciences content into the regular course instruction for all of the other students enrolled in their classes. So while the NOSB team was limited to five young people, it was clear that all of the students in these schools, at least the ones who would take science courses with these coaches, were being exposed to ocean science content. Additionally, while much of the data remain anecdotal because it was tangential to the primary study goals, numerous teachers over the years reported that because of their involvement with NOSB, they eventually obtained a desire to teach a formal ocean science course, and in fact went through the process of writing and obtaining approval to add such a course in their high school.
- For the STEM Workforce: by 2010 in the study process, it became clear that there were increasing numbers of past NOSB participants who had remained in the STEM pipeline and who were entering the STEM workforce. This fact resulted in intentional efforts to measure and interact with these young scientists, and the 2011 data captured extensive survey results from 49 young scientists who work in STEM careers. They reported that their exposure to science through the NOSB directly contributed to their decisions to endure in this pipeline. The benefit, then, to the nation’s STEM workforce attributable to NOSB is positive. The researchers are hopeful to be able to do more indepth study of

these young scientists to continue to expand on our understanding of STEM workforce recruitment as it is influenced by secondary education efforts such as NOSB.

### **Strengths of the Project**

In conclusion, and by analyzing and reflecting on the breadth of the research program over the past thirteen years, it is clear that this longitudinal effort is unique among STEM education programs in the length of time it has functioned, and its methodological complexity in assessing the impacts of NOSB. It is rare that STEM education programs have the capacity, or the vision, to implement consistent evaluation activities over multiple years of programming. The fact that NOSB and its parent organization have identified and incorporated fiscal support toward research evaluation for over a decade is a statement of the importance that the organization holds for identifying the impacts and outcomes of its flagship education effort. From the activities summarized in Table 1 above, the following strengths of the research program emerge:

- Consistent database of past participants
- Historical archive of project
- Multidimensional view of NOSB as a system with a variety of stakeholders
- Unique perspective on academic competitions
- Perspectives of social implications
- Understanding of what motivates students to enter the STEM pipeline
- Longitudinal tracking of interested alumni
- Peer-reviewed publications
- Regular reporting of educational experiences of past participants
- Used a variety of research methods
- Literature foundation

In final analysis: the NOSB is indeed much more than an academic competition. It is a social community which directly benefits multiple stakeholder groups. As an interactive hub for these stakeholders, it provides a platform for a complex cross-section of ocean-concerned agencies and individuals, allowing each to meet multiple levels and types of goals—in the immediate context of directly supporting secondary students. In this, it seems highly effective and beneficial, ultimately, to its host organization, the Consortium for Ocean Leadership, to these students and their teachers, to the constellation of federal and state science agencies, and to the nation.

### **Recommendations for Programming**

Across the data analyses conducted in association with the various stakeholder groups and research methodologies summarized in the table above, a series of recommendations for enhancements, revisions, or leveraging to the NOSB program have emerged. Clearly, many of these recommendations emerge logically from the data and possess strong, theoretical or potentially positive outcomes, but are beyond the budgetary or strategic goals and vision of Ocean Leadership for the NOSB. Nevertheless, in an attempt to be comprehensive and thorough in presenting a summary of the longitudinal effort, a similarly comprehensive report of the recommendations over the years of the study is included as follows.

1. To Support Past Participants/Alumni—
  - a. Organize interactions between graduate and undergraduate students and between college and secondary students;
  - b. Strengthen the ties with oceanographers; connect these scientists with the teams and coaches;
  - c. Provide mechanisms for the past participants to support and be connected to the organization;
  - d. Consider the possibilities for a college level academic competition similar to NOSB.
2. To Support Coaches—
  - a. Consider an online communications portal to share information about STEM opportunities toward which to direct students;
  - b. Coordinate with Ocean Leadership institutions to create a meaningful mechanism to better connect these universities and research centers to secondary classrooms for enhanced recruitment of high potential secondary students into the undergraduate pipeline;
  - c. Provide support for the instructional and curriculum needs of coaches to meet the needs of second tier students in these schools.
3. To Support Volunteers/Scientists—
  - a. Provide opportunities for networking in the field of ocean sciences for volunteer scientists during the competitions;
  - b. Consider incentives or rewards such as luncheons or recognitions for volunteers in ways that transfer to typical resume' and promotion systems;
  - c. Consider identifying exemplary volunteers across the regions and facilitating their involvement at the national competition;
  - d. Create video biographies of key scientists who have consistently volunteered at NOSB over the years, and highlight these on program web sites to demonstrate the commitment of ocean scientists to the project.
4. To Support Current Students—
  - a. Implement a planning process to identify meaningful mechanisms to broaden the reach of NOSB and Ocean Leadership content and institutional concerns to larger populations of secondary students and teachers for STEM workforce impact;
  - b. Invite current scientists who are past participants to a forum to speak to and engage with current high potential secondary students regarding persistence in the STEM pipeline, and to create opportunities for social relationships and mentorships between these two populations.
5. To Support Science/STEM Careers—
  - a. Create an advisor panel of past participants now engaged in the STEM career workforce to review planning documents and progress reports concerning NOSB, and to advise Ocean Leadership and NOSB staff regarding impactful enhancements to broadening the reach of NOSB toward a transformation of STEM pipeline efforts and energy investments;

- b. Work with current past participants who are employed in the STEM workforce to identify and anticipate the ocean science workforce of 2020 and beyond, so as to meaningfully evolve the NOSB program to best meet these needs.

### **Recommendations for Future Research**

1. Continue to seek creative ways to consider the impact on, and solicit feedback from student participants who represent diverse and underrepresented populations.
2. Provide additional focus toward understanding diversity participation beyond the funded diversity projects that have been included in NOSB over the years.
3. Does academic competition serve as an effective method for enhancing the transfer of science content knowledge compared to other, more traditionally pedagogical approaches.
4. Implement deep case analyses of past participants who are now engaged in the STEM workforce to identify factors relevant to recruitment which might be exploited in current NOSB competitions to successfully identify and mentor high potential scientists from the broader population.
5. Identify curricular changes, innovations, and expansions in secondary schools which emerged as a direct result of NOSB programming through coaches and teams, and identify mechanisms where these efforts can be leveraged and expanded in broader contexts. Consider implementing, through appropriate learning science research methods and design considerations, an introductory ocean sciences high school course that could be offered nationally for school systems that lack other mechanisms to obtain such a course.
6. Deeply examine additional and broader impacts of the oceans on the world through economics, globalization, global trade, social justice concerns, tourism, world health and resource distribution and uses—with a view toward re-conceptualizing the content focus of the competition.
7. Consider the use of virtual platforms and social networking software approaches to enhance the breadth and depth of Ocean Leadership education efforts by leveraging the NOSB network (building and activating a virtual community for extended purposes.)
8. Identify opportunities for capturing the enhanced environmental stewardship and secondary activity (hobbies, interests, etc.) and leverage these to other programmatic and involvement efforts by past participants as potential marketing and funding avenues for NOSB.
9. Continue efforts to visualize the emerging social network of individuals, from a variety of stakeholder groups, who are committed to the implementation and success of the NOSB.