**National Science Foundation**

**ANNUAL SITE VISIT REPORT**

**Science and Technology Centers: Integrative Partnerships Program**

**Name of the Center/Award No**.: Center for Dark Energy Biosphere Investigations (C-DEBI) 0939564/1457195

**Name of the Lead Institution/PI:** University of Southern California/Jan P Amend

**STC Site Visit Period/Venue:** Year 6, February 9-10, 2016 (Pre-Meeting, February 8),

University of Southern California, Los Angeles, CA

**Executive Summary**

The site visit panel was impressed by the accomplishments of the Center for Dark Energy Biosphere Investigations (C-DEBI) and recognizes the strength of its scientific findings. The scope of C-DEBI’s work spans orders of magnitudes in scales of time and space, and crosses several disciplines, and C-DEBI is to be commended for its science as well as transfer of new knowledge to the scientific community and to the public at large. Despite being a geographically dispersed center, C-DEBI’s management appears to be effective and cohesive. The panel also recognized C-DEBI’s efforts and strengths in undergraduate, graduate and postdoctoral training. The hiring of the new diversity director is very encouraging and the panel anticipates that this will help C-DEBI expand its diversity efforts. The panel recognizes that C-DEBI has taken on the challenge of increasing diversity in the pipeline, and is very actively increasing diversity at the undergraduate level by bringing in underserved minority students into labs both through summer programs and year-long programs. But while the panel recognizes the limits of C-DEBI to affect faculty-hiring decisions at institutions, we strongly encourage C-DEBI to engage in innovative, out of the box approaches to address the complex issue of increasing diversity at the graduate student, post-doctoral, and faculty levels. The panel notes that C-DEBI is recognizing its data management challenges and has engaged the NSF funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) to assist with hosting data and enhancing discoverability and access. However, as noted in the Data Management section and elsewhere, it is still not clear that this approach suggests a vision for a value-added Center perspective for data management.

Overall, the panel was concerned that the C-DEBI team did not present a compelling overall conceptual framework that describes how all center activities are integrated. The panel encourages the executive committee to develop such a framework, not to fulfill a mandate, but as a management and communication tool. It can help identify areas of strength and potential gaps that might be barriers to accomplishing the objectives of each of the three themes within the remainder of the granting period. In addition, a framework that includes feedback between themes 1, 2, and 3 would reveal strengths and weaknesses in the flow of information between the themes.

**Introduction and Background**

The NSF Site Visit Panel met at the University of Southern California on Monday February 8, 2016 through Wednesday February 10, 2016. The purpose was to review the accomplishments of C-DEBI as an NSF Science and Technology Center during the last year and to review their proposed activities for the next four years of Phase 2. This review is intended to provide guidance and to provide helpful feedback and advice to the C-DEBI team and to NSF.

The panel visit followed the schedule set by the C-DEBI team. The panel met for three hours on Monday evening for a briefing on the purpose and structure of the site visit. Tuesday was filled with presentations from the C-DEBI team, with extra time for questions and answers and also for the panel to meet alone. The panel met with students and postdocs during lunch and during a late afternoon poster session. At the end of the day, the panel gave questions to the C-DEBI leadership. On Wednesday morning, the panel heard from USC administrators about the support for and impacts of C-DEBI and then the C-DEBI team responded to the panel’s questions. The panel then spent the rest of the day crafting this review document.

**Organization and Management**

The panel was impressed by the cohesive and effective nature of the management team. Previous concerns about potential overcommitment of the Director, Jan Amend, appear to be unfounded. The Director seems to be ably supported by the Associate Director as well as an engaged executive committee that represented the diverse disciplines and goals of the Center. The addition of John Heidelberg and Stephanie Schroeder representing the data management and education aspects of the Center was seen as a potential plus. The rotating membership on the executive committee is also seen as an innovative strategy to engage other senior investigators in the leadership team. The panel was impressed by the purposeful use of workshops and annual meetings to achieve the integration goals of the Center. The administration of the Center is clearly very effective. The panel noted that the Managing Director is no longer collocated at USC. Given the distributed nature of this center, it is not yet clear how this might affect the effectiveness of the administration. The panel was encouraged by changes to the External Advisory Board to match the goals of Phase II, but noted that the team has still not followed previous recommendation of adding people with experience in data management, big data, and diversity to the Board. There was some concern that this may reflect lower priorities of these issues within C-DEBI.

Concerns, if any:

By tasking the Diversity Director with coordinating communications across C-DEBI, the panel was concerned that she is being asked to focus on too many critical functions.

The panel was also concerned that, given all his other commitments, the Data Management Director doesn’t have the bandwidth for advancing effective data management and engaging with the larger Geo-informatics community to support the data management efforts within C-DEBI.

Recommendations:

The panel recommends C-DEBI consider enlarging the External Advisory Board to include people with expertise in data integration and data management as well as provide advice in innovative approaches to deal with enhancing diversity at all levels of C-DEBI activity.

**Intellectual Merit: Proposed Research and Accomplishments to Date**

In Phase I, the Center has demonstrated the ability to explore subsurface ecosystems at four major sites. In Phase II, they have added some new sites and have assembled a new Leadership team with plans to focus on studies of microbial ecology and with the broader goal of connecting processes at the scale of molecules, cells, organisms, and ecosystems. The highlights of new and continuing research directions, as demonstrated by the publication record and the poster session, promise exciting technological and scientific advances. These activities follow the plan outlined in the proposal for Phase II. The newly assembled leadership team is excellent and has expanded into new research areas, with strong emphasis on microbiology.

Strengths: The new team is a major strength of the Center: it consists of well-established researchers who are leaders in their respective fields. The on-going and proposed activities are certain to describe microbial diversity and ecology in the ocean floor subsurface. They also have the potential to reveal microbial activity and the molecular underpinnings of microbial processes at least at the well-studied sites. The addition of microbiologists who were previously outside of the microbial oceanography community demonstrates the inclusiveness, the openness of the team, and the intention to integrate insights from microbial evolution and ecology and delve into molecular and physiological details. The panel was excited about the development of new methods to detect microbial activity (protein synthesis) in systems in which growth may not be actively occurring and their promise for the future.

Graduate students and postdocs working with the team are excited and familiar with various aspects of cruises, field research, sample collection and analytical details of their research and well prepared to discuss their research. The students and postdocs from different teams have ample opportunity to interact and feel like a part of a larger community and many seem to remain within this community. The small grants program is used effectively to bring in researchers from the broader community and enable further collaborations. The team has built a diverse international network leveraging other programs. They have followed the suggestion of the previous review and have made progress in determining the composition of microbial communities at various sites and as a function of different lithologies.

Concerns: The panel expressed the desire to hear a clearer description of big picture questions, with some specifics beyond “exploring microbial life below the seafloor”. What are some of the major questions and reasons to study this? What are some of the major hypotheses that arise from data collected during the previous cycle? What are some potential contributions of subsurface life to the biogeochemical cycles? What are some expected findings and potential contributions of integrated themes to fields that study other systems (e.g., soils, continental subsurface)? The C-DEBI team mentioned that the three themes offer obvious answers, but the panel did not see a clear conceptual framework and integration of the three themes. We also asked for better illustrations of connections among different teams and questions. The described research was certainly multidisciplinary, but its interdisciplinarity and collaborations should be emphasized more.

C-DEBI (and the review panel) recognizes that there is a grand challenge to describe the deep biosphere not only descriptively but also quantitatively. The proposal for Phase II mentions integration with a reactive transport model but does stop short of integrating the “genes to ecosystems” approach. Yet, the strategic plan outlines in research outcome number one that “the next-generation of coupled fluid-energy-biochemical-microbial models will be developed”. The panel recognizes that this is a lofty goal, but it is the next frontier toward understanding the impact of microbial life on Earth systems. If this is a grand challenge within the field and part of the strategic plan, how do the integrated themes and their expected outcomes push the science closer to this goal?

The planned expeditions may not reach all originally proposed research sites and there is much of the ocean floor left to be explored. New data will need to be collected through the proposed laboratory studies and incubations to achieve the objectives outlined for Theme 2. How will C-DEBI maintain a balance between exploration and in-depth analyses in the next four years to reasonably achieve the goals outlined in the proposal?

Recommendations: The panel recommends that the team prepare a brief, more clearly articulated vision and the integration of themes in Phase II (conceptual framework). This vision should spell out the major questions and reasons to study the deep subsurface to non-experts. It should describe how the three themes and planned activities contribute to answering these questions and how they are related to exploration or hypothesis-driven research. Having this ready concept map would benefit any future endeavors in fundraising, outreach and communication and facilitate the transfer of knowledge to fields outside of ocean sciences.

**Data Management and Integration**

Strengths:

The site review team was very impressed by the progress in C-DEBI’s overall data management activities. It is considered to be a good initial approach to collaborate with BCO-DMO for primary data management while using other appropriate repositories simultaneously and linking all data resources through the BCO-DMO interface. It appears that metadata fields are well populated (or are planned to be so) and it is easy to navigate C-DEBI’s projects, participants, and available datasets.

Concerns, if any:

C-DEBI appears to be satisfied to have found a limited niche in involvement with EarthCube as an end user and providing use cases for further developments. However, for an interdisciplinary center like C-DEBI end user input does not represent enough of a leadership role. The review panel is very concerned about the ‘check box’ approach C-DEBI is taking with data submission to BCO-DMO to meet NSF’s minimum requirements. Particularly the area of data integration and synthesis is not being addressed at all despite the need of even the current somewhat siloed data analyses. Many student posters clearly illuminated the need for accessing data from other projects and other parts within C-DEBI. The review panel was very concerned that the C-DEBI leadership doesn’t consider it appropriate to contribute ideas and directions to BCO-DMO developments that would address data integration for the larger community.

Another major concern is the fact that the data management budget allocation was very small to begin with and has dropped even further in last year’s allocations. Providing significant leadership is not a part time job and requires active participation in geo-informatics meetings (e.g., Earth Science Information Partners, ESIP), being active in the EarthCube community (regular online meetings) and engaging in proposal development in this area.

The review panel was concerned that the C-DEBI leadership is very reluctantly entering the age of data sharing and is therefore setting a poor example for its students. Responses that data need to be worked up and published by the grad students first, as well as the perception of competitors scooping investigators, should be critically revisited. Generally, communities that are more open to data sharing have the experience that this leads to more publication and interesting collaborations. The panel generally agrees that the great benefits of early and open data sharing far outweigh the concerns over the potential for misuse of data. As a STC, C-DEBI has an opportunity to lead the way in changing the attitudes and culture of data sharing in this community.

Recommendations:

Clearly, a stronger involvement with the geo-informatics community in general and EarthCube in particular is needed for C-DEBI to position itself in a leadership role with synthesis and data analysis involving players from the different disciplines both within C-DEBI and from outside. Furthermore, development of a clear vision for advances in data management that will accelerate scientific inquiry needs to be expressed in outside collaboration and proposal developments.

Tracking of data downloads and data use may provide important metrics and may help to provide information on the importance of these activities to the broader scientific community, as well as facilitate future collaborations.

It was mentioned that some investigators are quicker than others in submitting their data to BCO-DMO. C-DEBI may want to consider hiring some specific data curation help (student) for the project as a whole. This may speed up the process without a major investment and can make the dataset documentation more uniform and, hence, datasets better discoverable. Although BCO-DMO already has standardized content in many metadata fields, the C-DEBI research community may want to define certain research concepts that datasets are tagged with (keywords) for easier discovery of thematically similar data. This tagging is then better accomplished centrally, rather than by each investigator separately. Another area where some centralization may benefit the discoverability of data is in the title of datasets and projects. Currently a lot of project specific lingo and abbreviations seem to be used which is hard to understand for an outside person. Synthesis questions as use cases will be helpful in defining best practices for a dataset title (e.g., include years of study, important parameters, geographic location - as appropriate, rather than the title the original investigator used which usually is somewhat idiosyncratic).

**Broader Impact: Education Plan and Accomplishments to Date**

In general, the panel felt the education and outreach efforts had broad reach and were commendable.

Strengths:

Addition of the Education Director to the executive committee, and expansion of the Education/Diversity team with the hiring of a new Diversity Director is seen as a very positive set of steps towards enhancing the educational efforts of C-DEBI.

***Undergraduate training***. The inclusion of the GGURE has added substantially to the undergraduate exposure and training for C-DEBI. This program has clearly focused on diversity of participation, and from all indications has been, and will continue to be, an effective mechanism for exposing undergraduates to science.

CC-RISE continues to increase the number of students involved, and is certainly focusing on a group where real scientific exposure is needed. Recently, it has also expanded effectively from USC to other participating campuses. The GEM course continues to provide undergraduate education and hands-on experience for underrepresented groups.

***Graduate and Postdoctoral Training.*** C-DEBI continues to provide a wide variety of valuable experiences for graduate students and postdocs. These include intense field experience, travel to other sites to do research, various meetings that include people from across C-DEBI institutions and opportunities to present their work to the broader group. Individual discussions between the site visit team, students, and postdocs provided a universally positive view of the environment and leadership, and it was clear that the participants were making good use of the opportunities made available to them.

***Broader Outreach Activities***. Summer camps and other activities both for K-12 students and teachers continue to be provided and represent an important part of the overall educational effort.

Concerns, if any:

Education, Outreach, and Diversity management was previously proposed to involve the hiring of an ExCom member that would oversee both the Education and Diversity Directors. Instead, the Education Director was elevated to a position on the ExCom, with the Diversity Director in a non-equivalent position. The panel notes that this solution may be adequate, but its effectiveness needs to be assessed in the future.

The scientific expanse of the C-DEBI effort spans multiple scales and disciplines. This is a great opportunity to both test approaches to interdisciplinary training and to study the effectiveness of those approaches. While C-DEBI is currently collecting descriptive data through surveys and informal routes, there does not appear to be any formal aspect of normative evaluation to help the program evolve. It is noted that while previous site visits have encouraged engaging expertise available on campus in the area of educational research, this has not yet happened. In Phase II, expansion of the research portfolio dictated a significant decrease in funding allocated to education. It is not clear to the site visit team what the impact of these budget decisions will be on the educational effort.

Recommendations:

This seems like a perfect opportunity to engage faculty who study the educational process, and to involve them in the continued evaluation and development of the graduate and postdoctoral experience. In terms of additional funding for education, C-DEBI is already availing themselves of REU funding opportunities to enhance the education program. They might want to consider additional funding opportunities for graduate education such as the NSF NRT program. Going forward, particularly as the budget in this area has tightened, it critical to ensure that the education and diversity directors are adequately empowered to achieve their objectives.

**Broader Impact: Diversity Plan and Accomplishments to Date**

Strengths:

C-DEBI has made meaningful improvements in diversity in some areas. In particular, targeted summer and undergraduate programs (GGURE, CC-RISE, GEM, C4, and TCP) show promise of fostering interest in STEM among a diverse group of community college students. Wages provided for students allow them to focus on research, while efforts to prevent “transfer shock” among these students may be particularly important in retaining students beyond the program period.

Though some of the numbers of students reached through these efforts are small, the cumulative impact in the field could prove important.

If done properly, the tactic of encouraging fellows to consider broader impacts as part of their professional development activities may similarly provide an opportunity for the next generation of interdisciplinary scientists to adopt an attitude of responsibility and empowerment regarding their own role in improving representation in ocean sciences going forward.

The addition of Leticia Sanchez also stands to put the program on track for additional gains in inclusion. Her stated goal of creating a climate of inclusion, and of helping others to consider diversification as an empowerment activity rather than a service is particularly laudable.

Concerns, if any:

One key area of concern is the decrease in the portion of the budget dedicated to Education and Diversity. It is hoped that this does not signal a decrease in the program’s commitment towards inclusion.

Gains in gender representation are appreciated, however, this alone does not solve problems related to the absence of participation by other large segments of the society. While efforts to improve diversity among C-DEBI-supported undergraduates are notable, successful diversification of graduate, postdoctoral and faculty ranks appears to be largely absent, with important opportunities for such inclusion missed. For example, the re-configuration of the External Advisory Board provided an important chance to diversify the senior scientist ranks. The salient addition of Rina Roy notwithstanding, it is important for C-DEBI to “think outside the box” when it comes to bringing new players to the table - looking for people with the appropriate expertise in bioinformatics, genomics, microbiology, and so forth, without insisting that these players be ocean scientists, per se.

Recommendations:

Adding a person of color to the External Advisory Board is a potential mechanism for improving cross-talk between C-DEBI and the community of minority scientists.

Targeted opportunities through the small grants program may be an effective way to increase the diversity of faculty, graduate students or postdoctoral researchers, and should be strongly considered.

Challenging current faculty to engage with individual students (e.g., by having them volunteer to judge posters at the upcoming SACNAS National Conference in Long Beach) may prove fruitful in increasing the diversity of graduate students into C-DEBI.

Proper targeting of the distribution of educational and outreach materials may be used reach diverse audiences, particularly the public and K-12 students.

**Broader Impact: Partnerships and Knowledge-Transfer Plan and Accomplishments to Date**

C-DEBI is committed to facilitating the transfer of knowledge, expertise, physical resources and new methods and technologies within the STC and across the broader scientific community. Knowledge transfer in the broadest sense here is separated from data management and sharing activities, and focuses primarily on the transfer of knowledge through partnerships, publications, websites and other resources. Additionally, knowledge transfer happens across a variety of programs and C-DEBI activities in the realm of education and outreach, however, here we consider those activities related to education in the separate ‘Education Plan’ section.

Knowledge transfer objectives are articulated in the Phase II renewal proposals and include objectives ranging from publication of scientific results in peer-reviewed journals to developing a presence in social media.

Strengths:

The small grants program is seen as an effective means to develop and encourage new partnerships. 18 graduate and postdoctoral fellowships were active during this reporting period, and almost 65 individuals received funding this year through the C-DEBI grants and fellowships program. These partnerships have created valuable networking and career building opportunities for both graduate students and postdocs (through conferences, participation in field and oceanographic expeditions, and national and international laboratory exchanges and collaborations) and are seen as a strength. Similarly, there is strength in the many partnerships with institutions outside of core funded group. These partnerships also add to the diversity and expertise of participants in C-DEBI.

The group has been active in the development of an impressive array of products outside of the traditional venue of peer-reviewed literature (including sensors, samplers, platforms, laboratory techniques and computer models and software).

The group’s publication record is laudable, with 58 publications, including 48 peer-reviewed journal articles. The group has also been active in the transfer of knowledge in the form of oral presentations with 131 oral or poster presentations at venues ranging from international to local scientific meetings. A bi-monthly newsletter (distributed to over 1000 individuals in nearly 30 countries) highlights the activities of C-DEBI in areas of outreach, publications, meetings and employment.

The group has also been active during 2015 in organizing and participating in basement and sediment workshops that cross research themes, and reports of those workshops are available through the C-DEBI website.

Concerns:

Our main concern regarding the transfer of knowledge outside of the scientific arena (oral presentations and publications) focuses on the need for a clear communication plan to highlight the main audiences, and the means of communication among C-DEBI and these audiences. The renewal proposal describes a plan to broaden the exposure of the general public (and journalists) in the scientific and technical outcomes of C-DEBI. Although the organizational structure of C-DEBI includes both Education and Diversity Directors, we are concerned that there is a need for someone to have a specific focus on communication. This person would be responsible for the development, sharing and overall dissemination of various products and oversight of website content and social media.

Recommendations:

The descriptions, documentation, plans and other links to the developed resources outside of the realm of scientific publications (e.g. descriptions of sensors, lab protocols, software) should be made available through the website as a means of dissemination of the information. This type of information is not always easily accessible nor readily discoverable through the primary literature. These materials could be hosted on the C-DEBI website or made available through links to other sites (e.g. github or others).

**Institutional Support**

Strengths:

There is **continuing strong financial, facilities, and personnel support from USC** in Phase II, including hiring additional faculty members that have natural collaborative opportunities within C-DEBI. The USC administrators, Vice Dean McKenna and Vice President Hall, are aware of diversity challenges and have ongoing plans to address this.

Concerns, if any:

While the commitment from USC is readily apparent, the resources contributed by the home institutions for non-USC senior personnel has yet to be demonstrated. This issue was raised during the previous site visit and has still not been addressed.

Recommendations:

Looking into the future, the **relative contributions of institutional commitment** post NSF funding should begin to be addressed. Since the distributed center involves several member institutions (and more now have been included in Phase II), it would be prudent to procure commitments to the future success of C-DEBI from beyond USC, including financial support for computational resources and diversity hires.

**Value-Added of Center-Mode Operation**

Strengths:

One of the primary sources of added value is in the **synergistic research activities** that arise from the various C-DEBI researchers having a shared mission and a commitment to shared goals. Based on feedback from PIs, students, and postdocs, it was obvious many of the relationships that are vital to the ongoing research successes have occurred specifically because of meetings and other encounters that would not otherwise have happened without the C-DEBI structure. The research directly benefits from the variety of different investigators approaching the same sites and samples with different perspectives and expertise, which, because of the resources required to access these parts of the Earth, would be unlikely to occur outside of a STC framework.

Furthermore, the scope of the research community within C-DEBI provides outstanding opportunities for **interdisciplinary training** among students and postdocs. There are formalized meetings and workshops, along with considerable informal interaction among participants at all levels, that serve to enrich the overall experience of being involved with C-DEBI. A self-referenced “flat hierarchy” enhances participant accessibility to expertise and members at all levels reported excellent inclusivity across career stages. The strength of the center-mode with respect to training is exemplified by highly optimistic student and postdoc attitudes towards career opportunities.

Finally, the **small grants program** run by C-DEBI is seen as a major strength because it 1) Broadens participation among community members beyond the leadership group, 2) Provides access to resources and expertise for participating postdocs and students that would be difficult or impossible to obtain in their home laboratories, 3) Allows C-DEBI to be flexible in pursuing opportunities outside of planned or ongoing research activities. The small grants program is therefore an laudable use of funding that exemplifies the ideal of the center having capabilities that are greater than a group of collaborators working together.

Concerns, if any:

The status and accessibility of **C-DEBI data** from a legacy perspective is a work in progress. There have been advances since the previous site visit, but extended viability of the current strategy is an issue of concern (see, Data Management, above). This is also problematic from the perspective of the value added by center-mode operation because a solution to this widespread issue should be an area where STCs can provide leadership.

Recommendations:

Recommendations regarding the longevity of the data management strategy are addressed in the Data Management section, above.

Based on direct feedback during the panel visit, there is a desire within the C-DEBI participant group to see the **training sessions expanded** to include topics such as project management, budget planning, best personnel practices, mentorship techniques, and team science. Resources for developing team science training:

* Bennett, L. M., H. Gadlin, and S. Levine-Finley. 2010. Collaboration and team science: A field guide. NIH Office of the Ombudsman, Center for Cooperative Resolution.
* Cheruvelil, K. S., P. A. Soranno, K. C. Weathers, P. C. Hanson, S. J. Goring, C. T. Filstrup, and E. K. Read. 2014. Creating and maintaining high-performing collaborative research teams: the importance of diversity and interpersonal skills. Frontiers in Ecology and the Environment 12:31–38.
* M. O’Rourke, S. Crowley, S. D. Eigenbrode, and J. D. Wulfhorst, editors. Enhancing communication and collaboration in interdisciplinary research. First edition. Sage Publications, Thousand Oaks, California.

**Shared Experimental Facilities (if applicable)**

The research facilities accessible to C-DEBI researchers, post-docs, and students provide for cutting edge-research using novel techniques. The students and post-docs describe an informal, welcoming atmosphere that is supportive of access to instrumentation. Additionally the culture that has been established in C-DEBI has allowed for the interdisciplinary training to use techniques as well as communication to address experimental challenges at numerous participating institutions. The panel recommends establishing a link to resources and techniques to further facilitate knowledge transfer (see Knowledge Transfer section for details).

**Signatures (on separate page)**

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**Ajit Subramaniam, 10 February 2016**

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**J. Cameron Thrash, 10 February 2016**

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**Corinna Gries, 10 February 2016**

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**Neale W. Woodbury, 10 February 2016**

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**Karrie A. Weber, 10 February 2016**

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**Tanja Bosak, 10 February 2016**

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###### Lee Anne Martinez, 10 February 2016

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**Carol Anne Blanchette, 10 February 2016**