COSEE's Influence on Scientists' Professional Practices:

Findings from the COSEE Scientist Study

Andrea Anderson
SoundView Evaluation & Research

Rena Dorph
The Lawrence Hall of Science
The University of California, Berkeley

Patricia Kwon
Patricia Kwon & Associates

❖❖❖
COSEE OLC & COSEE Alaska

❖❖❖
COSEE California

❖❖❖
COSEE West

With the support of

Joo Chung
Matthew Cannady
The Research Group • The Lawrence Hall of Science
The University of California, Berkeley

David Plude
SoundView Evaluation & Research

and the

COSEE Evaluation Working Group

September 2012

This study and preparation of this report were sponsored by the National Science Foundation, Directorate for Geosciences, Division of Ocean Sciences, under Grant No. OCE-0753224. Any opinions, findings, and conclusions, expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Table of Contents

List of Figures

List of Tables

Executive Summary

Background

The *2010 COSEE Scientist Engagement Survey Key Findings* reported that 28% of scientists who participated in COSEE in 2010 agreed or strongly agreed that COSEE had a positive impact on their scientific research. This finding sparked interest in better understanding the impact COSEE had on scientists' professional practices. In response to this interest, the National Science Foundation commissioned COSEE evaluation researchers to design and implement the study described herein.

Study data collection began with interviews of 14 scientists selected from among the 28% of scientists referenced above. These interviews were designed to support the development of a scientist survey that served as the main data collection method for this study. The final scientist survey was sent to 1,841 COSEE-involved scientists. With a response rate of 41%, we analyzed 767 completed surveys. Scientists answered 48 Likert-style items examining the impact of COSEE on scientific research, involvement in education and outreach (E&O), and university/college level teaching. There was also opportunity for free response to open-ended questions and scientists at all career stages, equally from men and women, provided further elaboration of the survey responses through their comments.

Three main sources of evidence for impact are: 1) factor analysis scores— determining a statistical measure of the scientists' perceived impact of COSEE in their scientific endeavors, including instruction, research, and E&O; 2) descriptive or secondary indicators of professional responsibilities; and 3) comments made to the free-response questions.

Results

The study resulted in several findings regarding survey respondents' perceptions of COSEE's impact on various aspects of their professional practice, most notably the impact of COSEE on respondents' professional responsibilities.

1. **Survey respondents are accomplished professionals and increasingly involved with Center and Network activities and partnerships.** The majority (78%) work in academic institutions, and reflect the full range of career stages. During 2011 75% of respondents participated, while 70% have done so for three years or less.

2. **Respondents indicated that COSEE had a positive impact on their professional responsibilities, including education & outreach, college-level teaching, and research.** More specifically, 81% of scientists responding to the survey said that COSEE had a positive impact on their E&O and 45% of respondents said that COSEE had a positive impact on their scientific research and on their college-level teaching.

3. **Scientists' thinking about research, teaching and E&O is evolving—in part due to involvement with COSEE.** Survey results showed that more than one-third of the scientists (37%) agreed or strongly agreed that COSEE involvement changed the way they *think* about research questions, with 34% indicating a *shift in focus* toward more societally relevant questions.

4. **The quality and quantity of education and outreach increased because of COSEE, according to respondents.** Nearly three-quarters of the scientists taking the survey said COSEE helped improve the quality of their work and gave them opportunities to plug into existing education and outreach (73% and 72%, respectively).

5. **Respondents report that their college-level teaching improved.** Nearly three-quarters of the respondents (70%) said their science teaching improved, while 78% asserted that COSEE expanded their network of colleagues (i.e., educators and other scientists) to support their teaching.

6. **Length and type of affiliation with COSEE influenced the degree to which COSEE impacted respondents' professional activities.** Statistical analysis showed positive correlation between *number of years* with COSEE and impact on factors: research, education and outreach, teaching and institutional support, while there were significant differences on those factors based on the *type* of involvement.

7. **COSEE activities (e.g., professional development and proposal support) targeted at scientists had an impact on respondents' professional practices.** There were significant differences with those who involved COSEE in proposal development and/or participated in professional development for three of four factors, compared with those who did not participate.

8. **Respondents' perspective on the impact of COSEE on their teaching is related to their personal and professional characteristics.** There were significant and positive relationship for females and those not tenured on the "teaching" factor, but a significant negative correlation between academic degree and the "teaching" factor.

9. **Respondents note other personal and institutional benefits from COSEE.** Three-fourths of the responding scientists (75%) agreed or strongly agreed that COSEE had a positive impact on their understanding of science education practices and science learning research.

10. **Respondents are reaching out to underrepresented audiences, but institutions are still finding it challenging to recruit them into the sciences.** The survey results revealed that 52% of respondents agreed or strongly agreed that COSEE had a positive impact on reaching out to underrepresented audiences, yet only 24% similarly agreed that COSEE had a positive impact on their institution's success at recruiting underrepresented students into the sciences.

Conclusions

The study described herein contributes to understanding the benefits of COSEE to scientists and the scientific enterprise and provides evidence and support for NSF's investments in education and outreach. This contribution is three-fold. First, researchers used factor analysis to develop and evaluate a survey instrument, which may be useful in future studies. Second, the scientists who participated in this study provided us with key insights about the ways in which COSEE impacted their professional practices. Third, the study raised questions that are worthy of future investigation.

Finally, this study shows there is an intensity and duration of engagement needed in order to witness the types of transformative outcomes we observed among these respondents. It suggests that substantial investment is required to meet NSF's goals for Broader Impacts and to transform relationships between scientists and educators.

COSEE Scientist Survey—Impacts on Professional Practices

Survey Background

In mid-2011, the COSEE Evaluation Working Group (EWG) and Inverness Research published the *2010 COSEE Scientist Engagement Survey Key Findings,* which reported on the results of the second COSEE Network survey of scientists *(COSEE EWG with Inverness Research 2011).* This report expanded upon the 2009 report, not only documenting how many scientists were involved in that calendar year, but also providing insights about who was participating and how they were participating. One of the findings reported in the 2010 document sparked interest: 28% of scientists who responded to the COSEE survey, administered to participating scientists during the academic year 2010, agreed or strongly agreed that COSEE had a positive impact on their scientific research. Yet there was little additional information to describe the nature of that impact. Accordingly, many were interested in gaining a better understanding of the impact COSEE had on scientists' professional practices. In response to this interest, the National Science Foundation funded the study described herein. The study was conducted by the COSEE scientist study team, a subset of COSEE Center evaluators, who benefitted from assistance, contributions and collaboration with COSEE Center Project Investigators (PIs) and evaluators.

Methods

Survey Development

The first phase of survey development included interviews with scientists that were designed to help researchers understand the phenomena under investigation and develop survey items that could measure the target constructs. These extensive interviews provided interviewees an opportunity to share stories and perspectives about how their work in research, academic teaching and education and outreach (E&O) were influenced or changed because of COSEE engagement. An interview protocol was adapted from one previously used by researchers at the Lawrence Hall of Science(Dorph and Randol 2009). Interviews of this nature were conducted with 14 scientists selected from among the 28% of scientists referenced above. These fourteen scientists were identified by COSEE evaluators and PIs and selected because of their history with and contribution to COSEE. The scientists ranged in career experience from graduate students and post-docs to early, mid- and advanced career scientists. Researchers intentionally included scientists of diverse ethnicity, geographical location and a nearly equal number of men and women. Interviews were conducted during December 2011.

Transcribed interviews were analyzed to support understanding and survey item development. Statements, ideas and themes were extracted and categorized to help generate survey stems for each of the four sections related to professional practices: 1) scientific research, 2) academic (university/college level) teaching, 3) E&O, and 4) institutional support and other COSEE benefits. The COSEE scientist study team reviewed the survey stems, deleting some and refining others to capture and construct a broad range of potential impacts of COSEE on participating scientists.

Survey Administration and Response Rate

Centers were responsible for identifying their group of scientists based on the definition established for the first two COSEE Scientist Surveys. Scientists were defined as: *Anyone doing marine or aquatic research in a scientific discipline (or who has done research in the past).* Some Centers thus included undergraduates, while others disallowed them. Individual Centers also had the opportunity to add an optional link of additional (i.e., Tier III) questions, which were hosted on the Center's own online survey page. Tier III questions were not analyzed as part of this study.

From all active COSEE Centers, evaluators and PIs submitted 1,870 unique scientists' names and email addresses to Lawrence Hall of Science (part of COSEE California). This list represents scientists who were active in a COSEE Center during the years 2009-2012 (only part of calendar year 2012 since the survey was administered in March 2012).

The survey was administered through Qualtrics, an online survey subscription service, which allowed the use of customized links to participants via email. A total of 767 completed (i.e., reached the end of the survey) responses were collected, giving a return rate of 41%. An additional 102 scientists submitted survey responses, but their responses were considered incomplete (i.e., started the survey, but did not reach the end of the survey) and were not included in the analyses. The online survey allowed participants to respond or omit questions freely. The consequence of this

allowance was that participants – even those considered complete in the current report – often skipped large portions of the survey.

The complete data set was analyzed for this report, but scientist responses for each Center were returned to the individual Centers for their own subsequent analysis. Confidentiality was maintained as Lawrence Hall of Science researchers coded responses and returned only de-identified data to individual Centers.

Survey Analysis Approach

Survey analysis included three main strands: descriptive analysis of individual items, construction of scales through factor analysis, and analysis of open-ended comments. The descriptive analyses of items regarding the impact of COSEE on professional responsibilities were a set of three Likert-style items examining the impact of COSEE on scientific research, involvement in E&O, and university/college level teaching. While these constructs were examined with the factor scores (i.e., factors 1, 2, and 3, respectively), they were added to the 2012 survey specifically as a means of comparing its results with the 2011 survey, which did not implement factor scores. Researchers conducted a factor analysis of the data, producing four reliable scales, which were then used to understand impacts across a variety of measures (see next section for further information). The scale scores were examined to determine whether the score was significantly different between grouping variables. There were a total of 13 different grouping variables that were utilized. For example, the factor scores were examined for differences between the three levels within Highest Academic Degree using the one-way analysis of variance (ANOVA) test, while the factor scores were compared between two conditions within Tenure Status using the independent sample t-test. In the case with Years with COSEE, correlation coefficients were used to determine the strength of the relationship between the factor scores and the number of years participants were involved with COSEE[1]. These results are examined in greater detail within the individual findings. Finally, free-response comments regarding respondents' experience with COSEE in impacting their research, teaching, and E&O were coded and analyzed for themes and included as examples in this report.

Scale Measurement Properties[2]

The analysis described herein utilizes 48 Likert-style items that were included in the survey with the intent of determining a statistical measure of the scientists' perceived impact of COSEE in their professional practices, including teaching, research, and E&O (see Appendix A for a complete list). As part of analysis in the current report, these 48 items were examined for scaling characteristics so that a collection of items could be identified as measuring specific constructs (i.e., a factor score). In the analysis that underlies the current report, the use of factor scores was valuable in producing robust survey scales that were comprised of several questions measuring the same type of professional practice. Further, the use of factor analysis to devise survey scales and related scale scores accounted for the Likert-style scaling (i.e., ordinal-scaled) of the items used in the analysis, which typically violates an important prerequisite for the use of traditional statistical analyses.

Horn's parallel analysis (Horn 1965) (using minimum residual estimation) and factor analysis (using maximum likelihood estimation and promax rotation) were used for exploratory factor analysis. Polychoric correlation coefficients (Horn 1965; Olsson 1979) were used (rather than Pearson correlations) to better account for the ordinal scaling of the Likert-style items. A measure of internal reliability (Cronbach's α) was also utilized. Factor scores were generated using simple averages of each of the items in the factor (omitting scores with over 50% missing values for a particular factor) to facilitate the use of these items in future research. Other options for the production of factor scores that can be used in future iterations include Thurstone regression (Thurstone 1935), and Anderson and Rubin's method (Anderson and Rubin 1956).

These factor scores were built to measure four key constructs that we designed the survey to measure regarding scientists' perceptions of COSEE's impact on their professional roles. To facilitate analysis we constructed four factors: research, teaching, E&O, and institutional support for E&O. Each factor was derived from multiple rating scale survey

---

[1] Spearman's rho was opted instead of the traditional Pearson's *r* because of the substantial positive skewness of the number of years participants were involved in COSEE. In general, more participants were involved for a few years rather than many years.

[2] See Appendix A: Chung, J., R. Dorph, et al. (2012). COSEE Scientist Survey: Scale Construction & Psychometric Properties. Berkeley, CA, The Lawrence Hall of Science: 10.

stems associated with the relevant survey question. Statistical analysis began with assessing scale reliability. We found strong reliability scores for each scale:

Table 1: Factor Reliability

Factors	Cronbach's α	N of items
Factor 1: Impact of COSEE on Research	.874	6
Factor 2: Impact of COSEE on E&O	.919	9
Factor 3: Impact of COSEE on Teaching	.840	4
Factor 4: Impact of COSEE on Institutional Support for E&O	.861	3

These scales appear to reliably measure four different dimensions of impact of COSEE on scientists' professional practice that are of compelling interest to the COSEE community.

Study Limitations

These data only describe those scientists who responded to the survey. They are not generalizable to the larger population of ocean scientists and may not apply to COSEE scientists who chose not to respond to the survey. At the same time, these findings suggest interesting trends among the large number of COSEE scientists who responded to the survey. Further, the COSEE scientist study team stresses the exploratory nature of the procedure to evaluate the psychometric properties of the reported scales. As such, we recommend future research that will vet the items in the scientist survey on another group of scientists, which will make possible the use of this instrument to investigate the impacts upon scientists on other science E&O programs.

The study was also constrained by unexpected external factors as well as time and resource considerations. The study commenced in October 2011, with survey administration planned for early February 2012 so that a report might be provided at the COSEE Network meeting in May 2012. A few factors challenged this timeline. First, although only six interviews were planned, the richness of responses from this initial set of interviews compelled the research team to expand this part of the study. Next, the survey launch was delayed to accommodate the Ocean Sciences meeting held in mid-February 2012 in Salt Lake City. Coincidental to this survey, the Association for the Sciences of Limnology and Oceanography (ASLO) was also conducting a membership survey, tapping into the same population of scientists. Accordingly, the team extended the survey administration window into March 2012. Further, many of the COSEE Centers participating in the survey work were simultaneously wrapping up their final year of COSEE funding. These two factors may have reduced the response rate for the survey.

Finally, report authors acknowledge the complexities of bridging the descriptive data with the factor analysis, but we feel that use of a mixed-methods approach provides a richer picture of the kinds of impacts from COSEE. The statistical analysis of the survey responses gives us a set of reliable scales with a response structure that fits with *a priori* theorized constructs for looking at impacts, rather than using results from individual survey items. These scales do not necessarily correspond with the way the survey stems were organized. The descriptive findings add nuance by including individual survey items that interview data suggest are rich areas for consideration.

Study Findings

Evidence of COSEE's impact on scientists derives from individual items that serve as descriptive indicators, analysis of survey scale scores, and comments made to open-ended questions. The descriptive results of all survey items as well as the details from the factor analysis, resulting scaled scores, and results by factor are included in the appendix. This section provides a brief synthesis of study findings regarding the perceived impact of COSEE on various aspects of responding scientists' professional practices that resulted from the detailed analyses depicted in the appendices.

1. Survey respondents are accomplished professionals and increasingly involved with Center and Network activities and partnerships

Career and Education Status

Scientists who responded to this survey hail from approximately 250 universities, agencies and other institutions. The

majority of respondents work in academic institutions (78%). Respondents also indicated working for government agencies (11%), non-profits (7%), business (1%) or other entities (2%). Twenty-one percent (21%) of respondents indicated they had tenure, while 44% indicated the question of tenure was not applicable for their situation. More than half (55%) said they had a Ph.D. or Ed.D, while 26% said they had a Master's degree.

The respondents were fairly evenly distributed by career stage. The largest response group self identified as mid-career professional (27%) followed closely by early career professionals (25%) and advanced-career professionals (23%). Graduate students made up 19%, undergraduates 2%, and retired professionals 2% of the sample. The *other* group was 2%, and included individuals who further specified being a mother, a post-doc, and/or someone who has shifted careers. In describing career-related activities, 78% were conducting scientific research, teaching part time (28%), teaching half time or more (22%), and/or serving as a director or administrator of programs (28%).

Involvement with COSEE

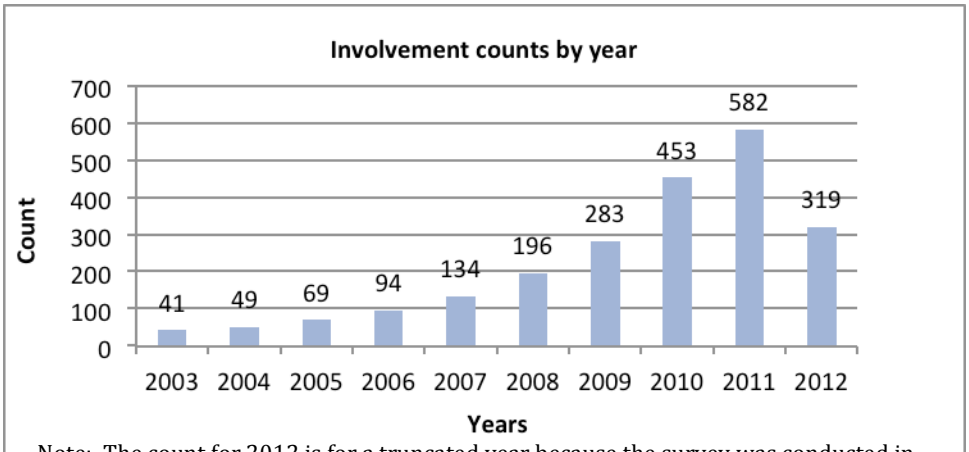
The survey asked respondents how they were involved with COSEE and in which years they had participated. Most said they had been participants (79%) in COSEE activities; respondents also indicated that they had engaged with COSEE as a resource (36%), advocate/advisor (19%), partner (16%) and/or leader (6%).

COSEE involvement can take many forms, including gaining support for proposal development or being a participant in professional development activities designed for scientists. COSEE was a partner in research proposals for 24% of the respondents, while 27% indicated this question was not applicable to their circumstances, and nearly half (48%) indicated COSEE was not a partner in grant proposals. In contrast, 61% indicated participating in professional development activities such as COS/COSIA, concept mapping and other workshops, trainings, or seminars.

The survey asked scientists to mark which years they were involved with COSEE. Figure 1 depicts respondents' participation in COSEE by calendar year. The exact breakdown by number of years of participation is displayed in Figure 2.

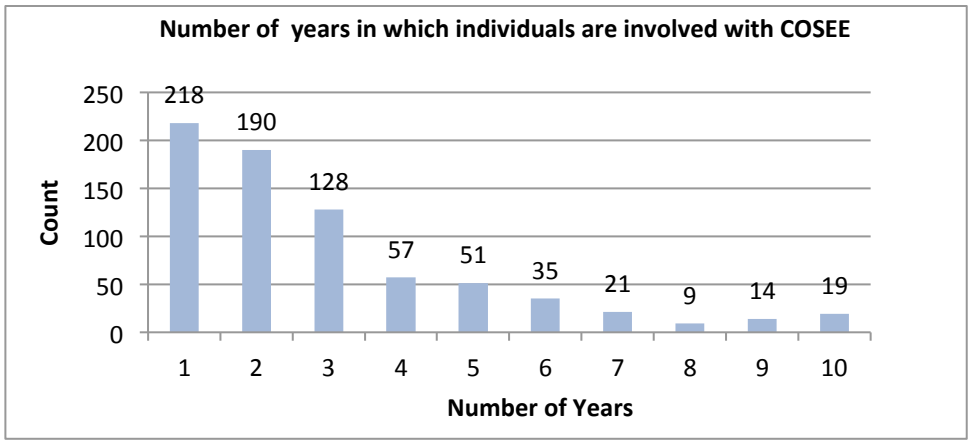
Among the 767 scientists who responded to the survey, the greatest percentage (75%) indicated participation in COSEE in 2011; a majority (59%) indicated participation in 2010; fewer (36%) indicated participation in 2009. The involvement count for 2012 shows 319, but only accounts for participation in 3 months in 2012 because the survey was conducted in March before most of the COSEE Centers had implemented their major annual activities. Further, we learned that among the 767 scientists who responded to the survey, most (70%) of the scientists had participated three years or less.

Figure 1: Survey Respondents' Involvement In COSEE By Year



Note: The count for 2012 is for a truncated year because the survey was conducted in March

Figure 2: Total Number Of Years Survey Respondents Were Involved In COSEE



Other Centers Scientists Are Involved With

Respondents were asked to identify which other COSEE Centers they were involved with, beyond their primary Center. The largest proportion (13%) of respondents indicated non-primary participation in COSEE California, most likely because this Center disseminated the COS/COSIA programs to other sites and coordinated the Ocean Literacy Initiative that worked with scientists across the COSEE Network. Six percent (6%) of respondents indicated non-primary participation in COSEE Ocean Learning Communities while 5% indicated non-primary participation in COSEE West and 5% indicated non-primary participation in COSEE Pacific Partnerships.

Ethnicity and Gender of Survey Respondents

Fifty-three percent (53%) of respondents were female and 47% were male. The majority of respondents were white (84%). Other races represented were: Asian (6%), mixed/multiracial (3%), black or African American (2%), and 1% American Indian and other Pacific Islanders. Native Hawaiian was less than 1% and 4% declined to state their race/ethnicity. In a separate question 5% identified themselves as Latino.

2. Respondents indicated that COSEE had a positive impact on their professional responsibilities, including education & outreach, college-level teaching, and research

COSEE was launched as an initiative to support scientists in communicating about their research. It is unsurprising then that 81% of scientists responding to the survey said that COSEE had a positive impact on their E&O. More surprising is that 45% of respondents said that COSEE had a positive impact on their scientific research and on their college-level teaching.

Table 2: Scientists Report COSEE Had An Impact On Professional Responsibilities

Professional Responsibilities	N	Negative Impacts	Positive Impacts	No Impact	Not Applicable
Scientific Research	750	0.8%	44.7%	35.5%	19.1%
College Teaching	755	0.5%	44.8%	20.5%	34.2%
E&O	758	0.9%	80.5%	11.2%	7.4%

Factor analysis (more fully described below) affirmed four areas of COSEE impacts—the three mentioned above and a fourth area identified as institutional support of E&O. [3]

[3] See Appendix for tables displaying the full set of survey stems and scientists' responses and other details for each of the four COSEE categories

3. Scientists' thinking about research, teaching and E&O is evolving—in part due to involvement with COSEE

Interviews with COSEE scientists, especially those long associated with COSEE, described an evolution toward an integration of research and education (both in academic instruction and E&O) as a consequence of this relationship. Multiple scientists told us their initial work with COSEE E&O was through "plug-in" opportunities. Over time their engagement changed, with scientists beginning to weave E&O and research together in new ways. They indicated changes in thinking about research questions to changes in how to gather data. We think this might reflect a developmental trajectory for how research is influenced by extensive E&O endeavors through COSEE. These interview excerpts illustrate the point.

> *I no longer think of research as separate from education. I think of them at the same time, it's more than that they are linked, it is just that they are not separated at all. It is the same process. That our research is going to also have graduate students in it, it's going to have undergraduate involvement in it, we are going to use the results in our classroom. We are going to be telling people about the results in our (outreach program). It is all part of the same process. We'll be communicating to the newspapers. The whole pipeline of education is now just part of the research process for me. That's the biggest change.*

> *I don't think it …change(s) the way that we would collect and gather the data. You know the questions drive that. But it would definitely help in framing the question. The way that it is changing is in this…it's changing the way that I communicate the research and so you frame the research a little bit different in that. And so that is where I think COSEE has had the biggest impact for me in terms of my research….To do that I have got to sort of re-craft the research and how it is presented and shared.*

> *I have found that I tried to focus my research on the biggest, most pressing problems. You know I could do research in the (his preferred field research site). I have the ability to do that, and I could write those proposals, and then I go, 'Who cares?' So I think it has changed my choice of research to those which I think are more impactful.*

> *But a lot of science - in my opinion - a lot of scientists - every single sample is super critical. But as soon as you move into the realm of having many, many, many samples you have a new - you have to put your mind in a new position, which is, your samples are less valuable. Because there are so many of them you can filter out the bad ones. Whereas if you only have three samples it is virtually impossible to tell if one of them is bad. And they are so precious - you can't imagine letting a novice collect one of your three samples. Think about whale researchers 10 years ago who have spent a whole summer collecting 40 whale calls. Now there is this massive network that in 5 years has collected 300,000 whale calls. By accident! While they were looking at underwater volcanic activity! So the whole community is changing its mind, from a dozen samples to 12,000 samples. And that is the future. For me the unique COSEE angle is that it is also 12,000 individuals or whatever it is. It doesn't have to be me in that (data collection role) - if the question is worth asking, then the next question is how many people can be involved to do this even better than if they were just involved with graduate students.*

Within the group of scientists who completed the survey, COSEE's impact on research seems to be more about new ways of *thinking* about research questions and less in the actual actions being taken. Survey results showed that more than one-third of the scientists (37%) agreed or strongly agreed that COSEE involvement changed the way they *think* about research questions. That change is reflected mostly in *shifts in focus* toward more societally relevant questions (34%). There was also a substantial focus from scientists toward thinking about the need to communicate research to the public (83%). A few of the comments related to the research questions follow.

> *COSEE helped me think about how my science can better relate to societal needs.*

> *My involvement in COSEE has definitely changed my approach towards research--with any research project I partake in now, I think about not only how this will affect the current body of knowledge on the issue, but also about how to disseminate the research findings and objectives in an easily digested way to a broader audience.*

Interactions (with COSEE) have redirected my research toward ecosystem science with a strong outreach component that I view as important or more important to effective ecosystem management than the research. I am not sure I would have understood that if I had not interacted with the COSEE staff.

Our research goals are specifically tied to creating environmental change and action through science - among the public, students, educators and lawmakers. Our project design now looks at the information we believe is relevant to the public and the building blocks of scientific knowledge needed by the public to assimilate the data presented. COSEE enabled our association to better communicate the scientific knowledge we obtain in a manner most useful to these audiences. Without this communication there is a disconnect and ultimately a breakdown of the common goal we share - to promote marine conservation action through scientifically based information. This saves time and money and delivers our message in a clear and concise manner.

A small number of scientists dismissed the idea that COSEE had an impact on their research, as illustrated in the following comments. In general, their responses indicate that expectations for change in research were unfair and unrealistic given the initial charge to COSEE.

The above questions emphasize changes in research direction/focus as a result of engagement with COSEE. I have never seen this as a significant aspect of the mission of COSEE or the COSEE-researcher interaction.

The implication in Question 16, that COSEE will change my research focus, is fundamentally flawed. Research is too competitive to have it influenced by COSEE. We adjust our focus in research because of new demands in our science; COSEE is not "in our science." If we change focus for other reasons, we will fail as research scientists. The question puts an unrealistic expectation on COSEE.

Despite concerns expressed above, there were apparent changes. Further research efforts could help us uncover additional evidence of this possible change trajectory, identify the steps in this change process, discern what factors might advance this change, and which scientists are more amenable to this evolutionary approach. Possible explanations are advanced in the next set of findings.

4. The quality and quantity of education and outreach increased because of COSEE, according to respondents

Nearly three-quarters of the scientists taking the survey said COSEE helped improve the quality of their work and gave them opportunities to plug into existing education and outreach (E&O) (73% and 72%, respectively). Nearly two-thirds said their involvement increased and they were able to advise others on how to accomplish E&O (65% and 62%, respectively). Two comments below reflect scientists' perspectives about changes in E&O attributable to COSEE.

As a result in my involvement in the COSEE program, I have been involved in considerably more E&O activities than ever before and have found myself reaching out to volunteer for other E&O events beyond the COSEE program.

As I mentioned before, this is the biggest benefit of COSEE for me. The opportunity to interact with interested non-scientists usually provides at least one moment of seeing something a little differently. More important, it is EXCELLENT practice in figuring out how to translate science to the public; learning what works and what doesn't, what people are interested in.

5. Respondents report that their college-level teaching improved

Nearly three-quarters of the respondents (70%) said their science teaching improved. At the same time, scientists asserted that COSEE expanded their network of colleagues (i.e., educators and other scientists) to support their teaching (78%) and gave them opportunities to learn about science learning research (76%). In addition, more than half the respondents (59%) said that COSEE supported them to include more hands-on, inquiry-oriented pedagogy in their teaching practices, while giving students opportunities for field-based learning experiences (51%). The shift in

teaching practices is reflected in these comments below.

> *I will emphasize again that the opportunity to work for a period of time with education professionals (K-12, informal educators, science outreach) on curricula development, teacher training and field-based courses has been an extremely valuable experience. It has helped me to better understand what a broader audience finds relevant about our scientific research and to improve how I communicate the results of our science.*
>
> *The most important thing I learned from COSEE is that good teaching is a multi-dimensional endeavor that utilizes a variety of methods and tools. It expanded (my) approach and attitude towards undergraduate teaching. I am now much more likely to try inquiry-based approaches and involve students through hands-on activities.*
>
> *I am more proactive in designing my lectures to include the students in the teaching process. They seem receptive to learning from their peers, and it gives them opportunities to improve their presentation skills during their scientific training. When I was in school, we were rarely allowed to talk in class, and had to sit still in lectures, which I remember as being very off-putting when I thought about science classes. It motivates me to make every class an active learning opportunity for the students. I learn just as much as the students sometimes, because now we have 30 problem solvers working together instead of just one expert lecturing to a static audience.*
>
> *The best thing I have gained from COSEE is becoming part of network of scientist educators who all have a common mission of enhancing E&O.*

These results suggest that respondents' teaching practices improved in part due to their expanded connections with educators and learning scientists.

6. Length[4] and type of affiliation with COSEE influenced the degree to which COSEE impacted respondents' professional activities

The factor analysis of data produced four scales, which were then further analyzed to understand the relationship between certain respondent characteristics and the construct measured by the scales. Respondent characteristics included: 1) length of time associated with COSEE; and 2) the type of involvement with COSEE (e.g., as participant). Statistical analysis showed that COSEE had an impact on scientists' professional activities. Recall that the four scales measured respondents' perceptions regarding: (1) impact of COSEE on research, (2) impact of COSEE on education and outreach, (3) impact of COSEE on teaching, and (4) impact of COSEE on institutional support. Specific results follow.

Influence Of The Number Of Years With COSEE

Participants were given 10 items in check-box format for each of the 10 years COSEE has been active (2003 to 2012). The number of checks for each participant was analyzed as a total sum. Results show the non-parametric correlations between the four scale scores and the total number of years with COSEE was found to be significant and positive for all comparisons. However, none of the correlations were particularly strong.

Influence By Type Of Involvement With COSEE

For this section, please note: The survey allowed multiple roles to be selected, so each role was examined dichotomously (e.g., a participant or not a participant).

Participant. An independent samples t-test revealed significant differences between participants and non-participants of COSEE on the "Impact of COSEE on Teaching" scale and the "Impact of COSEE on Institutional Support for E&O" scale. For the "teaching" scale, participants were <u>higher</u> in ratings than non-respondents. For the "institutional support" scale, participants were <u>lower</u> in ratings than non-participants.

[4] See Appendix for Table11 Detectable and statistically significant differences for factors by category (p. 20) and Factor Findings (p. 29).

The higher score for the "teaching" scale is most likely due to the expansive efforts of multiple COSEE Centers to bring COS/COSIA, concept mapping, and other professional development activities to participants. The lower score for the "institutional support" scale may reflect the increased awareness of productivity issues related to tenure — that is, most institutions focus on publications rather than E&O for granting tenure, and there is a perception that federal agencies also have this focus. This can be felt as being non-supportive of the participant. Some of the comments from scientists reflect this perspective.

> *The main problem I find with E&O is the time commitment. Once you volunteer once for E&O, you end up being pegged for it again and again and it can be stressful and time consuming.*

> *In spite of all the positive outcomes coming from my COSEE experiences, they have not translated in securing funding. The time spent in COSEE activities is time taken away from publishing one more peer reviewed paper. Federal grant agencies, mainly National Science Foundation, value PIs based on how many publications they had. On a major NSF grant proposal we had rejected, we had included a robust education and outreach component (with specific funding allocated). But reviewers, although happy about the E&O, said the PI (me) could have spent more time producing more papers, and should have spent less time in outreach activities. Therefore, I strongly suggest that NSF should value E&O products and activities at the same level they value peer-reviewed publications, and use such value scale when reviewing research proposals. Since this is not yet the case, as a researcher, I know that by spending time in E&O efforts, I'm taking time away from my research and peer-reviewed publications, and therefore, I'm limiting my chances at securing NSF funds.*

Resource. An independent samples t-test revealed significant differences between resources and non-resources for COSEE for "Impact of COSEE on E&O" scale and the "Impact of COSEE on Institutional Support for E&O" scale. For the "E&O" scale, resources were higher in ratings than non-resources. For the "institutional support" scale, resources were higher in ratings than non-resources. This finding provokes the question of who are the resources and what did they actually contribute to COSEE activities. Answers to this kind of question might better explain why there were impacts on the E&O and institution and no significant differences for the "Impact of COSEE on Research" scale and the "Impact of COSEE on Teaching" scale.

Advocate/Advisor. An independent samples t-test revealed significant differences between advocates/advisors and non- advocates/advisors for all four scales ("Impact of COSEE on Research," "Impact of COSEE on E&O," "Impact of COSEE on Teaching," and "Impact of COSEE on Institutional Support for E&O"). For all four scales, advocates/advisors were higher in ratings than non-advocates/advisors.

Partner. An independent samples t-test revealed significant differences between partners and non-partners for the "Impact of COSEE on Research" scale, the "Impact of COSEE on E&O" scale, and the "Impact of COSEE on Teaching" scale. For each of these scales partners had higher scores than non-partners. The lack of significant impact for partners on the "Impact of COSEE on Institutional Support" scale most likely reflects that partners were supporters of COSEE and not the target of COSEE endeavors.

Leader. An independent samples t-test revealed significant differences between leaders and non-leaders on the "Impact of COSEE on Research" scale, the "Impact of COSEE on E&O" scale, and the "Impact of COSEE on Institutional Support for E&O" scale. For each of these scales leaders had higher scores than non-leaders. The lack of statistical difference between leaders and non-leaders on the "Impact of COSEE on Teaching" scale is likely due to the COSEE leadership having fewer teaching responsibilities.

7. COSEE activities targeted at scientists had an impact on professional responsibilities

Additional disaggregation of scale scores revealed that professional development activities and engagement with scientists in proposal development had significant impacts.

Influence Of Participation In Professional Development Activities

We asked the question "Have you participated in professional development (PD) for scientists (e.g., COS/COSIA, concept mapping, other workshops/trainings/seminars)?" An independent samples t-test revealed significant differences between participants who participated in some form of professional development and those who did not on three of the

four scale scores: "Impact of COSEE on Research," "Impact of COSEE on E&O," and "Impact of COSEE on Teaching." On average, respondents who participated in professional development scored higher than non-PD participants.

Factor Scores By COSEE's Involvement In Proposals

The survey question was "Have you included COSEE or a COSEE partner in any of your research proposals?" An independent samples t-test revealed significant differences between those who involved COSEE in their proposals and those who did not for three of the four scales: "Impact of COSEE on Research," "Impact of COSEE on E&O," and "Impact of COSEE on Institutional Support for E&O." For all three scales, those who involved COSEE in proposals had higher scores than those who did not.

8. Respondents' perspective on the impact of COSEE on their teaching is related to their personal and professional characteristics

Further analysis considered the relationship between academic degrees, tenure and career status, gender and race as influences on each of the four scales. The only instance in which any of these professional characteristics were systematically related to respondents' scale scores was in the case of the "Impact of COSEE on Teaching" scale. We found a positive relationship for females and those without tenure; that is to say, their scale scores were higher on this scale. In contrast to these positive correlations, we found the higher the academic degree the lower the score on teaching.

9. Respondents note other personal and institutional benefits from COSEE

Analyses of responses to individual items also offer interesting nuance regarding the impact of COSEE on their professional practices. Three-fourths of the responding scientists (75%) agreed or strongly agreed that COSEE had a positive impact on their understanding of science education practices and science learning research. However, it should be noted that this survey stem had two elements and it is impossible to discern accurately whether scientists meant both or just part of the item. COSEE also had a positive impact on their feelings about the need for E&O for ocean sciences (74%). Speaking with colleagues about E&O and collaborating with educators were also viewed as benefits from COSEE (68% agreed or strongly agreed with the survey items).

Scientists said their ability to develop high-quality broader impacts proposals or programs increased (63%). Half the respondents (50%) agreed or strongly agreed COSEE had a positive impact on their institution's support of scientist involvement with E&O, but just 27% indicated their institution's funding for E&O had increased. Finally, scientists agreed or strongly agreed that their ability to mentor students improved with COSEE support (59%).

10. Respondents are reaching out to underrepresented audiences, but institutions are still finding it challenging to recruit them into the sciences

Scientists were asked about their efforts to reach out to underrepresented audiences/groups. The survey results revealed that 52% of respondents agreed or strongly agreed that COSEE had a positive impact on them. Yet, only 24% agreed or strongly agreed that COSEE had a positive impact on their institution's success at recruiting underrepresented students into the sciences. One scientist provided this perspective on how COSEE was helpful in working with and recruiting underrepresented students.

> *I am much more sensitive to the needs of indigenous students and have tried to improve my interactions with them. I would definitely appreciate more workshops that are specifically directed at how cultural values influence teaching and learning.*

At the same time there are challenges that exist within the broader society that work against the desired recruitment goals. One scientist who has spent years seeking to broaden participation made the point that for many students from underrepresented populations a critical factor in choosing majors is whether there is "community value" for the work. That is, does the course of study result in being able to meaningfully contribute back to the community?

> *We need to start making people understand that what we do is relevant and important, and a huge contribution to society. Especially under-represented groups, I can tell you it's absolutely true. I see this at (my institution) everyday because all of the students come in, many, many students come in and want to be pre-med, and they want to be pre-med in many cases for the noblest of reasons. They want to give*

back to society and they don't realize that that is not the only way you can do it with a biology degree. So they need some role models of people who are actually making contributions that are relevant, and important in real time. We have to convince them that being a doctor is not the only way that you can contribute to society. Because that's the only way they think they can give back to their community in a practical way. And we have to convince them that sustaining ecosystem health, maintaining communities, natural communities and populations of organisms, both on the ocean and the land, is equally important as maintaining human health. And indeed that human health can't be maintained without healthy ecosystems

Conclusions

The study described herein contributes to understanding the benefits of COSEE to scientists and the scientific enterprise and provides evidence and support for NSF's investments in education and outreach. This contribution is three-fold: First, researchers gained insight about the impact of COSEE on scientists' professional practices. Descriptively, we found that responding COSEE scientists confirmed that COSEE had a striking impact on E&O. The research also showed that respondents believed COSEE impacted their scientific research and college-level teaching. Several scientists indicated their thinking about their research questions had changed and some noted deep changes in how they view (and act on) the integration of education with their research. There were also solid indications that COSEE programs were having an impact on scientists' teaching activities, as well as on E&O.

Second, researchers were able to develop a survey instrument and present evidence that the underlying structure of responses is reliable and consistent with theorized constructs. These surveys may be useful in future scientist studies. Factor analysis combined with reliability analysis yielded four survey scales that supported analysis of the impacts of COSEE activities on scientists' professional practices. Both the survey instrument and the analytic methodology have been documented in an appendix to this report for future use.

Third, the study surfaced intriguing questions and insights that may provide the foundation for future studies. Among these was added *evidence of a developmental trajectory in education and outreach. Further study could support the emergence of a framework that robustly characterizes this trajectory and the implications for supporting scientists' professional development for E&O.* Researchers also suggest a review of the existing interview protocol and coding scheme, and use of content analysis to create a new standardized interview protocol and coding scheme for use in other scientist PD programs. Further, researchers and their colleagues throughout COSEE's network of evaluators are interested in pursuing further revision, use and validation of the survey instrument and scales. Such activities could provide the basis for future comparative studies designed to support causal inferences between participation in scientist/educator E&O networks and outcomes on both scientists' professional practices and the scientific enterprise. Finally, this study shows there is an intensity and duration of engagement needed in order to witness the types of transformative outcomes we observed among these respondents. It suggests that substantial investment is required to meet NSF's goals for Broader Impacts and to transform relationships between scientists and educators. Additional study of the type, intensity, and duration of engagement that results in changes to scientists' professional practices is warranted.

Bibliography

Anderson, R. D. and H. Rubin (1956). Statistical inference in factor analysis. Third Berkeley Symposium of Mathematical Statistics and Probability.

Chung, J., R. Dorph, et al. (2012). COSEE Scientist Survey: Scale Construction & Psychometric Properties. Berkeley, CA, The Lawrence Hall of Science**:** 10.

COSEE EWG with Inverness Research, I. (2011). 2010 COSEE Scientist Engagement Survey Key Findings**:** 7.

Dorph, R. and S. Randol (2009). Catalyzing Change: COSEE California's Local and National Impact, Lawrence Hall of Science. University of California, Berkeley.

Horn, J. L. (1965). "A rationale and a test for the number of factors in factor analysis." Psychometrika **30**: 179-185.

Olsson, U. (1979). "Maximum likelihood estimation of the polychoric correlation coefficient." Psychometrika **44**: 443-460.

Thurstone, L. L. (1935). The vectors of mind. Chicago, University of Chicago Press.

Appendix

Demographics of Respondents

Table 3: Description of Primary Institution of Respondents

Which of the following best describes your primary institution/agency? (choose one)	N	Percent
Academic	600	78%
Government	87	11%
Business	10	1%
Non-profit	52	7%
Other (please specify)	15	2%

Table 4: Highest Academic Degree of Respondents

What is the highest academic degree that you have completed? (choose one)	N	Percent
H.S.	0	0%
A.A.	4	1%
B.A./B.S.	110	14%
M.A./M.S./M.B.A.	201	26%
Ed.D./Ph.D.	423	55%
Other (please specify)	11	1%

Table 5: Current Career Stage of Respondents

Which of the following best describes your current career stage (choose one)	N	Percent
Undergraduate student	17	2%
Graduate student	146	19%
Early career professional	191	25%
Mid-career professional	209	27%
Advanced career professional	174	23%
Retired	14	2%
Other (please specify)	13	2%

Table 6: Current Engagement in Professional Activities Among Respondents

Which of the following activities are you currently actively engaged in? (choose all that apply)	N	Percent
Conducting Scientific Research	600	78%
Teaching, Part-Time	212	28%
Teaching, Half-Time or More	172	22%
Director or Administrator of Programs	216	28%

Table 7: Tenure Status of Respondents

Are you tenured? (yes or no)	N	Percent
Tenured yes	162	21%
Tenured no	263	34%
Tenured NA	340	44%

Table 8: Gender of Respondents

What is your gender?	N	Percent
Female	398	53%
Male	354	47%

Table 9: Race/Ethnicity of Respondents

What is your race or national origin? (choose all that apply)	N	Percent
White	641	84%
Asian (includes Indian, Chinese, Japanese, etc.)	48	6%
American Indian	11	1%
Black or African American	16	2%
Mixed/Multiple races	20	3%
Native Hawaii	2	0%
Other Pacific	7	1%

Table 10: Latino or Hispanic Heritage of Respondents

Are you of Latino, Hispanic or Spanish heritage (choose one)	N	Percent
Yes	38	5%
No	688	90%
Decline to respond	33	4%
Blank	8	1%

Table 11: Detectable And Statistically Significant Differences For Factors By Category

Question	Factor 1- Impact of COSEE on research	Factor 2- Impact on COSEE E&O	Factor 3- Impact of COSEE on teaching	Factor 4- Impact of COSEE on institutional support
Academic Degree	No Difference	No Difference	**Significant:** Higher the degree the lower the impact	No Difference
Career status	No Difference	No Difference	No Difference	No Difference
Tenure status	No Difference	No Difference	**Significant:** "no" scored higher on factor	No Difference
Gender	No Difference	No Difference	**Significant:** "female" scored higher on factor	No Difference
Race/Ethnicity	No Difference: white (non-Latino)/non-white	No Difference: white (non-Latino)/non-white	No Difference: white (non-Latino)/non-white	No Difference: white (non-Latino)/non-white
Involvement: participant	No Difference	No Difference	**Significant:** participants scored higher than non-participants	**Significant:** participants scored higher than non-participants
Involvement: resource	No Difference	**Significant:** resource people scored higher than non-resource people	No Difference	**Significant:** resource people scored higher than non-resource people
Involvement: advocate/advisor	**Significant:** advocates scored higher than non-advocates	**Significant:** advocates scored higher than non-advocates	**Significant:** advocates scored higher than non-advocates	**Significant:** advocates scored higher than non-advocates
Involvement: partner	**Significant:** partners scored higher than non-partners	**Significant:** partners scored higher than non-partners	**Significant:** partners scored higher than non-partners	No Difference
Involvement: leader	**Significant:** leaders scored higher than non-leaders	**Significant:** leaders scored higher than non-leaders	No Difference	**Significant:** leaders scored higher than non-leaders
Years with COSEE	**Significant:** positive correlation for number of years	**Significant:** positive correlation for number of years	**Significant:** positive correlation for number of years	**Significant:** positive correlation for number of years
Professional development	**Significant:** Participants scored higher than non-participants	**Significant:** Participants scored higher than non-participants	**Significant:** Participants scored higher than non-participants	No Difference
Proposals with COSEE	**Significant:** Those who involved COSEE in proposals scored higher than non-involved	**Significant:** Those who involved COSEE in proposals scored higher than non-involved	No Difference	**Significant:** Those who involved COSEE in proposals scored higher than non-involved

Details of Indicators for Impact on Professional Responsibilities

1. Details of Indicators for Impact on Research

A key finding from the Scientist Engagement Survey (2011) showed that 28% of respondents agreed or strongly agreed that COSEE had an impact on the way scientists conduct their research. (COSEE EWG with Inverness Research 2011) In 2012, the result was higher with 43.7% indicated some or significant positive impact on scientific research.

One purpose of the 2012 *COSEE Scientist Survey — Impacts on Professional Practices* was to better understand the nature of these impacts on scientific research. To prepare the survey questions we interviewed 14 scientists, gaining specificity and detail about what it means to have an impact on research. The interviews also garnered information about their academic teaching, broader impacts, professional priorities and relationships.

Interviews were analyzed for distinguishing comments and formed the stem choices for the survey questions about Impact on Research. We also provided for open-ended responses to this question from the survey respondents.

Table 12: Level of Agreement With Statements About Scientific Research

Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…				
	N	**Disagree or Strongly Disagree**	**Neither Agree Nor Disagree**	**Agree or Strongly Agree**
Prompted me to think about the need to communicate my research with the public	652	4%	13%	83%
Changed the way I think about my research questions	612	15%	48%	37%
Shaped my research focus towards more societally relevant questions	609	21%	46%	34%
Changed my research focus in order to generate interest in ocean sciences research by underrepresented populations	591	24%	46%	30%
Changed my research focus because of new opportunities	587	49%	26%	25%
Helped me leverage new funding which redirected my research	538	28%	50%	22%
Changed my research by providing me with access to new data collection methods and/or sources (e.g. Citizen Science)	583	30%	49%	21%

The data table above indicates that 20-30% of the respondents felt that COSEE had an impact on their research in ways similar to that described by interviewees.

Survey Comments

A total of 183 scientists (out of 767) contributed comments about the impact COSEE had on their research. The responses were from participants at all career stages, with greater responses from the mid- and advanced career stages. By gender 80 comments came from men, 101 from women.

Table 13: Proportion of Comments About Scientific Research By Career Stage of Respondents

Career Stage of Comments	Percent of Commenters
Advanced Career Stage	28%
Mid-Career Stage	28%
Early Career Stage	22%
Graduate Students	14%
Various Others	5%

Comments provided further elaboration of survey responses. The open-ended responses were coded 1) in correspondence with the survey stems, with an additional coding option of 2) not applicable, 3) future plans, or 4) *other* impacts. Five percent indicated they were making future plans to connect COSEE to their research, while 27% indicated that questions about research were not applicable in their circumstances.

- 17% — COSEE prompted me to think about the need to communicate my research with the public
- 8% — COSEE changed the way I think about my research questions
- 7% —COSEE shaped my research focus towards more societally relevant questions
- 27% — indicated not applicable to their circumstances
- 45% — described "*other*" impacts on research in these ways:
    - Broader impacts proposals
    - Inspiring and educating other scientists to think differently about research
    - Attraction of a different type of graduate and undergraduate student to their research programs
    - Expanded professional development opportunities
    - Changes in information exchanges and ways of interacting with other scientists
    - Increased communication skills to share research

2. Details of Indicators for Impact on Education and Outreach

The 2010 scientist survey indicated that COSEE had a positive impact on scientists' broader impacts efforts. In that survey 80% answered yes that COSEE had a positive impact on their opportunities to engage in education/outreach. Slightly fewer (75%) confirmed that COSEE provided opportunities to work with educators, while 63% said that COSEE provided opportunities to present research to non-scientific audiences.

This survey reaffirmed the previous survey result and sought to further illuminate the nature of those activities.

Table 14: Level of Agreement With Statements About Education and Outreach

Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE has…				
	N	**Disagree or Strongly Disagree**	**Neither Agree Nor Disagree**	**Agree or Strongly Agree**
Improved the quality of my E&O	641	5%	22%	73%
Gave me opportunities to plug into existing E&O events	658	7%	21%	72%
Increased the level of my involvement in E&O (e.g., one-time events to ongoing activities, more interactive/participatory engagement)	639	11%	24%	65%
Helped me advise others on doing E&O (e.g. students or colleagues)	632	10%	28%	62%
Helped me integrate my E&O with my science research	561	9%	33%	58%
Provided a niche for me to accomplish my E&O goals	619	8%	35%	57%
Introduced me to the Ocean Literacy Principles (as a framework for teaching about science)	606	15%	31%	54%
Helped me critically review E&O sections of grant proposals	518	11%	42%	47%
Helped me integrate my E&O with my university-level teaching	432	13%	42%	45%
Helped me use new technologies for E&O	616	14%	42%	44%
Used E&O to increase underrepresented students in ocean sciences	573	17%	40%	43%
Changed my expectations of my students' involvement in E&O	481	12%	46%	42%
Changed my view of E&O to being as important as my research	581	15%	45%	40%
Changed my involvement with E&O to make it a lab-wide or team endeavor	528	17%	46%	36%

Survey Comments about Education and Outreach

A total of 76 scientists (out of 767) contributed comments about the impact COSEE had on their E&O. Survey fatigue may have set in by the time scientists got to this section, as there are fewer comments in this section than in the previous two sections on Impact on Research or Impact on Teaching.

The responses were from participants at all career stages, with greater responses from the mid- and advanced career stages. By gender, 41 comments came from women, 33 from men.

Table 15: Proportion of Comments About Education and Outreach by Career Stage of Respondents

Career Stage of Comments	Percent of Commenters
Advanced Career Stage	29%
Mid-Career Stage	29%
Early Career Stage	20%
Graduate Students	8%
Various Others	8%

Survey comments were coded and categorized by 1) the survey stems listed in the question about impacts on E&O, 2) not applicable, 3) future plans, and 4) *other*. Many of the comments indicated that E&O was not part of the individual's professional work (21%). An important sub-group indicated that COSEE involvement would be of help in their future E&O—once they were finished with school (8%).

By survey stem categories, the comments clustered in the following manner:

- 24% — COSEE improved the quality of my E&O
- 15% — COSEE provided a niche for me to accomplish my E&O goals
- 13% — COSEE helped me use new technologies for E&O
- 11% — COSEE increased the level of my involvement in E&O (e.g., shifting from one-time events to ongoing activities, more interactive/participatory engagement)
- 17% described *other* impacts derived from COSEE on their E&O, including these categories
    - Networking and linking together to achieve E&O aims
    - Recruiting teachers for research experiences
    - Having an influence on other organizations' E&O efforts
    - New appreciation for constraints for K-12 teachers
    - Acquisition of greater skills for working with the public and students

3. Details of Indicators for Impact on Teaching

The 2010 survey of scientist engagement also indicated that 56% agreed or strongly agreed that COSEE had a positive impact on scientists' teaching practices. We queried the 14 interviewees about impacts on their teaching as a way to construct appropriate survey stems. The survey findings are provided here, followed by the analysis of comments from the survey.

Table 16: Level of Agreement With Statements About Teaching

Please indicate the extent to which you agree or disagree with each of the following statements about your university/college level teaching. My involvement in COSEE has…				
	N	**Disagree or Strongly Disagree**	**Neither Agree Nor Disagree**	**Agree or Strongly Agree**
Expanded my network of colleagues (e.g. educators, scientists in other disciplines, other professionals) to support instruction	577	6%	16%	78%
Provided me an opportunity to learn about science learning research	579	7%	17%	76%
Improved my science teaching	525	6%	23%	70%
Supported me to include more hands-on, inquiry-oriented pedagogy in my teaching practice	507	11%	30%	59%
Provided students with opportunities for field-based learning experiences	486	15%	34%	51%
Provided students with opportunities to conduct scientific research	490	16%	37%	47%
Motivated me to teach courses on communicating ocean sciences to public audiences	484	17%	36%	47%
Supported me to use the Ocean Literacy Principles as a resource for teaching	491	16%	40%	45%
Changed how I teach through my involvement with COS/COSIA	430	11%	49%	40%
Helped me use new technologies in my teaching	494	15%	48%	37%
Helped me and my colleagues reshape our undergraduate and/or graduate program	404	21%	54%	26%

Survey Comments

Based on the interviews, a set of survey stems was constructed. Recognizing that scientists could offer more insights through open-ended responses, a question was added providing that opportunity. A total of 110 scientists (out of 767) contributed comments about the impact COSEE had on their research. The responses were from participants at all career stages, with greater responses from the mid- and advanced career stages. By gender, 46 comments came from men, 64 from women.

Table 17: Proportion of Comments About Teaching by Career Stage of Respondents

Career Stage of Comments	Percent of Commenters
Advanced Career Stage	28%
Mid-Career Stage	31%
Early Career Stage	22%
Graduate Students	10%
Various Others	6%

Comments were coded to correspond with the survey stems and percentages computed. The majority of comments (51%) were disclaimers that the question did not apply to their circumstances. Other comments clustered in these categories:

- 13% —Improved my science teaching
- 10%— Supported me to include more hands on, inquiry-oriented pedagogy
- 26% offered *other* (i.e., non-stem aligned) perspectives on how COSEE had an impact on their academic teaching, which included these actions:
    - Planning to use teaching skills and knowledge gained after Ph.D. completion
    - Realizing the kind of impact one can have on underrepresented students
    - Being inspired to pursue teaching
    - Encouraging graduate students to get involved
    - Anticipating opportunities in the future
    - Personal gain of knowledge
    - Integration of cultural knowledge with scientific studies

4. Details of Indicators for Institutional Support and Other Influences of COSEE

The 2010 survey of scientist engagement showed that 63% of respondents agreed or strongly agreed their institution's capacity to participate in education/outreach had a positive impact from COSEE. That survey also included some yes-no questions and provided for open-ended comments, which formed the basis for many of the survey stems included below.

Table 18: Level of Agreement With Statements About Institutional Support

Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on….				
	N	**Disagree or Strongly Disagree**	**Neither Agree Nor Disagree**	**Agree or Strongly Agree**
My understanding of science education practices and science learning research	657	6%	19%	75%
My feelings about the need for E&O for the ocean sciences	666	5%	21%	74%
My willingness to discuss my E&O experiences with my colleagues	635	5%	27%	68%
My effectiveness collaborating with educators	610	6%	26%	68%
My ability to develop high quality broader impacts proposals or programs	542	6%	30%	63%
My ability to mentor my students	486	10%	32%	59%
My efforts to reach out to underrepresented audiences/groups	619	10%	38%	52%
My institution's support of scientist involvement in E&O	601	12%	38%	50%
My students' participation in E&O	424	11%	43%	46%
My effectiveness collaborating with research colleagues	580	13%	46%	41%
My undergraduate students' participation in research (please select N/A if you only oversee graduate students)	354	14%	53%	34%
My interest in a journal dedicated to E&O endeavors	563	16%	51%	33%
My success in securing funding	496	16%	56%	28%
Increasing my institution's funding for participation in E&O	568	23%	50%	27%
My institution's success at recruiting underrepresented students into the sciences	543	19%	57%	24%
My publication of journal articles related to E&O in the ocean sciences	431	27%	55%	18%

Survey Comments about Other Influences and Benefits of COSEE

Of the 767 respondents to the survey, 124 made comments about the other influences and benefits of COSEE. The majority of those making comments were advanced career professionals (31%) followed closely by those in a mid-

career stage (28%). Several individuals declined to state their gender, but 71 indicated they were female and 51 male.

Table 19: Proportion of Comments About Institutional Support by Career Stage of Respondents

Career Stage of Comments	Percent of Commenters
Advanced Career Stage	31%
Mid-Career Stage	28%
Early Career Stage	19%
Graduate Students	5%
Various others	5%

As with previous sections we coded and categorized the comments. Scientists further elaborated on how COSEE had a positive impact on these benefits:

- 20% — Effectiveness in collaborating with educators
- 18% — Effectiveness in collaborating with research scientists
- 13% — Understanding of science education practices and science learning research

Factor Findings

Joo Chung

The Lawrence Hall of Science • The University of California, Berkeley

1. Finding 1: Impact of COSEE on Research

Factor Score. As shown on Table 17, the first factor score, which examined the impact of COSEE on the participants' academic research, was examined using 13 different conditions. Seven of the 13 comparisons were not found to be statistically significant. The remaining six comparisons were found to be statistically significant: Involvement in COSEE as Advocate/Advisor[5], Involvement in COSEE as Partner[6], Involvement in COSEE as Leader[7], Years with COSEE[8], Attended Professional Development[9], and Proposals with COSEE[10]. For "Years with COSEE", the correlation was significant (i.e., $p<.01$) but the correlation itself was not substantial (Spearman's rho=.176).

Table 20: Results of Factor 1 (Impact of COSEE on Research) by Conditions

Condition	Levels in Condition	Factor 1 Significance
Highest Academic Degree[1]	• B.A./B.S./A.A. (n=90) • M.A./M.S./M.B.A. (n=136) • Ed.D. or Ph.D. (n=364)	No Difference
Career Status[1]	• Graduate Student (n=133) • Early career Professional (n=154) • Mid-career Professional (n=153) • Advanced Career Professional (n=136)	No Difference
Tenure Status[2]	• Tenured (n=136) • Not Tenured (n=211)	No Difference
Gender[2]	• Female (n=308) • Male (n=288)	No Difference
Race/Ethnicity[2]	• White/non-Latino (n=465) • Non-White (n=110)	No Difference
Involvement in COSEE as Participant[2]	• Participant (n=483) • Non-Participant (n=123)	No Difference
Involvement in COSEE as Resource[2]	• Resource (n=221) • Non-Resource (n=385)	No Difference
Involvement in COSEE as Advocate/Advisor[2]	• Advocate/Advisor (n=121) • Non-Advocate/Advisor (n=485)	Advocate/Advisor > Non-Advocate/Advisor
Involvement in COSEE as Partner[2]	• Partner (n=99) • Non-Partner (n=507)	Partner > Non-Partner
Involvement in COSEE as Leader[2]	• Leader (n=34) • Non-Leader (n=572)	Leader > Non-Leader
Years with COSEE[3]	• 1 - 10 (Continuous) (n=767)	Positive Correlation
Attended Professional Development[2]	• PD Participant (n=397) • Non-PD Participant (n=192)	PD Participant > Non-PD Participant
Proposals with COSEE[2]	• Included COSEE in Research Proposals (n=166) • Did Not Include COSEE in Research Proposals (n=315)	Included COSEE > Did Not Include COSEE

[1] One-way ANOVA
[2] Independent Samples t-test
[3] Spearman Correlation

[5] $t(171.752)=3.179$, $p<.01$; Equal variances not assumed
[6] $t(604)=4.483$, $p<.01$
[7] $t(604)=2.942$, $p<.01$
[8] Spearman's rho=.176, $p<.01$
[9] $t(587)=3.447$, $p<.01$
[10] $t(479)=4.592$, $p<.01$

2. Finding 2: Impact of COSEE on Education and Outreach

Factor Score. As shown on Table 18, the Factor 2 score, which examined the impact of COSEE on the participants' education and outreach (E&O), was examined using the same 13 different conditions. Six of the 13 comparisons were not found to be statistically significant. The remaining six comparisons were found to be statistically significant: Involvement in COSEE as Resource[11], Involvement in COSEE as Advocate/Advisor[12], Involvement in COSEE as Partner[13], Involvement in COSEE as Leader[14], Years with COSEE[15], Professional Development[16], and Proposals with COSEE[17]. For "Years with COSEE", the correlation was significant (i.e., $p<.01$) but the correlation itself was not substantial (Spearman's rho=.263). In all cases examined using this factor score revealed higher perception of the impact of COSEE in E&O for those who were heavily invested in the various roles.

Table 21: Results of Factor 2 (Impact of COSEE on E&O) by Conditions

Condition	Levels in Condition	Factor 2 Significance
Academic Degree[1]	• B.A./B.S./A.A. (n=80) • M.A./M.S./M.B.A. (n=158) • Ed.D. or Ph.D. (n=378)	No Difference
Career status[1]	• Graduate Student (n=115) • Early career Professional (n=164) • Mid-career Professional (n=176) • Advanced Career Professional (n=154)	No Difference
Tenure status[2]	• Tenured (n=145) • Not Tenured (n=222)	No Difference
Gender[2]	• Female (n=325) • Male (n=297)	No Difference
Race/Ethnicity[2]	• White/non-Latino (n=494) • Non-White (n=110)	No Difference
Involvement in COSEE as Participant[2]	• Participant (n=509) • Non-Participant (n=123)	No Difference
Involvement in COSEE as Resource[2]	• Resource (n=239) • Non-Resource (n=393)	Resource > Non-Resource
Involvement in COSEE as Advocate/Advisor[2]	• Advocate/Advisor (n=137) • Non-Advocate/Advisor (n=495)	Advocate/Advisor > Non-Advocate/Advisor
Involvement in COSEE as Partner[2]	• Partner (n=111) • Non-Partner (n=521)	Partner > Non-Partner
Involvement in COSEE as Leader[2]	• Leader (n=41) • Non-Leader (n=591)	Leader > Non-Leader
Years with COSEE[3]	• 1 - 10 (Continuous) (n=767)	Positive Correlation
Professional Development[2]	• PD Participant (n=415) • Non-PD Participant (n=198)	PD Participant > Non-PD Participant
Proposals with COSEE[2]	• Included COSEE in Research Proposals (n=168) • Did Not Include COSEE in Research Proposals (n=318)	Included COSEE > Did Not Include COSEE

[1] One-way ANOVA
[2] Independent Samples t-test
[3] Spearman Correlation

[11] $t(630)=3.353$, $p<.01$
[12] $t(630)=5.431$, $p<.01$
[13] $t(630)=6.902$, $p<.01$
[14] $t(630)=4.088$, $p<.01$
[15] Spearman's rho=.263
[16] $t(611)=3.207$, $p<.01$
[17] $t(484)=6.832$, $p<.01$

3. Finding 3: Impact of COSEE on Teaching

Factor Score. As shown on Table 19, the third factor score, which examined the impact of COSEE on the participants' teaching, was examined using the same 13 different conditions. Five of the 13 comparisons were not found to be statistically significant. The remaining eight comparisons were found to be statistically significant: Highest Academic Degree[18], Tenure Status[19], Gender[20], Involvement in COSEE as a Participant[21], Involvement in COSEE as Advocate/Advisor[22], Involvement in COSEE as Partner[23], Years with COSEE[24], and Professional Development. For "Years with COSEE", the correlation was significant (i.e., p<.01) but the correlation itself was not substantial (Spearman's rho=.214).

Table 22: Results of Factor 3 (Impact of COSEE on Teaching) by Conditions

Condition	Levels in Condition	Factor 3 Significance
Highest Academic Degree[1]	• B.A./B.S./A.A. (n=76) • M.A./M.S./M.B.A. (n=130) • Ed.D. or Ph.D. (n=378)	B.A./B.S./A.A. > Ed.D. or Ph.D; M.A./M.S./M.B.A. > Ed.D. or Ph.D
Career Status[1]	• Graduate Student (n=109) • Early career Professional (n=137) • Mid-career Professional (n=143) • Advanced Career Professional (n=121)	No Difference
Tenure Status[2]	• Tenured (n=141) • Not Tenured (n=193)	Not Tenured > Tenured
Gender[2]	• Female (n=276) • Male (n=249)	Female > Male
Race/Ethnicity[2]	• White/non-Latino (n=411) • Non-White (n=93)	No Difference
Involvement in COSEE as Participant[2]	• Participant (n=435) • Non-Participant (n=100)	Participant > Non-Participant
Involvement in COSEE as Resource[2]	• Resource (n=193) • Non-Resource (n=342)	No Difference
Involvement in COSEE as Advocate/Advisor[2]	• Advocate/Advisor (n=126) • Non-Advocate/Advisor (n=454)	Advocate/Advisor > Non-Advocate/Advisor
Involvement in COSEE as Partner[2]	• Partner (n=99) • Non-Partner (n=436)	Partner > Non-Partner
Involvement in COSEE as Leader[2]	• Leader (n=38) • Non-Leader (n=542)	No Difference
Years with COSEE[3]	• 1 - 10 (Continuous) (n=767)	Positive correlation
Attended Professional Development[2]	• PD Participant (n=362) • Non-PD Participant (n=160)	PD Participant > Non-PD Participant
Proposals with COSEE[2]	• Included COSEE in Research Proposals (n=131) • Did Not Include COSEE in Research Proposals (n=273)	No Difference

[1] One-way ANOVA
[2] Independent Samples t-test
[3] Spearman Correlation

[18] $F(2,517)=10.839$, $p<.01$; Post-hoc Bonferroni comparisons revealed significant differences with all comparisons with "Ed.D. or Ph.D.".
[19] $t(332)=3.363$, $p<.01$
[20] $t(523)=1.965$, $p<.05$
[21] $t(533)=3.540$, $p<.01$
[22] $t(533)=2.479$, $p<.05$
[23] $t(533)=4.689$, $p< .01$
[24] Spearman's rho=.214, $p<.01$

4. Finding 4: Impact of COSEE on Institutional Support and Other Influences

Factor Score. As shown on Table 20, the fourth factor score, which examined the impact of COSEE on the support for E&O within the participants' institution, was examined using the same 13 different conditions. Seven of the 13 comparisons were not found to be statistically significant. The remaining eight comparisons were found to be statistically significant: Involvement in COSEE as Participant[25], Involvement in COSEE as Resource[26], Involvement in COSEE as Advocate/Advisor[27], Involvement in COSEE as Leader[28], Years with COSEE[29], and Proposals with COSEE[30]. For "Years with COSEE", the correlation was significant (i.e., $p<.05$) but the correlation itself was not substantial (Spearman's rho=.098).

Table 23: Results of Factor 4 (Impact of COSEE Institutional Support for E&O) by Conditions

Condition	Levels in Condition	Factor 4 Significance
Academic Degree[1]	• B.A./B.S./A.A. (n=74) • M.A./M.S./M.B.A. (n=144) • Ed.D. or Ph.D. (n=346)	No Difference
Career status[1]	• Graduate Student (n=110) • Early career Professional (n=147) • Mid-career Professional (n=162) • Advanced Career Professional (n=139)	No Difference
Tenure status[2]	• Tenured (n=137) • Not Tenured (n=205)	No Difference
Gender[2]	• Female (n=289) • Male (n=280)	No Difference
Race/Ethnicity[2]	• White/non-Latino (n=446) • Non-White (n=103)	No Difference
Involvement in COSEE as Participant[2]	• Participant (n=461) • Non-Participant (n=119)	Non-Participant > Participant
Involvement in COSEE as Resource[2]	• Resource (n=226) • Non-Resource (n=354)	Resource > Non-Resource
Involvement in COSEE as Advocate/Advisor[2]	• Advocate/Advisor (n=126) • Non-Advocate/Advisor (n=454)	Advocate/Advisor > Non-Advocate/Advisor
Involvement in COSEE as Partner[2]	• Partner (n=105) • Non-Partner (n=475)	No Difference
Involvement in COSEE as Leader[2]	• Leader (n=38) • Non-Leader (n=542)	Leader > Non-Leader
Years with COSEE[3]	• 1 - 10 (Continuous) (n=767)	Positive Correlation
Professional Development[2]	• PD Participant (n=381) • Non-PD Participant (n=184)	No Difference
Proposals with COSEE[2]	• Included COSEE in Research Proposals (n=154) • Did Not Include COSEE in Research Proposals (n=293)	Included COSEE >Did Not Include COSEE

[1] One-way ANOVA
[2] Independent Samples t-test
[3] Spearman Correlation

[25] $t(167.298)=2.079$, $p<.05$; Equal variances not assumed
[26] $t(578)=1.978$, $p<.05$
[27] $t(578)=2.629$, $p<.01$
[28] $t(578)=3.445$, $p<.01$
[29] Spearman's rho=.098, $p<.05$
[30] $t(445)=4.727$, $p<.01$

Scale Construction Report

COSEE Scientist Survey: Scale Construction & Psychometric Properties

Joo Chung, Rena Dorph, Matthew Cannady

The Research Group • The Lawrence Hall of Science • The University of California, Berkeley

The current report utilizes 48 items Likert-styled items that were included in the survey for the intent of determining a statistical measure of the scientists' perceived impact of COSEE in their scientific endeavors, including instruction, research, and outreach (see Appendix A for a complete list). As part of analysis in the current report, these 48 items were examined for scaling characteristics such that a collection of items could be identified as measuring specific constructs (i.e., a factor score).

In the context of the current report, the use of factor scores were valuable in producing robust indicators that were comprised of questions that were cross-checked for relatedness. Further, the use of factor scores accounted for the Likert-style scaling (i.e., ordinal-scaled) of the items used in the analysis, which typically violates an important prerequisite for the use of traditional statistical analyses.

Horn's parallel analysis[31] (using minimum residual estimation) and factor analysis (using maximum likelihood estimation and promax rotation) were used for exploratory factor analysis. Polychoric correlation coefficients[32] were used (rather than Pearson correlations) to better account for the ordinal scaling of the Likert-style items. A measure of internal reliability (Cronbach's α) was also utilized. Factor scores were generated using simple averages of each of the items in the factor (omitting scores with over 50% missing values for the particular factor) to facilitate the use of these items in future research. Other options for the production of factor scores that can be used in future iterations include Thurstone regression[33] (1935), and Anderson and Rubin's method[34] (1956).

The research team stresses the exploratory nature of the scale vetting procedure. As such, we recommend future research that will utilize these items to confirm the factoring described in this report.

Factor Analysis. A preliminary factor analysis was completed on all 48 Likert-styled items (1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree) using polychoric correlations. While splitting the sample into two halves to perform an exploratory and confirmatory factor analysis using the same dataset would have been ideal, the overall sample size was reduced significantly during the factor analysis procedures due to the necessary list-wise deletion of participants with missing data. However, the number of participants with complete data increased as items were iteratively removed from the dataset (i.e., as variables with potential blank responses were removed).

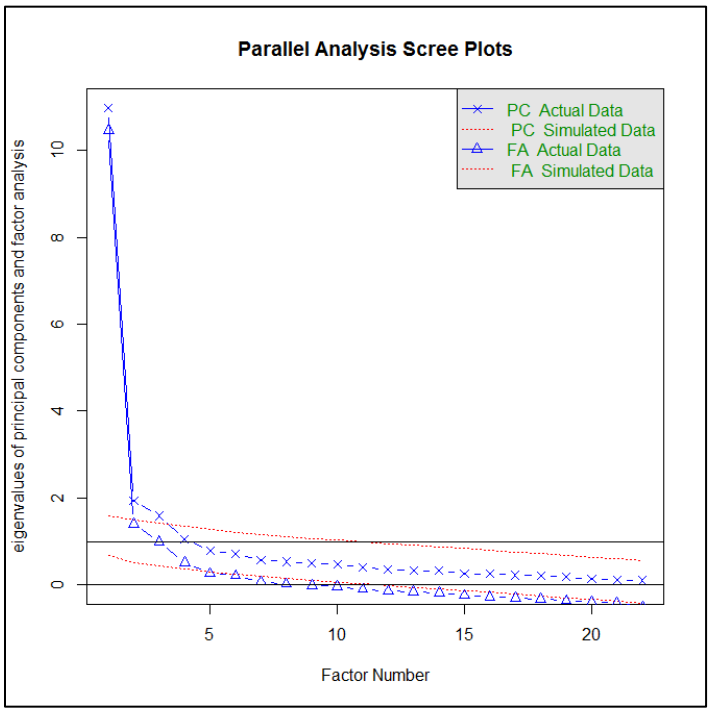
A preliminary parallel analysis suggested as many as 10 factors, which prompted the elimination of any items that failed to load greater than .30 onto any of the available factors and items that loaded onto more than one factor. This iterative process resulted in 4 distinct factors with strongly loading items and good fit with the theorized underlying constructs (see Table 1 and Figure 3). However, the overall item count was reduced to 22 from the original 48 (N=257). The indicators of internal reliability (polychoric Cronbach's α) for each of the item sets were satisfactory (see Table 2).

The resulting four factors were 1) the impact of COSEE in research, 2) the impact of COSEE on E&O, 3) the impact of COSEE on teaching, and 4) the impact of COSEE on institutional support for E&O, and 4). Factor 1 (Impact of COSEE in Research) was comprised of questions related to the influence of COSEE in the scientists' research endeavors (e.g., "My involvement in COSEE has...-a. Changed the way I think about my research questions"). Factor 2 (Impact of COSEE on E&O) was comprised of questions regarding how COSEE facilitated the scientist's involvement in E&O activities (e.g., "My involvement in COSEE [...] Helped me integrate my E&O with my science research."). Factor 3 (Impact of COSEE on Teaching) was comprised of questions regarding how COSEE facilitated aspects of instruction for scientists who were actively engaged in instruction in some form (e.g., "My involvement in COSEE has […] Improved my science teaching").

[31] Horn J. L. 1965. "A rationale and a test for the number of factors in factor analysis." *Psychometrika*. 30: 179–185.
[32] Olsson, U. (1979) Maximum likelihood estimation of the polychoric correlation coefficient. *Psychometrika* 44, 443-460.
[33] Thurstone, L. L. (1935). *The vectors of mind*. Chicago: University of Chicago Press. (pp. 226-231).
[34] Anderson, R. D., & Rubin, H. (1956). Statistical inference in factor analysis. *Proceedings of the Third Berkeley Symposium of Mathematical Statistics and Probability*, 5, 111-150.

Factor 4 (Impact of COSEE on Institutional Support for E&O) was comprised of questions specifically related to the influence of COSEE on the scientist's working institution on E&O activities (e.g., "My involvement in COSEE had a positive impact on [...] Increasing my institution's funding for participation in E&O").

Figure 3: Results of Parallel Analysis (Scree Plot)



* The number of factors (triangles) with greater-than-chance eigenvalues (lower red line) was 4. PC=Principal Components (not used in this report); FA=Factor Analysis.

Factor scores for each of the factors were generated by simply averaging out the response for each item within each factor. These factor scores were generated for any participant that had valid items (i.e., non-blank) for at least half of the items in each factor. As such, the number of participants with factor scores for each of the four factors was larger than the number of participants used for factor analysis (i.e., closer to the 767 total completed surveys). The descriptive statistics for each of the four factors are available on Table 3 and histograms are shown on Figure 4. While the resulting distributions were unlikely to be perfectly normal, the researchers deemed the factor scores sufficiently normal for statistical analyses with cautious interpretation.

Table 24: Results of Factor Analysis (Pattern Matrix)

	Factor 2	Factor 1	Factor 4	Factor 3
COSEE_EO4	0.58	0.21	-0.04	0.06
COSEE_EO5	0.75	0.04	0.06	-0.08
COSEE_EO6	0.87	-0.01	0.07	-0.14
COSEE_EO10	0.87	-0.05	-0.15	0.08
COSEE_EO11	0.64	0.37	-0.09	-0.17
COSEE_EO12	0.93	-0.31	0.00	0.25
COSEE_OtherInfluences7	0.81	-0.10	0.11	-0.03
COSEE_OtherInfluences12	0.58	0.11	0.01	0.14
COSEE_OtherInfluences15	0.43	0.35	0.08	-0.01
COSEE_Teaching1	0.09	0.01	-0.05	0.90
COSEE_Teaching2	-0.04	0.16	0.11	0.73
COSEE_Teaching3	0.17	0.29	-0.06	0.38
COSEE_Teaching6	-0.12	0.61	-0.02	0.23
COSEE_OtherInfluences1	0.05	-0.06	0.74	0.11
COSEE_OtherInfluences2	0.01	-0.10	1.00	0.00
COSEE_OtherInfluences3	0.01	0.20	0.79	-0.08
COSEE_Research1	0.00	0.61	-0.05	0.26
COSEE_Research2	0.04	0.82	-0.02	-0.07
COSEE_Research3	-0.05	0.88	-0.03	0.02
COSEE_Research4	-0.01	0.90	-0.10	-0.10
COSEE_Research6	0.21	0.52	0.12	-0.12
COSEE_Research7	-0.21	0.83	0.14	0.03

*Forced 4 factor solution; Maximum likelihood with Promax rotation. Factors are in the order of most variance explained (i.e., not numeric order). Highlighted cells represent the researcher-determined dominant factor for each item. See Appendix A for a full description of each of the items.

Table 25: Reliability Statistics

Factors	Cronbach's α	N of items
Factor 1: Impact of COSEE on Research	.874	6
Factor 2: Impact of COSEE on E&O	.919	9
Factor 3: Impact of COSEE on Teaching	.840	4
Factor 4: Impact of COSEE on Institutional Support for E&O	.861	3

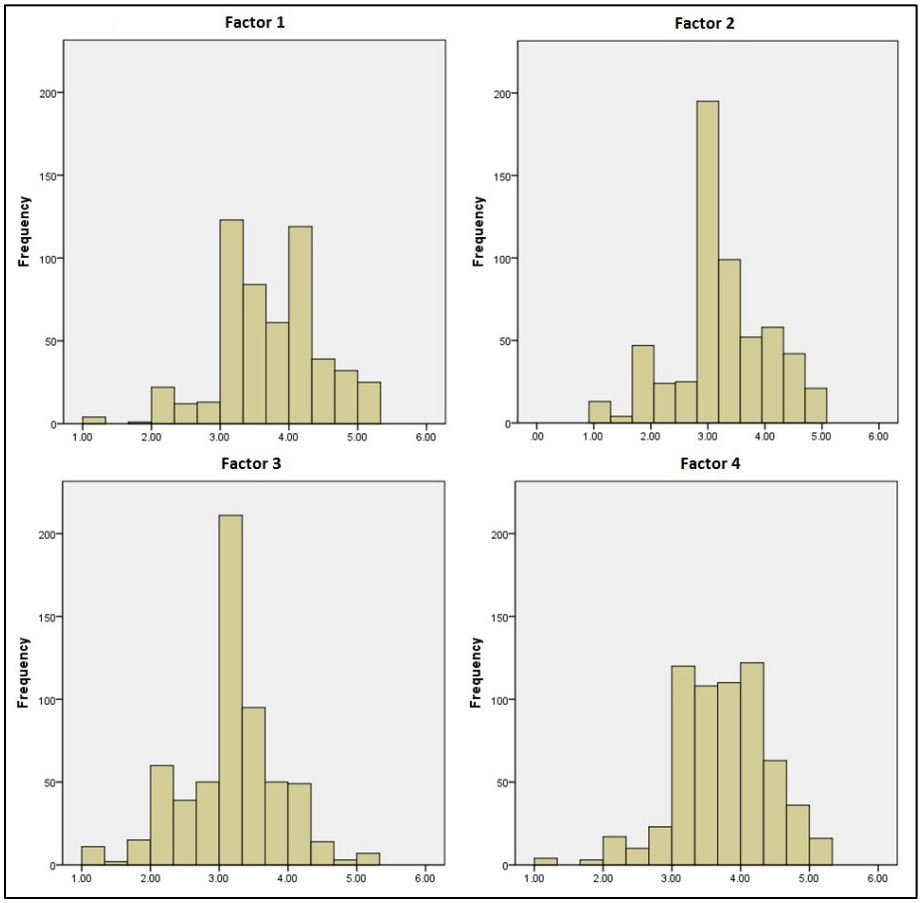
*Polychoric correlations were used.

Table 26: Descriptive Statistics for Factor Scores

	Factor 1	Factor 2	Factor 3	Factor 4
Valid	606	632	535	580
Missing	161	135	232	187
Mean	3.08	3.68	3.65	3.22
Median	3.00	3.67	3.67	3.00
Std. Deviation	.71	.68	.72	.79
Skewness	-.20	-.49	-.40	-.11
Std. Error of Skewness	.099	.097	.106	.101
Kurtosis	.53	.82	.59	.61
Std. Error of Kurtosis	.20	.19	.21	.20
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00

*1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree

Figure 4: Histograms of Factor Scores



Appendix to Scale Construction Report

Table 27: Likert-Scaled Items*

Item	Prompt	Text
COSEE_EO1	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	a. Gave me opportunities to plug into existing E&O events
COSEE_EO2	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	b. Provided a niche for me to accomplish my E&O goals
COSEE_EO3	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	c. Helped me use new technologies for E&O
COSEE_EO4	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	d. Helped me advise others on doing E&O (e.g. students or colleagues)
COSEE_EO5	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	e. Helped me critically review E&O sections of grant proposals
COSEE_EO6	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	f. Helped me integrate my E&O with my science research
COSEE_EO7	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	g. Helped me integrate my E&O with my university-level teaching
COSEE_EO8	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	h. Changed my view of E&O to being as important as my research
COSEE_EO9	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	i. Changed my expectations of my students' involvement in E&O

COSEE_EO10	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	j. Increased the level of my involvement in E&O (e.g., one-time events to ongoing activities, more interactive/participatory engagement)
COSEE_EO11	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	k. Changed my involvement with E&O to make it a lab-wide or team endeavor
COSEE_EO12	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	l. Improved the quality of my E&O
COSEE_EO13	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	m. Introduced me to the Ocean Literacy Principles (as a framework for teaching about science)
COSEE_EO14	Please indicate the extent to which you agree or disagree with each of the following statements about your E&O. My involvement in COSEE…	n. Used E&O to increase underrepresented students in ocean sciences
COSEE_OtherInfluences1	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	a. My institution's support of scientist involvement in E&O
COSEE_OtherInfluences2	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	b. Increasing my institution's funding for participation in E&O
COSEE_OtherInfluences3	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	c. My institution's success at recruiting underrepresented students into the sciences
COSEE_OtherInfluences4	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	d. My students' participation in E&O

COSEE_OtherInfluences5	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	e. My undergraduate students' participation in research (please select N/A if you only oversee graduate students)
COSEE_OtherInfluences6	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	f. My ability to mentor my students
COSEE_OtherInfluences7	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	g. My ability to develop high quality broader impacts proposals or programs
COSEE_OtherInfluences8	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	h. My success in securing funding
COSEE_OtherInfluences9	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	i. My effectiveness collaborating with educators
COSEE_OtherInfluences10	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	j. My effectiveness collaborating with research colleagues
COSEE_OtherInfluences11	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	k. My understanding of science education practices and science learning research
COSEE_OtherInfluences12	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	l. My feelings about the need for E&O for the ocean sciences

COSEE_OtherInfluences13	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	m. My publication of journal articles related to E&O in the ocean sciences
COSEE_OtherInfluences14	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	n. My interest in a journal dedicated to E&O endeavors
COSEE_OtherInfluences15	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	o. My efforts to reach out to underrepresented audiences/groups
COSEE_OtherInfluences16	Please indicate the extent to which you agree or disagree with each of the following statements about your involvement in COSEE. My involvement in COSEE had a positive impact on...	p. My willingness to discuss my E&O experiences with my colleagues
COSEE_Research1	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	a. Changed the way I think about my research questions
COSEE_Research2	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	b. Shaped my research focus towards more societally relevant questions
COSEE_Research3	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	c. Changed my research focus because of new opportunities
COSEE_Research4	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	d. Changed my research focus in order to generate interest in ocean sciences research by underrepresented populations
COSEE_Research5	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	e. Prompted me to think about the need to communicate my research with the public

COSEE_Research6	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	f. Helped me leverage new funding which re-directed my research
COSEE_Research7	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	g. Changed my research by providing me with access to new data collection methods and/or sources (e.g. Citizen Science)
COSEE_Teaching1	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	a. Improved my science teaching
COSEE_Teaching2	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	b. Changed how I teach through my involvement with COS/COSIA
COSEE_Teaching3	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	c. Provided me an opportunity to learn about science learning research
COSEE_Teaching4	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	d. Supported me to include more hands-on, inquiry-oriented pedagogy in my teaching practice
COSEE_Teaching5	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	e. Supported me to use the Ocean Literacy Principles as a resource for teaching
COSEE_Teaching6	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	f. Helped me use new technologies in my teaching
COSEE_Teaching7	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	g. Helped me and my colleagues reshape our undergraduate and/or graduate program
COSEE_Teaching8	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	h. Motivated me to teach courses on communicating ocean sciences to public audiences

COSEE_Teaching9	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	i. Expanded my network of colleagues (e.g. educators, scientists in other disciplines, other professionals) to support instruction
COSEE_Teaching10	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	j. Provided students with opportunities for field-based learning experiences
COSEE_Teaching11	Please indicate the extent to which you agree or disagree with each of the following statements about your scientific research. My involvement in COSEE has…	k. Provided students with opportunities to conduct scientific research
* All items were scaled as: 1=Strongly Disagree; 2=Disagree; 3=Neither Agree Nor Disagree; 4=Agree; 5=Strongly Agree.		

Scientist Interview Protocol

Center for Ocean Sciences Education Excellence (COSEE)

Thanks for agreeing to participate in an interview designed to learn about how your involvement in COSEE has impacted your professional practice. This information will be used to support the development of a survey which will be administered to a selected group of participating COSEE scientists. This interview will take approximately 1 hour.

In appreciation for your time and participation we will send you a $50 Amazon gift card upon completion of the interview.

Before we begin, I need to ask you if you would mind if I recorded this interview on audio tape. The tape will be kept completely confidential and will only be used for research purposes. Recordings are destroyed once we have completed our evaluation. It is a tool I use so that I don't have to take copious notes while conversing with you. If you are uncomfortable with it, however, I can take notes instead. Would it be alright with you if I recorded this conversation?

Do you have any questions before we begin?

1. How would you characterize your engagement with your COSEE?
    a. A scientist who is doing education and public outreach activities…such as professional development for teachers?
    b. A participant in workshops or activities designed for scientists to enhance skills, knowledge or capacity to do education and public outreach OR broader impacts.
    c. Engaged in Broader Impacts with COSEE…such as doing policy-oriented endeavors, or building collaborations and partnerships or doing work with informal science learning organizations or working with underrepresented group, or
2. Please tell me about your area of research in the ocean sciences.

3. What sorts of outreach activities and/or broader impact activities and/or workshops are you involved in? Please describe how your involvement has evolved (changed over the time frame of being involved with COSEE)

4. What types of outreach activities and/or broader impact activities and/or workshops have you found most rewarding (prompt for both professional and personal rewards)? Least rewarding?

5. **About your research:** Has your thinking about your research changed as a result of your involvement? If so, how? If not, could it?

6. **About your university-level teaching (if applicable):** Has your thinking about your teaching changed as a result of your involvement? If so, how? If not, could it?

7. **About professional/collegial relationships:** Has your involvement changed your relationships with any of the following… If so, how? If not, could it?
    1. professional colleagues (other researchers or faculty?
    2. educational partners or research collaborators?
    3. students or mentees?

8. **About professional priorities/pursuits:** Has your experience with COSEE activities affected your thinking about your professional priorities or pursuits? If so, how? If not, could it?

9. **About Broader Impacts proposals:** What, if anything or anyone, has supported the quality and quantity of the broader impact statements you have included in your scientific research proposals? How?

10. Because of Broader Impacts expectations have you changed the way you think about …?
    a. Teaching? –
    b. Research? –
    c. Relationships with colleagues and partners/collaborators?

d. Relationships with educators you work with? (e.g., in house colleagues or formal education or informal education professionals)
e. Interactions with the public

11. Anything else you want to say about your relationship with COSEE or what you gained from COSEE?

12. On a scale of 1 strongly agree to 5 strongly disagree how would you answer this question:
    a. COSEE has had an impact on my research –
    b. COSEE has had an impact on my teaching -
    c. COSEE has had an impact on my BI work –