Report on NOSB Coach and Student Surveys, Winter 2014-2015:
Instructional Choices and Team Preparation

Introduction and Method

The Consortium for Ocean Leadership annually implements the National Ocean Sciences Bowl as a regional and national competition-based program for high ability secondary students in the United States. Annually, a tracking survey has been implemented to follow students after high school graduation, through college and, for some, graduate school, and into the workplace. Beginning in 1999 and continuing annually since that year, Drs. Tina Bishop and Howard Walters, of the College of Exploration and Ashland University respectively, have developed the surveys associated to this now longitudinal tracking study, as well as numerous other instruments and data collection procedures. Each year, in addition to the student and past participant tracking surveys, an additional research project has been undertaken focused on one or more of the other constituency or stakeholder groups attached to the program, including scientists and graduate students, judges and volunteers, teachers and parents.

This year, in Fall 2014, two, extensive surveys were developed to look at instructional strategies and team preparation: one for the team coaches, i.e. secondary school teachers and, a second survey for students who participated in the two most recent years' competitions. These surveys were created with review and input from COL staff, and disseminated to the coaches as an electronic survey by the COL staff, with responses sent directly to the independent research team. The student survey was disseminated to the coaches and then to their respective students, but with responses sent directly to the research team.

These surveys were particularly focused on the instructional methods used by coaches in their classrooms or in out-of-school activities to prepare the teams for the regional and/or national competitions. This allowed triangulation of coach and student responses to increase the reliability and credibility of the findings. The summaries in this report will primarily follow the coach responses because of the much larger sample size, with student response data threaded throughout. Student responses will be presented to clarify and reveal any differences between perspectives from the two audiences, although this rarely occurred. In addition to these instructional issues, a more expansive set of questions was provided to students to achieve a more holistic perspective on the competition, and these are referenced at the end of the summary section.

Summary results follow, with interpretations and discussion, findings and conclusions at the end. Throughout the summary section, data will first be discussed using all responses, and then discussed in disaggregated form based on the team rankings at the national competition where this uncovers new insights into the program. The evaluation team used "ranked at first or second place at nationals" as an exploratory sub-group of students for comparisons across the survey. Several interesting findings emerged from the filtered data.

Summary of Demographics

A total of 81 classroom teachers who coach an NOSB school team provided responses to the survey. Of these teachers, only one was a first year coach. Thirty-four (42%) of respondents had coached from 2-5 years; Twenty-four (30%) of respondents had coached from 6-10 years, and twenty-two (27%) of the respondents had coached teams for more than 10 years. Certainly, these are a highly experienced pool of coaches and classroom teachers, and their feedback to the narrative sections (the open ended response items) of the survey is based on this valuable experience. Respondents further represented 24 of the regional ocean science bowl competitions including (with respondent N in parentheses):

Bay Scallop (2)	Hurricane (3)	Salmon (4)
Blue Crab (8)	Lake Sturgeon (3)	Sea Lion (2)
Blue Heron (3)	Loggerhead (4)	Shore (3)
Blue Lobster (1)	Manatee (2)	Spoonbill (6)
Chesapeake (3)	Nor'Easter (3)	Stingray (2)
Dolphin (3)	Orca (1)	Surf Bowl (2)
Great Lakes (3)	Penguin (7)	Trout (2)
Grunion (2)	Quahog (8)	Tsunami (4

Tables 1 and 2 below indicate respondents who have placed in the top three at regionals, and then have coached a team that competed in a National Finals Competition. For the respondents with teams that competed at the Finals, 8.62% (5) had a team place first; 6.9% (4) had a team place second; and 6.9% (4) had a team that placed third in competition rankings.

Table 1. Percentages of 81 coaches who have had a team place in the top 3 in regional competitions.

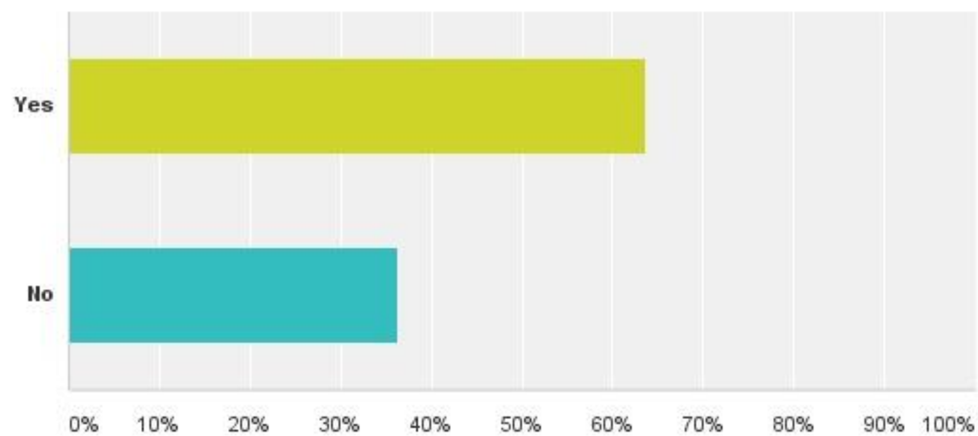
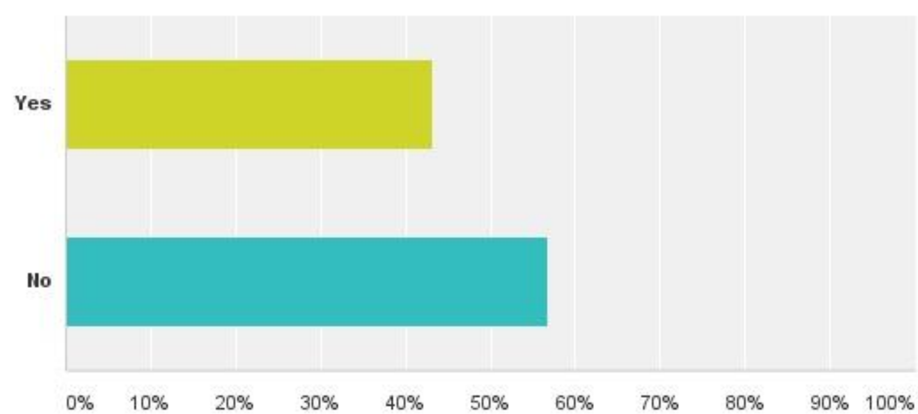


Table 2. Percentages of 81 coaches who competed at the NOSB National competition.



Filtering the response data on the variable of team rankings in first or second place, there were no significant differences in the number of years a coach had participated and the rank order of placement at the final competition, suggesting that teacher experience levels may not affect team success at the competition.

Of the thirty-three student responding, approximately 34% (11) of the respondents are college freshmen; 25% (8) are college sophomores; with the remaining students either high school juniors (18.75%) or seniors (21.88%). From this group, 97% (32) of the students' teams placed first at the regional competition, although none of the students reported placing higher than third at the national competition. Thirty of the respondents indicate that they either are or are planning to pursue a degree in a STEM related field, with three reporting humanities fields. Approximately 30% of respondents indicated that they were either two, three, or four year team members, with three respondents having participated only one year in NOSB.

Resources or Local Support for Team

Moving beyond demographic considerations, *item 6* revealed that 46.15% (36) of respondents received resources from their respective local schools or districts to support the team and the teacher's work on NOSB, while 53.85% (42) did not. Thirty-four of the respondents who received resources from their schools indicated these resources included things such as: small funds for supplies and registration costs, some transportation funding, extracurricular textbooks, hotel costs, copying support, food money for students and teachers, or small stipends for the coach. Other non-financial support included classroom space, release time for the coach, use of school buses, and a buzzer system. Interestingly, most (6/9) of the teams whose students placed in first or second at the Final competition do not receive resource support or fiscal support from their schools. While the response numbers are low for this filtering variable, there is some support here to conclude that financial support at the local level is not a variable that affects success of the team.

Team Preparation

Items 7 and 8 were focused on time issues with preparing the team for the competition. With respect to the amount of time that coaches devoted to preparing their team during the week, 90.12% (73) of the coaches used from 1-5 hours weekly; 6.17% (5) used from 6-10 hours weekly; 3.7% (3) used 10-15 hours weekly. With respect to the amount of time the coaches used to prepare themselves to work with their respective teams each week, 93.75% of the coaches used from 1-5 hours; 3.75% (3) of the coaches used from 6-10 hours; and 2.5% (2) of the coaches invested more than 10 hours each week. Student responses matched the coach responses in this pattern of time use, with 63.6% of students reporting 1-5 hours of time weekly, and 30% reported 6-10 hours weekly. While the pattern is the same, the difference in percentages of responses in the time range categories seems to be only a function of sample size differences between coaches and students responding. For both coaches and students, the general rule of time used for preparation is towards the low end (1-5 hours per week).

These variables were also filtered and compared to success in the finals rankings. Interestingly, none of the highest ranking teams' teachers (9 reporting) exceeded the lowest level of weekly time investment with the team. Only one of the nine first and second place finals teams had a coach that invested more than the minimum category of time in personal preparation. Again, sample size here is small, but the data move in a direction of student locus of control and engagement as more essential variables, and support at least a modest conclusion that success is not "riding on" those "super teachers" who are willing to make a complete life commitment to this single program. This would support the potential for broader expansion, as more typical or average teachers may indeed find team success.

Items 9 and 10 explores team preparation on their own, "without coach instruction or participation, for the competition." For these items (further referenced in the above paragraph), 86.42% (70) of the respondents indicated that their teams did prepare on their own, with 13.58% (11) of the respondents indicating that they did not. Filtering these data by team rankings in the final competition, 8 of 9 first or second place team coaches in the data report that their students prepare “on their own, without teacher instruction or participation for the competition” (*item 10*). The coach respondents were asked to delineate approximately how much time weekly the students worked on their own for preparation, and of the 66 responses, 42% (28) indicated from 1-3 hours; 23% (15) indicated from 4-10 hours; and the remaining 23 respondents were unsure of the time investment by students. Filtering the top ranked teams (9 total, first and second place team coaches responded), three reported from 1-3 hours, only one reported 4-10 hours, and the remaining five top ranked teams were not tracked by the coaches.

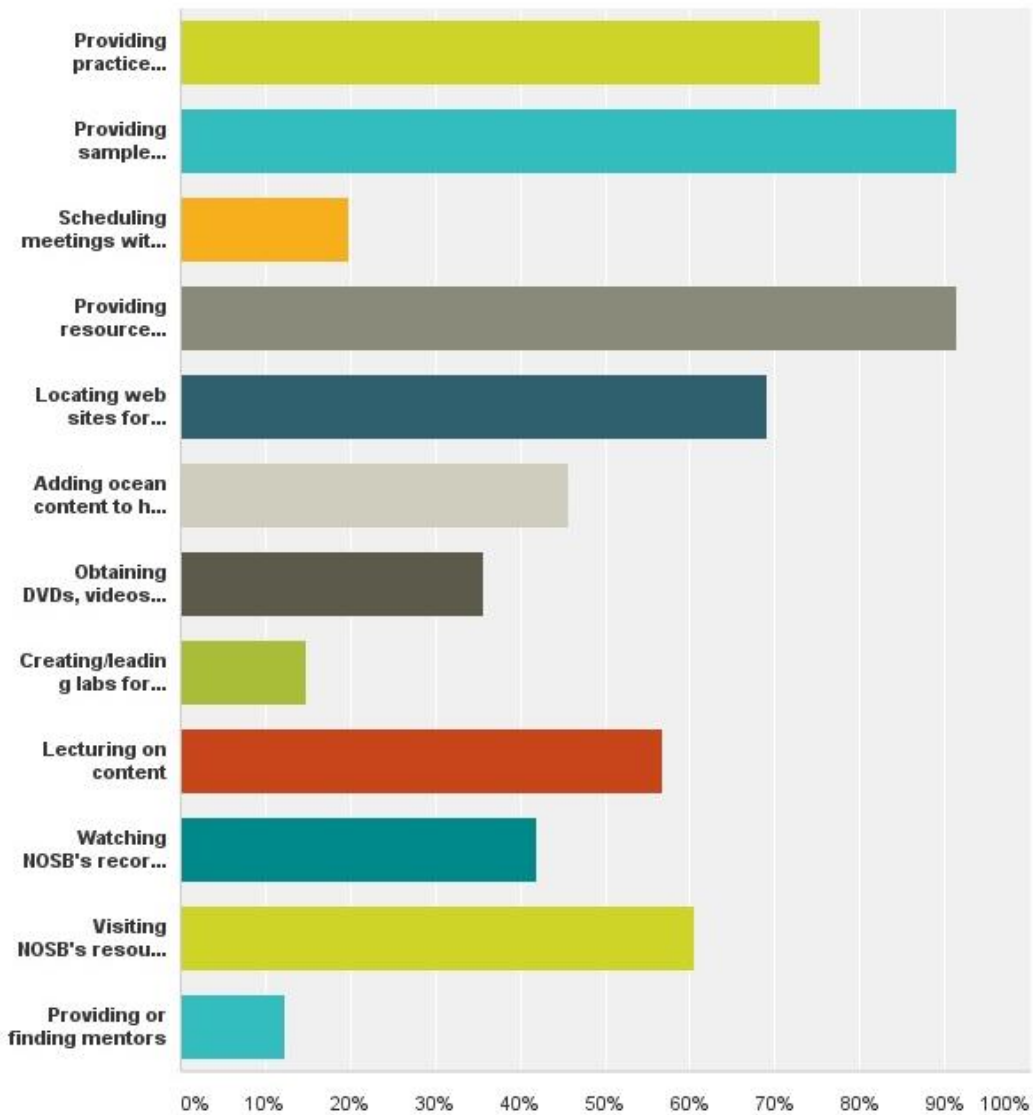
Student response data for this issue again mirrored the coach data: 63.6% of students reported 1-5 hours on their own, 27% reported 6-10 hours on their own, and 3% (one student) reported more than 11 hours alone. The general practice seemed to be about 1-5 hours on average, with a balance between time alone, time with teams alone and about 1-5 hours on average with a teacher. The highest ranked teams at national competition were from these lowest time use categories.

Instructional Strategies

Items 11 through 15 were focused on instructional strategies, teaching methods and resource utilization by the coaches in preparing their teams. For item 11, the focus was on specific instructional strategies used by coaches with their teams. *Table 3* below illustrates all of the responses, with sample questions, reading and textbooks, and practice quizzes as the top three responses.

Three interesting clusters are suggested by similarity of items in this list, i.e. responses 1-3, 4-9, and 10-12. Responses 1-3 as strategies may focus on a re-creation of the competition itself as a means of creating understanding and practice with buzzers, with the competition format, and with the types of question prompts likely to drive responses. Responses 4-9 really highlight the actions of the teacher in more traditional content development activities through lecture, content teaching, professional development, and importantly, adding content to classes where other students would be impacted. Finally, responses 10-12 suggest enrichment strategies beyond traditional class instruction and suggest network and social system building as a part of team development and growth. This last observation is important based on the researchers' 15-year longitudinal tracking data that past participants believe, years later, that they are part of a social system related to NOSB. This perception may in fact not be correlational or incidental, but the result of teacher choices early on.

Table 3. Instructional strategies used by coaches for team preparation.



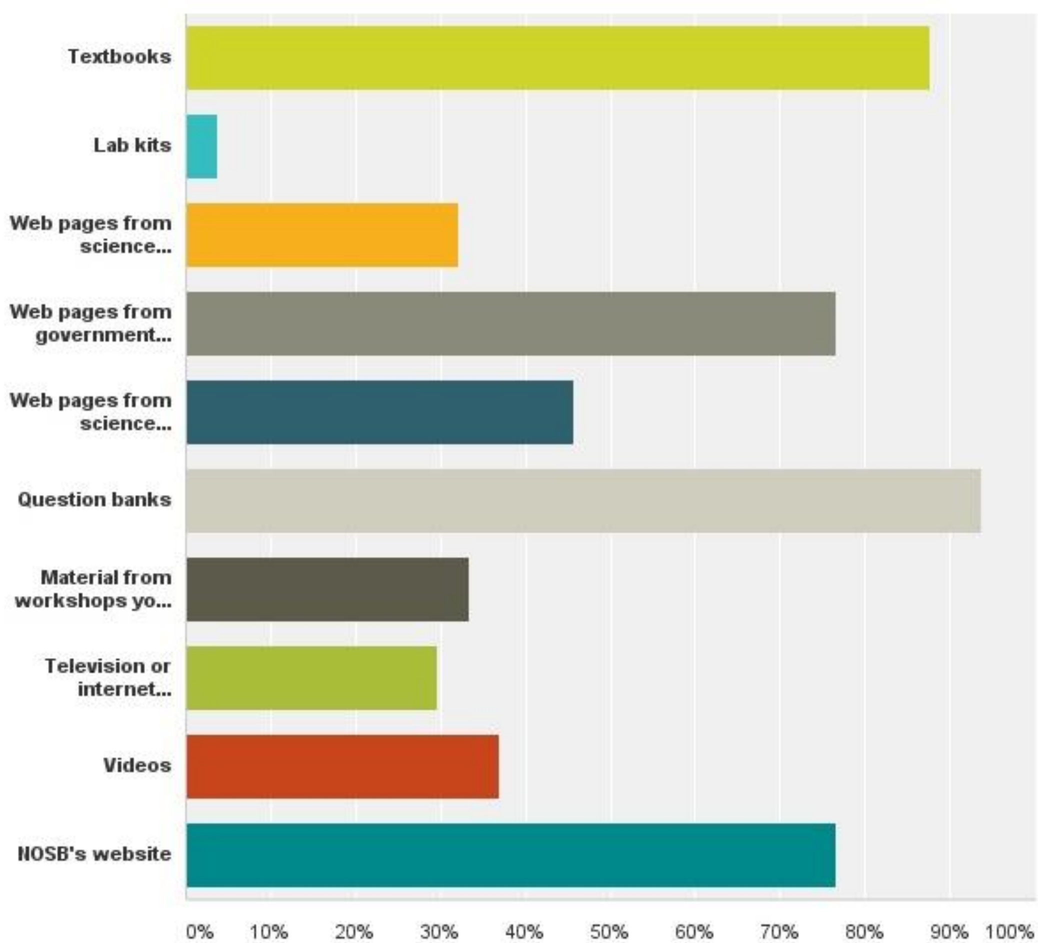
This observation bears careful thought and reflection. One unanticipated observation here is the proportion of teachers using the NOSB professional development videos (41.98% of respondents): one respondent described how her students watch these videos, something that the researchers had not considered before, as these videos were developed for coach content development. Further research with coaches and students would be needed to understand the proportion of students watching these presentations and how beneficial they are.

Item 11, instructional strategies, reveals an interesting finding when the data are filtered to look only at the responses of coaches whose teams placed first or second at the final competition. For these teams, the use of practice quizzing drops significantly out of the rank order, and is replaced by the use of these NOSB Professional Development Videos, and the teachers' use of content lectures in classrooms where other students are also benefitting from the instruction. It may be that the high team ranking for these teams is a positive reflection on teaching quality in the classrooms; however, other issues such as team motivation, individual team composition, and student characteristics should be studied carefully. It also suggests that high level performance at the competition may be more closely associated to authentic ocean science learning and not simply a function of "buzzer training" as some anecdotal comments have suggested over the years. It also supports a belief that substantive ocean teaching is occurring at the second tier level for a larger group of students than simply the ocean bowl team in these schools, with 56.79% of respondents providing lectures, which may imply there was a full classroom of students present, and 45.68% of respondents explicitly indicating they had added ocean content to courses of instruction that would have, of necessity, involved other students.

Student response data consistently matched the patterns of the coach responses, with practice quizzing (100%), reading textbooks (96.7%), reading web pages (90.9%) and writing practice questions (90.9%) the top four preparation strategies used by the students. And again, team challenge questions, writing sample questions, and obtaining enhanced content through lectures and reading are all reported by students as activities their teacher led—just as teachers reported.

Item 12 asked coaches to describe, with a selected response item, their leadership of their respective teams. The largest number of respondents (34.57%, 28 teachers) selected the choice, "Moderately teacher led, with some student work on their own." The next largest response category was "balanced between teacher and student initiative" with 24.69% or 20 teachers selecting this label. An additional 11 teachers or 13.58% of respondents selected each of the three other categories, i.e. Highly teacher led, moderately student led, or students mostly working on their own. These responses were, again, sorted based upon rank order of team performance at the national competition. There were no statistical or practical differences between the order of the typical response pattern and that of the highest ranking teams, with most of the top team coaches indicating "moderately teacher led" as their selection.

Table 4. Primary instructional resources used by coaches to prepare teams.



Item 13 asked teachers to identify the primary instructional resources that they draw from or encourage when preparing their teams. *Table 4* above includes all coach responses, revealing question banks, textbooks and various web pages as the top selections.

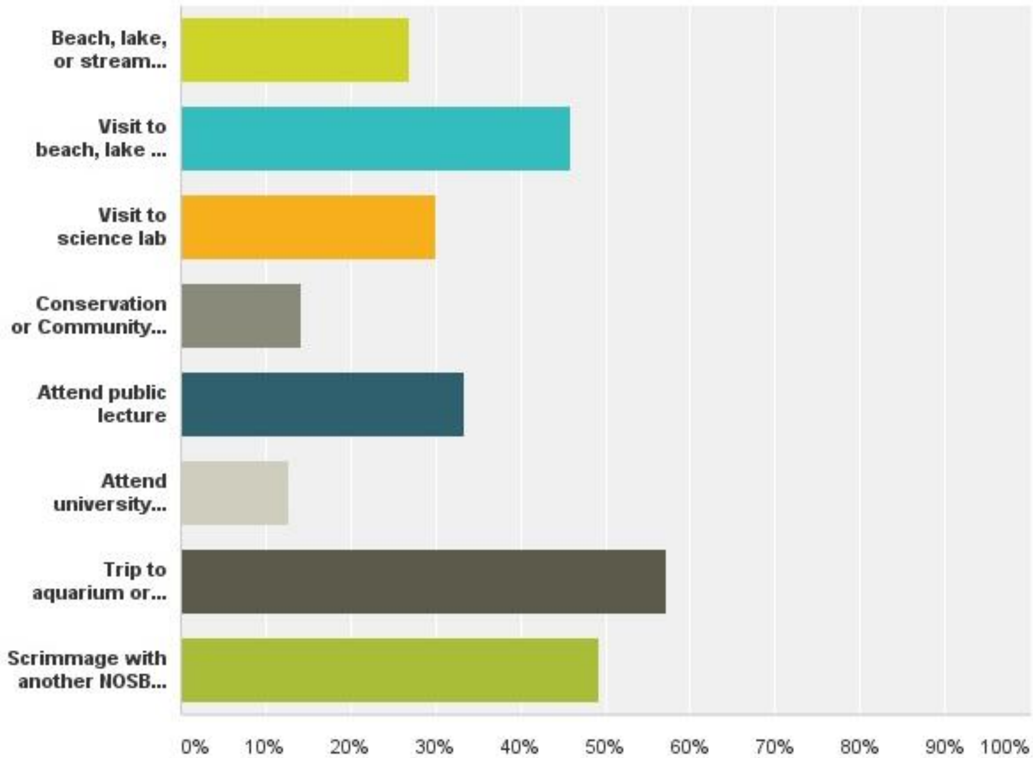
Sorting out these responses for the top performing teams at the national finals, only slight variations occurred between the teams based on resource materials. The two top resources exchanged order for the higher teams, with textbooks used by 100% of the teachers with a team scoring first or second place. This is an interesting observation with respect to the use of textbooks by all of these teachers.

Item 14 asked teachers, "which of the following (check all) are enrichment activities you have used with your team for preparation work or science knowledge enhancement? A set of eight common enrichment activities were provided, from which teachers selected field trips and scrimmages with other teams as most common, with full responses in *Table 6* below.

Filtering these enrichment activities to identify the responses of the teachers with teams scoring first or second at the national competition revealed an interesting difference in the patter of responses. The largest proportion of these high ranking teams had participated in scrimmage competitions with other NOSB teams, with the other possible enrichments substantially declining. This might suggest, different from an earlier observation in these data, that practice with the competition to develop strategies for the competition may be helpful, although no follow-up or probing questions were used to explore this.

Student responses to the enrichment activities item very nearly preserved the identical order of coach responses. Field trips were the highest category of student response (92%) followed by meetings with scientists (52%, which somewhat approximates visiting a science lab on the coach response list). Thirty-six percent of students reported lab experiments and visiting a laboratory as the third ranked choice, which somewhat approximates lab work at a beach, lake or stream on the coach list, or visiting a science lab on the coach list. Interestingly, while 49% of coaches (31) reported scrimmaging with another NOSB team as an enrichment

Table 6. Common enrichment activities used by coaches to prepare teams.



activity; 57% (19) of the students identified this as an activity. If these scrimmage competitions are with other schools, it is likely that these scrimmages are more authentic representations of the actual competition and may, then, be powerful preparatory advantages to these teams. Additionally, to the extent these scrimmages are with other schools, this is an additional dimension of the social network of the NOSB that has not been previously identified nor studied. This is a novel observation in this year's research that has not been described in the previous tracking efforts.

Item 15 explores the organizational dynamics of the respective teams, to gain insight into how pervasive ocean content might influence larger groups of students, and how ocean content is infused in these particular schools. For 46% of respondents (35), the students on the NOSB team were members of a larger science or ocean science club organization. For 26% of the respondents (22) the students were exclusively on the NOSB team as a stand-alone entity. An additional 17% of respondents (14) represent NOSB teams that also competed in other academic and science competitions beyond the NOSB program. Finally, 11% (9) of respondents taught an ocean content science course from which the NOSB team emerged during the year.

Student responses were similarly patterned, with student data matching substantially these categories and percentages that the teachers reported. One additional issue did emerge in student responses that was unique from the teacher data. However, this selection was based on a school competition, with 25.8% (8) of students describing this as a selection mechanism to join a team. This did not appear in the teacher data, but is conceptually consistent with larger groups of students being impacted in some way by the NOSB—and these other students may have come from classes or clubs. Among student respondents, 40% are taking or took an ocean science related course in high school, which would have directly related to preparation for the NOSB competition. For the high school graduates, 21% have taken or are taking a college course related to ocean science, which, while not related to NOSB preparation, may be related to other outcomes of the NOSB program or student career interest. Finally, 42% of students (14) reported that they did participate in other high school academic competitions—most of which were science related. This is higher than the percentage reported by the coaches and may be worth considering as a demographic variable related to the type of student recruited into NOSB participation and ultimately into the college and career STEM pipeline.

One early question in the NOSB program was whether the program was recruited historic academic quiz bowl teams from these schools, or drawing a new community of ocean-interested students and teachers. These data describe a broader ocean-related curricular and personal interest motivation for these students and teachers. In that context, *item 16* asked coaches how many students they reached with NOSB team preparation and inclusion of ocean content into their classrooms. The 80 teachers responding collectively delineated 3,654 individual students received ocean science content instruction because of the NOSB team preparation activities, to include high school classes that covered the content. This is an average of nearly 46 students per teacher, far beyond the number of students on the NOSB team itself. Clearly, NOSB as a program has become an effective mechanism to infuse ocean science content into curriculum that reaches many more students than participate in the competitions.

Classroom Resources and Teaching Approaches

Item 17, among a number of items in the survey, seeks to describe the types of teaching activities, theories, philosophies, or materials used by the science teachers completing this survey, who participate in the NOSB program. The intent is to enhance understanding of science teaching as it is used by these teachers, and to observe the varying results of select instructional approaches. Item seventeen asked, "Some science teaching is highly inquiry driven and constructivist; other models emphasize content delivery or acquisition of factual knowledge. How do your team preparation activities fit along or within these models?" The responses ranged from: Highly constructivist (2.63%, 2 responses) to Constructivist (2.63%, 2 responses) to Balanced (48.68%, 37 responses) to Focused on Factual Knowledge (36.84%, 28 responses) to Highly Focused on Factual Knowledge (9.21%, 7 responses). Filtering these responses for the teams placing first or second at the national competition reveals a statistically significant skewing of the response pattern (even with the small sample size of 9 teams). These higher ranking teams' teachers' responses highly focused on Factual Knowledge acquisition. Further exploration of these observations would be warranted to further isolate whether this focus is contextualized to the competition orientation of the NOSB, or whether this reflects a general approach to teaching in these classrooms. The item did not allow this type of disaggregation. The item does specifically address success in preparatory activities, however. While teachers may desire and appreciate a more holistic and constructivist model of science teaching, these respondents whose teams have placed first and second have a high focus on the acquisition of factual knowledge for recall in questioning, and focus heavily on test banks to obtain practice and drill questions in preparation for the competition. These should be observed as an effective strategy for winning the competition based on this set of respondents.

Similar questions provided to students generally conformed to this pattern of response. A high proportion of students (from 100% to 81%) reported content reading from textbooks, websites, and teacher provided reading materials, along with the creation of sample test questions as primary resources, tools and strategies for preparation. All of the students reported constructivist or inquiry type science activities to some degree, including labs, field trips, and similar activities, but there was a strong focus on basic, factual information.

Instructional Theory (Content Focus and Constructivism)

Item 18 asked "In preparing your team for competition, how do you determine the balance between inquiry and constructivist activities versus more basic, content acquisition efforts?" This item garnered 68 responses, which were arranged using a constant comparative process of content analysis. From the response data, the clusters of common responses suggested that teachers approach their instructional planning for teams in a highly student-focused and driven manner. The NOSB team is generally a voluntary commitment by students, allowing the students a greater degree of control in what they wish to do. Teachers seem to place before the students the unique challenges of a competition program, and then allow student prior knowledge and personal learning motivations to drive the team forward for the year. One teacher wrote, "The competition requires a great deal of knowledge before the students can even problem solve or do high school level "construction." Then they need to know a lot of new basic vocabulary. And we don't have much time. Often, I only have them 30-45 minutes a week, so content acquisition is primary." This teacher's response highlighted a common response: the issue of time. Many respondents noted very limited time with students outside of the classroom—with in class time dominated by course objectives and other activities. Filtering out the teachers that taught an ocean sciences course seemed to eliminate most or all of the concerns about time for preparation. However, these teachers did not appear to have an advantage in competition as discerned when the filter for high ranking teams was applied to the same question: whether or not these students were in a class on ocean science did not change the ranking of the team at the national competition. It is again noted that these are small sample sizes.

Item 19 asked respondents, “In what ways are innovation and entrepreneurship taught or incorporated into your teaching method/preparation for competition?” This item received 70 responses. Teachers responding to the survey did not indicate formal instruction on innovation and entrepreneurship, although one respondent noted that in the content areas of marine science technology and history there was substantial opportunity to address these, and this teacher did so. Many teachers saw these constructs in a secondary or less formal way in describing how students, many of them, were “in charge of” designing their or their team’s curriculum for study and preparation during the academic year. Student leadership organized the team, in a few respondent cases, as “teams of experts” who were co-responsible to each other to prepare on behalf of the team in a specific content area. Other respondents described how students developed explicit skills that were related to entrepreneurship through preparation and competition, including: showing initiative, making choices, organizing materials, designing lectures and engaging in self-selected, individualized study activities, being innovative with their time scheduling, and becoming an “individual expert” for her or his respective team. It may be that teachers are not defining *entrepreneurship* in the way it is defined in emerging federal policy. Students may in fact obtain exposure to these skills and principles, but not explicitly.

Instructional Technology

Item 20 asked “As instructional technologies change, how do you keep your educational approaches relevant to new learning modalities and relevant for this information age?” The responses were, perhaps, among the most disconnected and non-patterned of any of the items in the survey. Clearly, there are wide and deep gaps in access to and use of technology in schools across the nation, and these are reflected in the wide varieties of responses obtained from these effective NOSB coaches. It is difficult to identify clusters or themes of responses, and so readers are cautioned that the following summary of the responses is tentative at best. Teachers seem, in the midst of highly individualized patterns of technological adoption and access, to have adopted a "I'll do what I can and not worry about this a lot" attitude. It was impossible to observe a strong, internal locus of control with respect to technology use and growth among the responses. Teachers used what they could, when they could, but did not express strong attachments to "the latest and greatest." There was a fairly uniform cluster of responses that pointed to the internet as perhaps the primary source of information for new science content. This is not supported terribly well by earlier items that pointed to textbooks as a source of material. It may be that, for these teachers, the textbook and the internet are now interchangeable repositories of content.

Time constraints for teaching and for working with teams of students continue to appear in the data. Some limited use of formal professional development for technology appears, but with no substantiating data that these opportunities result in change of practices. One teacher wrote, "It is *very* difficult to change educational approaches on a large scale simply due to the *enormous* amount of planning time it takes from the teacher. I simply do not have the time to change every one of my lessons each year to keep up with every new approach that is put on the market, especially when some of these approaches are not proven to be successful. I try to change a few lessons each year and I pride myself in keeping up with the new "information age." This response would likely capture the assent of many respondents.

Environmental Stewardship and Self-Directed Learning

Item 21 asked respondents "How does participating in the NOSB create or encourage behavioral change among students, and increased environmental stewardship that benefits the environment?" The responses were rich, and conveyed several similar clusters of information. First, many respondents noted the competition fostered and enhanced awareness, understanding, and knowledge of ocean and environmental content and principles that they would likely have had far less access to and appreciation for otherwise. One teacher wrote in this regard, "Some of the top science students in our school have commented that they didn't really "get it" about how everything is so co-dependent, until putting it all together through their work and studying with the NOSB team." Another teacher wrote, "without our participation in the NOSB, the students would have almost no exposure to ocean sciences."

A second theme that was evident in the response data was that of environmental activity that was fostered through program participation. One teacher described this, "They have volunteered to do some stream and lake water testing, helped start programs for youth to learn about limnology in a local lake, contribute to and help maintain a couple of aquariums in the school." Another teacher wrote, "Our outdoor salmon restoration, beach cleanups, coastal monitoring and tree planting stewardship activities were excellent avenues for students to see the practical benefits of what they learned during the NOSB training sessions." These comments were similar to other stewardship activities other teachers connected to NOSB participation.

Finally, a third theme observed was that the NOSB motivated some students to continue in college with STEM related coursework and majors. Several teachers described this, "We have dramatically increased the number of students graduating from our school who intend to major in environmental science, marine science or geology…I have students going on to study environmental science in college….They are more in tune to heading toward college and also more aware of the environment….I have seen a great number of my students move into marine fields….Several NOSB students over the years have either received or are currently working towards degrees in geology, a science that may not have been on their radar screen before….The NOSB gets kids excited about the marine environment in ways they have not previously encountered. They are more conscious of the marine environment after participating (seeking out opportunities and reading about ocean issues) and several have chosen oceanography as a field of study because of the NOSB." These and other references to the STEM pipeline and the impact of NOSB on students' education decisions are powerful indicators, particularly in light of similar observations in past participant tracking data.

Item 22 asked, "How has the NOSB affected free-choice learning (self-directed, voluntary education guided by an individual's perceived needs and interests) in your team participants and also in other students in your school?" The responses, as with those in other items, varied in focus and were certainly influenced by respondent interpretation of key terms in the item. Nevertheless, some key ideas clustered around the effect of program participation in fostering independence of work habits and thought as much as serving as a vehicle for the expression of these characteristics. Thus, numerous respondents mentioned how participating strengthened and encouraged students to work independently, to assume ownership for work, to be self-directed in choosing topics and becoming expert in them, and taking responsibility for time management and study. Other respondents related the item to the opportunities for personal growth for students: affording opportunities for summer research programs, for continuing into college coursework. And finally, several teachers described how the high quality and accomplishments of NOSB team competition resulted in an enhanced valuing of academic success and science among their high school student bodies, with team members viewed as leaders and exemplary peers because of their work in NOSB.

Challenges and Benefits of Competing

Item 23 addressed the pragmatics of team preparation. This item asked, "what are the primary challenges faced in preparing for the competition?" More than any other item in the survey, the respondents nearly uniformly converged on the issue of time as the greatest challenge for preparing NOSB teams. The students are frequently described as highly involved, very busy, involved in many co-curricular and extra-curricular activities. Overlaying this, time is further constrained by systemic issues in the school systems: standards to meet in classes, no ocean curriculum to support the time to prepare, and teachers' schedules that are busy and increasingly so with state mandates. Clearly, many other meritorious activities, important to both schools and the students, challenge the time needs for the program. Given this, it remains an important observation that these students and teachers maintain the connection for many years of participation regardless.

Item 24 asked teachers about the primary benefits to their students from participating in the NOSB competition. The responses were, in many cases, detailed and rich with profound implications for competition based academic programs—both the NOSB and other similar programs. These teachers, experienced and accustomed to content-focused teaching and standards based education, note that the program results in increased awareness, knowledge and understanding for ocean science content and environmental science for the students. A similarly large cluster of these teachers described the excitement, fun, and joy obtained by these students because of the competition nature of the program—but at the end of the day, schools have a responsibility and purpose of increasing knowledge and understanding, and these teachers view NOSB as an effective method for them to employ in meeting this goal. Beyond these critical, basic observations in the data, the longer term impacts of NOSB on students are clear to these teachers. One respondent wrote,

> "This is really a life-changer for students. In my seven years coaching I've seen students latch on to the NOSB and literally take a different course in their education. I've had kids go to MIT, Princeton, Cal Tech, Stanford, and other top schools who may not have done so without NOSB as their shining star, and certainly without as much interest in the environment. I've worked with Science Olympiad, Science Fair, Mars Rover Teams, Flying Clubs, and others, and NOSB has had the strongest overall impact of any program I've encountered as a secondary science teacher."

Several other respondents also highlighted this longer term, college and career impact of the program, writing, "Their eyes are opened to the possibility of college and careers in science….An awareness of marine science and many choose a career path in marine science….Exposure to marine science professionals, exposure to university professors in marine science, broadened opportunities—one of our students won a place in a prestigious science college program, a school he may not have learned about except for his efforts in NOSB….for me, it shows me that my kids are really learning and inspires me to push even harder. For the kids, it has inspired many of them to look into marine science as a career." It is one thing for the leadership of a program such as NOSB to suggest that the program may be inspiring high school students to continue in the STEM education pipeline—but such comments from these young adults' high school teachers are compelling and powerful affirmations of NOSB impact.

NGSS and STEM Curriculum

Items 25 and 26 solicited feedback from teachers on the relationship of state science standards and the Next Generation Science Standards, cross-cutting science themes and content areas when preparing the NOSB teams. The responses were interesting in that they allowed, again, an observation of the gap across the various state and local districts with regard to the use of standards. There were also distinctions noted between and among the different organizational approaches to team formation in the schools. Many teachers clearly understand that ocean science is by nature a cross-cutting and interdisciplinary science field, with easy opportunities to pursue topical study of ocean issues, problems, processes, and content in areas of biology, geology, physics, chemistry, and technology. These approaches contribute to the assignment of topics to individual team members and, in some cases perhaps to lessons in classes. For numerous other respondents, however, the NOSB competition is somewhat isolated from these instructional standards, viewed as a club and, as one teacher commented, "protected space" where students and teachers can relax and just enjoy science.

Nevertheless, there were numerous comments regarding the impact of the program as a successful method for increasing awareness and knowledge of science content, as well as numerous examples mentioned (in item twenty-six) of places within the standard curriculum in science where ocean themes, topics, and exemplars can be easily integrated. Respondents listed biology, chemistry, physics, earth science, geology, math courses, and physical science as courses addressed in the NGSS that were excellent fits for integration and infusion of ocean content. Some respondents again expressed an understanding that ocean science was essentially cross-cutting and consequently appropriate for this approach.

Items 27 and 28 pursue responses around the struggle to infuse mathematics and engineering in science instruction generally and through team preparation, and also around issues of technology and marine policy. In the areas of math and engineering, it was clear that the confidence levels of many coaches were lower. Many teachers expressed their answers using terms such as "I hope….maybe…we try…on occasion…I hadn't thought about it." Such tentativeness is in line with findings from some policy research that these areas are in fact weaknesses in the secondary stem pipeline, and so observing this weakness here is not overly surprising. Coaches did indicate an awareness of the problem in many cases, with some solutions noted: the use of team challenge questions to infuse mathematics, assignment of select team members to be experts in math, engineering, or technology issues, and using ROV construction projects to create student awareness and focus. It seems many coaches rely on math classes and an assumption that math is somehow addressed for these students in those courses as an answer—without directly, necessarily, undertaking this themselves.

In the area of marine policy and technology, several coaches concluded this was the most difficult area with which to work with students. One coach wrote, "Marine policy is the hardest because there really aren't any textbooks or resources accessible to high school students to help them review." This comment resonates with the observation earlier that most of these teachers rely most heavily on textbooks as preparatory resources, and in the absence of a textbook, this area would be most difficult. Another teacher wrote, "These are the hardest to prepare for and require much more research outside of a single textbook chapter." As solutions to this deficiency, numerous respondents indicated that they rely on current event news articles and regularly collect these from internet sources to relay to students. One coach noted use of NOAA websites; one noted use of the U.S. Navy website. Student response data for these content areas similarly matched the coaches: reliance on textbooks, websites, and other teacher provided reading materials, with most students (78%) reporting little focus on engineering or mathematics.

It seems clear, from the default method of many of these respondents to internet news sources that an opportunity exists here for a curricular effort that could prove strategic for the historic ocean agencies across the federal government that maintain both policy initiatives and mandates for education and outreach. A simple collation of agency policy web sites under a common link at COL would be highly beneficial to these teachers across the country.

College and Career Information

Items 29, 30, and 31 solicited responses related to career information and resources and college information provided to students through NOSB preparation activities and programs. Of the 75 coaches, approximately 66% (49 respondents) reported that they provided some or quite a lot of career information, embedded into their team preparatory activities, while 28% (21 respondents) reported very little career information and approximately 7% (5 respondents) reported none intentionally. Student responses to the parallel question on the student survey revealed several students who received their first information about particular colleges and universities at the regional or national competition, with numerous students citing specific universities by name.

Given such a decision to embed career information, the sources of this information become quite important. Numerous respondents in *item 30* in the coach survey describe the use of government web sites such as NOAA, EPA, and others as sources of career information. A cluster of approximately twelve coaches utilized their school's guidance departments. Interestingly, these respondents use their own personal experiences, their professional development connections, personal knowledge of local researchers, and professional connections to provide this career information. This is consistent with prior NOSB tracking research. It seems clear that these high school teachers are critical vectors in the STEM pipeline. They should be viewed as such by those stakeholders with an interest in developing, supporting, and recruiting the next generation of this nation's scientists and researchers. Connections with high school science teachers and guidance counselors might prove to be highly impactful investments for universities and agencies that employ such scientists.

Professional Development for Coaches

Items 32 and 33 focused on the professional development in which these teachers have participated. Recent research has consistently pointed to the need for high school teachers to acquire deeper content and more conceptually rich understandings of science. Given that many of these teachers are recognized as exemplary, and as those who consistently seek high levels of quality science learning by their students, their experiences in professional development may be helpful in understanding the movement of ocean content into high school programs and curricula. There were distinct and important clusters of information that emerged from these survey responses, although only a subset of individuals (29 of 80) were able to identify discrete professional development in the ocean sciences. From this group, 86.21% (25 teachers) reported that they had participated in one or more workshops provided by Sea Grant. An additional 48.28% (14 teachers) had participated in workshops provided by the NSF COSEE program(s), and 31.03% (9 teachers) had participated in NOAA BWET workshops. As has been demonstrated in federal fiscal outlays over the past decades, NOAA and NSF have been highly involved in the ongoing professional development of teachers, as well as funding high quality STEM programs for students. Not coincidentally, NSF and NOAA have been pivotal in providing funding for the NOSB program since its inception. These data sustain a conclusion that these NSF and NOAA funds are appropriately and positively leveraged---with the teachers trained through NOAA Sea Grant and BWET becoming capable leaders to implement ocean content in their classrooms, and in this case to support the development of high ability students to participate in the NOSB. While not an intended outcome of this current data analysis, this particular finding may be quite interesting to education leadership at NSF and NOAA respectively as these data would most certainly contribute to an assessment of program impact in those agencies generally. This return on investment for those agencies should likely be communicated to the educational leadership at NSF/NOAA by COL program leadership as a related finding.

Relatively few teachers reported in *item 34* that they had made extensive changes to their NOSB preparatory activities over time. While 70 respondents, the multi-year coaches, responded to the question, nearly 76% of them indicate they have only changed some things (the mid-level, neutral response) over this time. As these teachers described the changes they had made, clearly they had shifted to use of the internet as it has grown and become a significant source of information (reflecting the third and fourth highest ranked source of materials in earlier items). Other respondents described the gradual shift of preparation toward encouraging the students to prepare themselves through adoption of self-directed learning strategies, team leadership, and adoption of a "club" orientation as opposed to a curricular or course-driven modality. Again, these transitions are supported by earlier response items. Finally, there is some evidence of a shift from content preparation to a focus on the techniques of the quiz competition itself, as teachers report their own learning curve over time leads to some of these strategies. It would be beneficial to consider whether this two-fold preparation focus by the experienced teachers is adequately represented in training and recruitment materials for new and younger NOSB coaches.

Student Specific Outcomes

A selection of specific student response items, without parallel items in the coach survey, were provided, allowing for greater understanding of the program from these young adults' unique perspectives. *Item 17* asked students "what ocean related out of school activities have supported your interest in the NOSB." 75% of respondents (21) and 60% of respondents (17) identified ocean or aquatic related vacations and parent support toward ocean science specifically. Clearly, these two are overlapping constructs, as parents must also support these vacations, and suggest effective parenting and home-supports for these young people. An additional 50% (14) of students reported science related hobbies, a characteristics observed in prior NOSB research, along with 28% (8) who reported community service and conservation projects—which could be overlapping constructs. This again points to the difficulty of correlational research and deductive data analysis: were these students encouraged to move into STEM areas because of the NOSB, or did prior interest and orientation toward science lead them to NOSB? While this is an important research question, it can distract from the overarching observation that either way, the NOSB is an important element in the education lives of these high ability young people, many of whom ultimately end up in STEM related college coursework and choosing STEM related careers. Whether causal or supportive, the NOSB provides an impactful intervention for these young adults.

Item 22 asked students, "how have your efforts in preparing for NOSB competition benefitted you in other areas of your life, school, or preparation for a future career?" The student responses were similar to the coach responses to this item. Students reported enhanced study skills, increased awareness and content knowledge for science generally, time management, public speaking, and leadership skills. Significantly, the students in this survey also noted the development of a network of peers, colleagues, and social connections through participation. Item twenty-four asked students what they most enjoyed about the NOSB, and a similar response pattern emerged: social connections, friends, a network, meeting scientists and graduate students. As previous NOSB research has noted and described, these social networks have proven highly durable over time, and may be among the most critical benefits and impacts of NOSB participation.

Item 23 asked students, "what do you most enjoy about learning science?" Among the variety of responses, three interesting clusters or patterns of responses emerged. First, students enjoyed the encompassing nature of the scientific world-view. Science explained everything, even though much was yet to be resolved definitively. Second, science was possessed of wonder, of excitement, of potential. Students found it interesting, compelling, incredible, and thought provoking. Finally, science was essentially open-ended, with many questions and challenges ahead, and with space to accommodate them. Taken together, i.e. science as an encompassing view of the world, as a wonderful and exciting field, and as an open-ended connection to the world of work and life, these interests may highlight pathways to learning theories and approaches for teachers and schools interested in involving more students in the STEM pipeline and with greater effect.

Summary, Conclusions, and Recommendations

Certainly, the summary of the item responses is dense and, as with all such survey data, reflects the perceptions of only a subset of the total pool of possible respondents. In this, 80 teachers/coaches provided responses to nearly all of the survey items, as a pool from a potential group of several hundred additional teachers who have worked with teams over the years. Nevertheless, this group represents each of the regional ocean bowls and represents teachers from many of the most consistently successful teams (63.75% have placed in the top three in their respective regions). As such, these respondents' experiences with the NOSB are valued. These respondents are likely among the most involved and most aware of the coaches who could have responded. In that vein, these response data are an important window into understanding the program, its impacts on teachers, team members, and other students, and the NOSB as a means of infusing ocean sciences content into high school classrooms. The strategies employed in classrooms and in team preparation activities by these teachers likely suggest typical patterns of practice in these schools and classrooms—although certainly skewed toward best practices.

Further, while the student responses were relatively fewer than the coaches, the pattern and content of student responses substantively matched that of the coaches. This consistency within the two sets of data enhances the credibility, and suggests stronger reliability for the observations and findings than would be the case absent this triangulated support.

First then, the finding in the data that these teachers' believe that the NOSB is a powerful contributor to students ultimately moving on to science related college programs is critical and profound. Many teachers report numerous students who have left high school for college programs in ocean, earth, marine, and other science fields. This survey was not particularly driven by a question in this area, but this observation is certainly profound. Many of the students completing parallel questions about college name specific institutions for which they had no awareness prior to the NOSB regional or national competition. They describe visiting the campus, meeting science faculty and graduate students. Prior year NOSB research further tracks past participants into many of these same colleges and universities, through STEM coursework, and into STEM careers.

Over many years of longitudinal tracking of students, researchers have contacted and collected data from many students who participated in NOSB and who are now post-collegiate and post-graduate science professionals. Many of these students continue to point to their experiences in NOSB and the importance of their coaches in making those career and college decisions. It seems obvious, but worth saying emphatically: the effort expended by COL, and previously CORE, education personnel and administration in seeking the funds to implement this program, and the decision by NSF, NOAA and other agency administration to fund this program, has proved a wise investment.

On a related level, the decisions at NOAA Sea Grant, in NOAA B-WET and central administration, and the decisions at NSF that led to COSEE in this nation were likewise powerful and impactful. A cadre of ocean educated and science-prepared classroom teachers continues to work with high school students many years after these workshops and programming decisions were made. There is an ocean science education community comprised of federal agencies, NGO personnel, science organizations—formal and informal, university departments and programs, high school teachers, students, and graduates who construe in their professional and personal lives a link to the planet's oceans and a responsibility to exercise stewardship for them. Capturing, sustaining, and mobilizing this community may be the "next iteration" of ocean funding in this nation.

In addition, this report observes a third level of NOSB competition, which has not heretofore been described and studied. Many coaches and students describe scrimmaging at the local level with other NOSB teams of students. This is clearly different from the regional competition and the national competition, and should be viewed as an organic expansion at the grassroots level of the ocean bowl competition. This third, local level of competition ranges from internal to classrooms and schools, to between-school matches, which reveal more complex educational networks. Further study of this phenomenon would be important to understand the overarching NOSB as a persistent social system, but also to discover and describe methods for leveraging federally funded programs at the local high school level.

Second, comparing the responses of the teachers of the highest ranked teams with those of the general population of teacher respondents reveals diverse variety of successful practices in classrooms and with teams that yield success at the regional and national level. Winning the competition is not a given based on funding, access to resources, access to buzzer equipment, teacher experience or training, or level of teacher engagement with preparation activities. It seems that a high level of individual student motivation, student decisions to assume ownership and to commit to highly disciplined study and preparatory behaviors may make the largest difference. Hard work, motivation, individual study, an individual commitment to success, willingness to select a topic and master it—all contribute to potential for winning. And all of these relate to entrepreneurial values, the practice of STEM through college and in professional life. Teachers perceive that these student characteristics are related to later life and career success, and the research supports them in this belief. The performance data of students at competition seems to foster a conclusion that there are short-term successes also related to these characteristics. This suggests the NOSB is highly egalitarian in nature—that teachers and students from diverse and various locations and situations have access to the program and the potential for success. This is an important marketing consideration, certainly, but coupled with long-term findings that many more students than the teams benefit from enhanced ocean content teaching and learning secondary to the NOSB team itself, the funding agencies should be confident that their funds are reaching, or can reach, many diverse populations across the socio-cultural fabric of our country.

Among the findings that have emerged in this current report is a much richer understanding of the outcomes of the NOSB program, that include environmental stewardship, leadership development, life skills (self-management, teamwork, study skills, time management), and college and career preparation. It is also certain, from coach and student perspectives, that ocean learning is an important feature of this program, as many teachers note they would not be infusing ocean content absent this program and its impact on their own understanding. Further, this ocean learning clearly extends beyond the team members to many hundreds and thousands of additional students in these high schools. As coaches described, "It is the only place that students at our school (which has about 2300 students) can learn anything about the ocean…the NOSB is one of the best programs, which greatly enhances student achievement and understanding of the oceans."

Finally, these data reveal again what is only partially understood by the public about K-12 education in this country: there are gaps within and among the states and districts across the country in the way science is taught. Science teachers are not required to teach the same science content to students who must compete in the same economic and employment spheres. Teachers do not have access to the same levels of support, the same resources, the same professional development, and the same levels of classroom quality. And yet they do persist to exemplary levels of commitment and work—even in circumstances, as revealed in this current survey, where they generally lack compensation for their commitments.

Based on current research in STEM education, what science will be for many students remains mostly dependent upon the individual district and state education system in which that individual was born and attended school, and the degree to which property values within those districts can support exemplary science education experiences above minimum, basic levels. TIMSS and NAEP assessments continue at marginal levels, far short of the exemplary performance standards required to maintain national, global competitiveness. It seems for now, this gap must be addressed by informal science education programs such as the NOSB, and by the federal science agencies that fund it. This current research study suggests that the NOSB is making a difference for its coaches and student participants.