2016 Arctic Section Committee of Visitors Report

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I. Questions about the quality and effectiveness of the program's use of the merit review process.

1. Are the review methods (panel, ad hoc, site visits) appropriate?
i.1 YES
The COV found the review methods were appropriate. In nearly all proposals that required external review, both *ad hoc* reviews and panel evaluations were used consistently. To the best of our knowledge, our portfolio of proposals contained no projects for which site visits were required.

One of the challenges for the ANS program in particular is the topical breadth of proposals that are received. The COV thought that the decision to have several panels, divided along disciplinary lines, enhanced the quality of the review process. This approach allowed for more focused discussions, more meaningful evaluation, and more insightful panel summaries. We commend the program for making this change and encourage its continued use.

2. Are both merit review criteria addressed in individual reviews, in panel summaries, in program officer review analyses?

i.2 YES, YES, YES

Intellectual merit and broader impacts were consistently addressed in the panel reviews and the review analyses. The same was true in nearly all of the *ad hoc* reviews, with rare exceptions.

While broader impacts were consistently addressed, exactly what constituted a broader impact, and the scale of that impact, varied greatly from one proposal to the next. It is clear that there is an ambiguity in the definition of this criterion, and assessment of impact is challenging.

The variability and ambiguity are an intrinsic part of the NSF's review process and the COV only wishes to make an observation. There is no judgment or criticism implied. That said, if there is concern about the role that broader impacts play in the award process, it might be worth tracking the number of requests that include dedicated funds for broader impacts. This information could be included in the review analyses and would highlight the reality that broadening impact always takes time, and usually takes money.

3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals?

i.3 YES
The COV found that the vast majority of *ad hoc* reviews were substantive, insightful and exhibited engaged critical thinking. In our entire sample, there were only two or three reviews that were cursory or contributed negligibly to the review process.

4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)?

i.4 YES/NO

Strictly speaking, the COV found that the panel summaries did justify their assessments of the proposals. Unfortunately, the justifications were often a simple reiteration of the arguments put forth by the *ad hoc* reviewers. While critical analyses and considered judgment may have occurred during the panel discussions, these summaries give the impression of 'rubber stamp' endorsement of the contents within the *ad hoc* reviews. The COV encourages the program managers to be sure that the panel summary is a summary of the deliberations of the panel, rather than a summary of the *ad hoc* reviews.

To have substantive panel discussions, it is important to have sufficient depth of expertise on the panel. This is the reason the COV was pleased to see panels with disciplinary focus (see i.1 above). With genuinely expert panels and appropriate guidance from the program managers, panel summaries will add value well beyond the *ad hoc* reviews alone.

5. Does the documentation in the jacket provide the rationale for the award/decline decision?

i.5 YES
The documentation in the jackets clearly provides justification for the award/decline decision. In particular, many of the review analyses are thoughtful and insightful accounts of the POs' thought processes, going well beyond summaries of the panels and the *ad hoc* reviews. These detailed analyses are particularly valuable when the *ad hoc* and/or panel reviews contain wide-ranging ratings, or when the PO's decision to approve/deny funding differs from the recommendation of the panel.

In some cases, the POs adopted a format for the review analyses in which they included the backgrounds and specializations of the individual reviewers and the ratings they gave. They paraphrased and analyzed the strengths and weaknesses given by each reviewer and the panel, and then they offered their own judgment with justifications. This structure is very informative and easy to read. The COV commends this practice and encourages all Arctic POs to adopt this format.

Does the documentation to the PI provide the rationale for the award/decline decision?

i.6 YES

In general, the materials provided to the PIs provide sufficient justification for the funding decision. As noted in the 2013 COV report, the COV does feel that the feedback provided to the proposers would be still more valuable if the review analyses, with appropriate redactions, were released as part of the program officer comments. The best of these analyses (described in i.5 above) would provide very valuable guidance to the proposers, particularly if they are new or early career investigators.

Additional comments on the quality and effectiveness of the program's use of the merit review process:

i.7
The COV commends the programs for maintaining a very high standard of peer review. It is clear the program officers have made great efforts to ensure the integrity of the decision-making process, from start to finish.

II. Questions concerning the selection of reviewers.

1. Did the program make use of reviewers having appropriate expertise and/or qualifications?

Yes.

After careful review of the eJacket materials, the COV confirms that reviewers of appropriate expertise and qualifications have been selected by the POs. The COV echoes the 2013 COV in commending the program on thoughtful selection of reviewers, particularly the *ad hoc* reviewers. Several of the programs identified the qualifications and expertise of the *ad hoc* reviewers in the Review Analysis. The COV feels this is quite helpful, and encourages all programs in ARC to adopt this practice, as it lends confidence to the quality of the review process. It was more difficult in general to assess the qualifications of the panelists, and more specifically, the qualifications of the panelists who contributed to the panel summary. The COV suggests that the Program include a similar description for the primary panelist assigned to a proposal, along with the *ad hoc* reviewers in the Review Analysis documentation.

Again, the COV commends the ANS Program for implementing sub-panel reviews as they provide more appropriate disciplinary coverage for proposals, adding value to the review process. The COV agrees that a single panel for ANS proposals would be too broad to provide sufficient expertise.

2. Did the program recognize and resolve conflicts of interest when appropriate?

Yes.

After careful review of the eJacket materials, the COV affirms that the Programs proactively identify potential conflicts of interest prior to and during the review process and deal with them appropriately, including consultation with the NSF Office of the General Counsel when necessary.

3. Additional comments on reviewer selection.

The COV encourages the Program to continue to include early-career investigators and underrepresented groups as part of the review process. The COV appreciates that it is difficult to quantitatively assess the participation of these groups, owing to the self-reported nature of the data, and the COV did not identify an obvious way to do this. Increasing the pipeline of reviewers from these groups benefits both the Program, which receives potentially new and

different points of view during review, as well as the individuals, who gain invaluable insight into the review process and the elements that make for a successful proposal.

III. Questions concerning management of the program under review.

1. Management of the program

Extensive Outyear Commitments and Program Mortgages: Over the three-year time frame covered by this COV, two programs developed extensive outyear commitments that greatly hindered their ability to commit substantial funds to the annual grant competition. It is the opinion of the COV that the Section should adopt a more conservative approach that limits outyear commitments, which safeguards resources to support new research proposals and provides a buffer against unanticipated programmatic cuts.

In 2015, the Arctic Social Science Program released a dear colleague letter (http://www.nsf.gov/pubs/2015/nsf15109/nsf15109.jsp?org=NSF) advising that it would not receive research proposals for the current year, and stating that "...the hiatus period is being used to review and update ASSP priorities...and to lower current out-year funding commitments in order to enhance responsiveness to new ideas." The COV appreciates the need for community planning, and commends the program officer for taking the opportunity to engage in extensive outreach to set new priorities. That said, it is unclear why the program was allowed to develop such an extensive outyear mortgage. Cancellation of a research proposal solicitation is disruptive for researchers that depend on annual funding opportunities, particularly early career scientists who are under pressure to obtain funding in the relatively narrow pre-tenure window.

In a similar vein, in 2015 the AON program did not process approximately 20 proposals submitted in October 2014, because there were very few funds to support new research, again due to extensive outyear commitments. Such events, and the attendant delays in funding decisions, generate uncertainty in the scientific community and once again, have the potential to impact early career scientists.

The COV recognizes that these situations developed during times of change in program staff responsibilities, changes in section management, and staff departures that were beyond the control of the program. The result was imposition of significant workload burdens on remaining staff and delays in the processing of proposals.

Extensive Dwell Times: The COV was advised by AON, ASSP, ANS and ARCSS that the objective for proposal response ("dwell times") was to have 75% of the decisions returned to the proposers within six months of submission. Of the ~160 jackets assigned to the COV, dwell times for ~80% (including those in the EAGER and RAPID categories) did not achieve this objective, which is represented by the horizontal red line in Figure 1. The distribution of the dwell times is bimodal, with approximately half of the decisions taking more than seven months to reach proposers. Unusual circumstances, including a cancelled submission opportunity for ASSP and holding proposals in review for an additional year in AON (see above), were responsible for all but two of the dwell times greater than 365 days (Figure 2).

The COV agreed that timely response on proposals is an important objective for NSF Arctic Science, especially for young investigators who are working to establish their careers. The COV recommends closer tracking of timing and priorities be implemented to:

1. shift dwell time distribution towards 180 days, and
2. remove future long-duration outliers, especially for declined proposals.

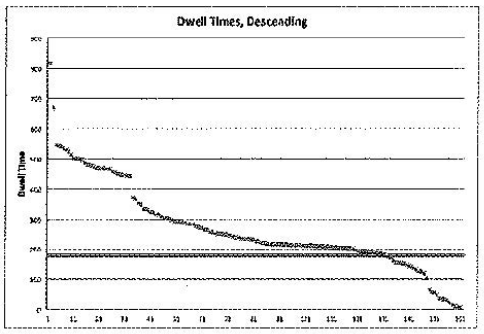

Figure 1. Distribution of dwell time (days) across the proposals evaluated by the 2016 COV. The red lines represents the target 180-day dwell time.

Consideration should be given to holding panel meetings within three months of proposal submission deadlines and to increasing the number of proposal submission opportunities within a calendar year to distribute the programmatic workload associated with evaluating proposals for funding.

ARC Staffing and Workforce Development: The COV unanimously agreed that ARC program staff are enthusiastic supporters of their respective communities and have worked diligently, amidst staff shortages, to serve the community and overall scientific enterprise. To guard against unexpected staff shortages, and to develop the workforce of program officers for NSF's future, the COV suggests that the section consider adding more visiting program staff (IPAs or Temporary Feds), to (a) keep perspectives fresh, (b) assist with workload and unanticipated staff changes (and reduce dwell times), and (c) contribute to the pool of academic scientists with sufficient administrative experience and acculturation to replace NSF staff that are likely to retire over the next 5-10 years.

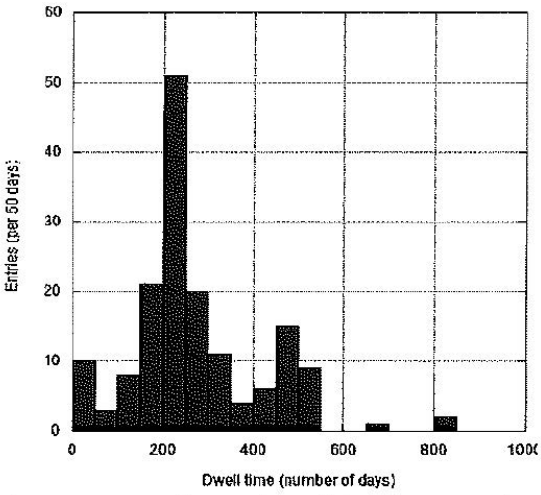

Figure 2. Dwell time (days) for the sample of eJackets reviewed by the 2016 COV.

2. Responsiveness of the program to emerging research and education opportunities.

The COV finds that individual programs and Arctic Sciences overall are responsive to emerging research and education themes. At some level, this is demonstrated by the portfolio of awards that are innovative and at the leading edge of the field, *i.e.*, projects are not funded unless they build on/explore new domains of research. However, programs vary in how explicit they are in identifying emerging research themes and responding to such knowledge through research support. As expressed by the section head, Programs tend to let investigators and the proposal-

review process guide the direction of research, rather than Programs providing top down directives about research direction. Also, there does not appear to be an explicit process whereby Programs accumulate knowledge of emerging research and educational opportunities. Two programs provided examples of activities intended to identify emerging research opportunities/themes. ASSP has recently funded *Arctic Horizons* that is bringing together ~150 scientists and traditional knowledge holders to reassess the goals and priorities of social science research in the far north, through hosting five regional workshops across the U.S. ARCSS has promoted self-organized groups and town-hall meetings to encourage proposals that address high-level thinking about the Arctic system. While the main goal of this effort was to promote the Arctic System Science program to the Arctic scientific community, the gatherings gave the POs insight on emerging research themes.

The COV also noted that Arctic Sciences should take steps to "keep up" with rapid technological changes, to ensure that programs have the opportunity to use cutting edge technology to support the best science possible. Rapidly evolving technology presents a significant challenge to any agency supporting sensor development and acquisition of time-series data. Recognizing the importance of maintaining consistency between time-series measurements, it can nevertheless be both cost-effective and robust to integrate new technology into sensors deployed for longer terms. Timely innovation drives and enhances scientific research.

To address the challenges introduced by the current rapid expansion of technological innovation, the COV again recommends that NSF ARC recruit young scientists into rotator positions. As stated in previous sections of this report, these recruitments will support NSF efforts to train the next generation of program managers, but they can also have the added benefit of organically augmenting the NSF workforce with technophiles who adroitly adapt to rapid changes in technology.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

The COV notes that the mandate of Arctic Section is to support research in a wide range of broadly defined disciplinary areas including oceanography, atmospheric and climate sciences, terrestrial sciences, glaciology and cryosphere sciences, social sciences, long-term Arctic observations, plus the wide range of logistical needs required to support all of these disciplinary areas. We were presented with data and summaries from Staff that were helpful in understanding the range of research that is supported by the Section. However, from the materials supplied it was not clear how POs decided to balance the distribution of funded projects in their respective portfolios. In dialog with Staff we frequently heard that the drivers for programmatic focus arise "from the ground up"; *i.e.*, from members of the research community rather from a top-down, mission-directed perspective. In further dialog with Staff, specifically from ANS, we learned that another important driver is the degree to which there are opportunities for funding from other programs and agencies. For example, DEB in NSF and NGEE in DOE can and do provide support for terrestrial research. But (until recently) NSF ANS and ARCSS were the primary national sources of funding for oceanographic research in the Arctic. Given that oceanographic research is considerably more expensive to conduct than, say, social science research, there are often large differences in allocations of funding to the various core disciplines supported by the section. This is understandable. Also, given that other sources of funding do exist for some disciplines, it is understandable that there are differences in the

number of projects funded within the core disciplines supported by the section. Given the decision to operate the section in response to distribution of projects submitted (*i.e.*, from the ground up), the COV presumes that the distribution of funded projects differs among disciplines but reflects the distribution of submitted projects by discipline.

In the past, ARCSS supported a number of community workshops and forums that generated useful guidance for productive collections of research, for example Human Dimensions of the Arctic System (HARC) and the Freshwater Initiative (FWI). But this type of activity has not been supported recently in this program. The Arctic Social Sciences program funded a similar year of introspection to define future research needs. In general, the COV applauds the fact that the programs of the Arctic section are responsive to good ideas than can originate from anywhere at any time. We suggest that the Section should also include a proactive approach, engaging in dialog with the research community to identify compelling research directions.

3. Responsiveness of the program to previous COV comments and recommendations. 3-4.

In preparing this evaluation, we reviewed the 2013 COV report and the initial plus the updated (2015) responses by the Arctic Section (ARC). This evaluation also includes information provided in presentations and discussions with the ARC staff during the 2016 COV meetings. The sections below provide paraphrased suggestions and recommendations from the 2013 COV (in regular text) followed by the evaluations of the 2016 COV (in italics).

I. Questions about the quality and effectiveness of the program's use of merit review process.

Regarding 1. Are the review methods (for example, panel, ad hoc, site visits) appropriate?

- The Program should periodically review the calendar schedule of proposal submission deadlines and subsequent ad hoc review gathering periods so as to avoid periods when potential ad hoc reviewers are less inclined to provide reviews (e.g., because of field activity, academic calendar activity, etc.)
- The Program should review the effectiveness of the Panels used in the decision making process
- The Committee noted that some panel reports were relatively insubstantial, or would often show little difference from consensus associated with ad hoc reviews.

The 2016 COV notes that in the 2015 updated response ARC reports that they "experimented" with different submission dates and early panel dates. The outcomes of that experimentation are unclear. The last two points are covered in greater detail below, but the 2016 COV notes that panels still have a critical role to play in the review process. Panels should be encouraged to explicitly document in their own words the logic for their recommendations without cutting and pasting unconnected thoughts from individual ad hoc reviewers.

Regarding 2. Are both merit review criteria addressed?
No comment required here. We address the current state of this criterion in the 2016 COV report.

Regarding 3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? The 2013 COV suggested that:

- "unsolicited" reviews be minimized
- Early career scientists should be engaged in ad hoc and panel review processes.

- Panel summaries should be analytical and not simply a "list" of strengths and weaknesses of given proposals gleaned from the ad hoc reviews.
- The strong interdisciplinary nature of the Program and proposals coming to the Program are adequately covered within panel analysis.
- The panel composition should be diverse in disciplinary representation.

In general the 2016 COV finds that ARC has been responsive to these recommendations. Additional efforts should be made to encourage detail and clarity in the panel recommendations, as noted in the next criterion.

Regarding 4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? The 2013 COV suggested that:

- Panel summaries should be analytical and not simply a "list" of strengths and weaknesses of given proposals gleaned from the ad hoc reviews.
- The panel analysis should reiterate the strong interdisciplinary nature of the Program
- Panels should have diverse disciplinary representation
- Where possible, panels should be formed for cohorts of proposals where there is sufficient number

As noted in the 2016 COV report, we think that this is an aspect of the review process that requires additional attention. We do note that there is a tension between depth and breadth in panel composition. One solution is to hold separate, discipline-focused panels that have good sub-disciplinary representation, a model that ANS has used effectively in recent years.

Regarding 5. Does the documentation in the jacket provide the rationale for the award/decline decision?

No comment required here. We address the current state of this criterion in the 2016 COV report.

Regarding 6. Does the documentation to the PI provide the rationale for the award/decline decision?

No comment required here. We address the current state of this criterion in the 2016 COV report.

Regarding 7. Additional comments on the quality and effectiveness of the program's use of merit review process. Several suggestions were made for future statistical compilations:

- More refined breakdown of awards among various types of institutions.
- An analysis of PI award success history
- Consider whether instructions to ad hoc reviewers and panelists for large facilities proposals are adequate.

The 2016 COV notes that ARC has endeavored to capture that data noted in the first two bullet points. We did not explicitly address whether the instructions for review of large facilities had been improved. Although infrequent, these are often large expenditures and so clear guidance is critical.

II. Questions concerning the selection of reviewers.

Regarding 1. Did the program make use of reviewers having appropriate expertise and/or qualifications?

The 2013 COV suggested that ARC should:

- Continue to seek a balance between expert, disciplinary and "broad stroke", interdisciplinary referees
- Have POs comment on their rationale for picking reviewers in their "review analysis"
- Ensure that POs are given resources (e.g., travel opportunities) to keep abreast of the scientific developments in their fields and maintain contact with the research community
- Avoid the use of "virtual" meetings

The 2016 COV notes that ARC POs generally have been responsive in selecting a wide range of experienced reviewers with a good mix of earlier career researchers. We note elsewhere, below, that POs do seem to have more opportunities to attend important meetings than has been the case in the past. We concur with the 2013 COV that "virtual" meetings (webinars) are less personally engaging that in-person meetings. However, this technology is widely used, is convenient, and saves time and money (and is "greener"). Thus, we have less concern about this matter than the 2013 COV. However, we concur that "virtual" meetings should not become a substitute for important, face-to-face meetings with the research community.

Regarding 2. Did the program recognize and resolve conflicts of interest where appropriate?
No comment required here. We address the current state of this criterion in the 2016 COV report.

III. Questions concerning the management of the program under review.
In this section the 2016 COV notes that the 2013 COV provided specific comments, suggestions and recommendations on the previous, 2009 COV and only three programs within ARC (RLS, ARCSS, and AON) there were no comments on ANS or Social Sciences.

Regarding 1. Responsiveness to previous (2009) COV recommendations.
Generally good. However, we note that some matters continue to be considerations today. These include tracking dwell time, target deadlines, and release of a more substantial portion of the review analysis to PIs. These points are addressed in greater detail elsewhere in our report.

Regarding 2. Arctic Research Support and Logistics (RSL) Program
The substantive suggestions seem to have been addressed.

Regarding 3. Arctic System Science (ARCSS) Program
Generally responsive. It remains difficult to articulate to the research community the nuanced differences between the ANS and ARCSS programs. Although clear in the minds of the ARC Staff, confusion remains in the research community.

Regarding 4. Arctic Observing Network (AON) Program
The 2013 COV Committee identified several issues:

- The program is relatively young and suffered from management changes during the ~5 years of its infancy.
- The program has not identified firm "hand off" strategies for established data streams
- The program is funded at a level that is too small compared to other current state-of-the-art observation
- The program does not yet have a recognizable "brand" in the scientific community
- The program's goals are diffuse and uncoordinated.

- the PO appears to be overwhelmed with duties that do not pertain directly to the AON program

The 2016 COV notes that substantial steps have been taken to refocus and reinvigorate the AON program. But much work remains to be done. We expand on this below and in much greater detail on our review of the current state of the AON program, elsewhere in this report.

2013 COV Overview and Recommendations:

- Future COVs should meet in person and not by teleconference or webinar.
- Future COVs should have ready access to ARC Senior and Program Staff during the in-person meeting
- Future COVs should receive meeting material 2-3 weeks in advance of the COV meeting

With one unavoidable exception (RF) the entire 2016 COV was able to meet in person at NSF from 17-19 May 2016. As noted by the 2013 COV, this was invaluable to our deliberations. The availability of e-conferencing facilities allowed us to connect with the remote COV member, though the technology was faulty and stressful for the remote member. The 2016 COV members in attendance felt that we had ready access to Program and Senior staff. Their willingness to talk to us candidly was essential and appreciated. The 2016 COV members received instructions and access to the e-Jacket materials about 2 weeks prior to the meeting in DC at NSF. This advance access was essential to our preparation and greatly appreciated.

2013 Summary of Key Recommendations (and 2016 Evaluations):

2013 COV Recommendation: The Committee recommends that the AON Program be reviewed in detail by the Program and by the program advisory boards (including, e.g., the Polar Research Board of the NRC). While this review is undertaken, the Program is advised to take steps to offload excessive interagency and international coordination activity, or to provide additional support to ensure that this activity does not impact negatively the functioning of the normal proposal processing.

The 2016 COV notes that ARC Senior Staff opted not to engage in this high-level review on the basis that it was critical to address core questions about the scope and management of the AON program. Elsewhere in the 2016 COV review we note that the strides to address these questions have been laudable and the program appears to be headed in a better direction. We also note that the expense of a high-level (NRC) review might not be warranted for a program of this small size. However, this does not obviate the need for some level of external review of the mission, scope and operation of the AON program and resulting network. Elsewhere in this report the 2016 COV notes that a functional AON network is unlikely to self-organize, organically, from ground-up proposals. Rather, it requires a substantial level of strategic direction and planning. This is a different perspective from the other programs that make up the ARC portfolio. For the AON program to be successful, this difference needs to be recognized and addressed. Some form of a high-level, external, strategic planning initiative needs to be mounted to assist the AON PO to identify the rationale and the structure of a functional AON network. This planning needs to include strategies to "hand off" mature data streams to willing partners and to introduce new and better technologies into the observing network in such a way that the value of existing data is not compromised and new data can be collected more efficiently and at lesser cost. We underscore this message elsewhere in our 2016 COV report.

2013 COV Recommendation: The Committee recommends that Arctic Program Officers attend at least two significant Arctic Science meetings per year to keep abreast of emerging results, new faces, new ideas, etc. Interaction between the Program Officers and the scientific community outside of Washington DC will help to energize the Program and allow exchange of perspective that is not always possible within the confines of the NSF offices.
The 2016 COV notes that ARC concurs with this recommendation to the extent that time and budgets allow. It is our observation that ARC POs do attend important meetings and should continue to do so. Attendance at "virtual" meetings (webinars) is less desirable for reasons noted elsewhere in this report, but are nonetheless a popular (and admittedly "greener") way in which we interact as a research community.

IV. Questions about Portfolio

4.1. Does the program portfolio have an appropriate balance of awards across disciplines and sub-disciplines of the activity?

The COV recognizes the challenges that Arctic Sciences Section at NSF faces in selecting an appropriate balance of awards across disciplines and sub-disciplines in each of its programs. In general, the Section recognizes separate disciplines such as Oceanography, Atmospheric Science, Terrestrial Science, Glaciology, and Social/Human dimensions. Each of these disciplines is a separate Directorate at NSF. Even categorizing proposals by discipline is a challenge, such as interactions between tidewater glaciers, bergy bits, and ocean dynamics.

In general, the programs we reviewed have an appropriate balance of awards across disciplines and sub-disciplines. The ARCSS and ASSP programs provided compelling evidence for their strategies to cultivate new ideas and subsequently fund novel proposals in various disciplines and sub-disciplines. By contrast, the ANS strategy is very "bottom-up", and based on the number and quality of proposals that cross their transom. It's worth noting that ANS has received numerous proposals in the disciplines listed above and has developed disciplinary subpanels to provide sufficient depth and expertise that adds value to the panel discussion. We endorse this new development and believe that even with a bottom-up approach, the subpanel decision results in a reasonably equitable distribution of grants across disciplines.

In contrast to the other programs in Arctic Science, the COV finds that AON has struggled with funding an appropriate balance of awards across disciplines and sub-disciplines. The COV concurs with the 2013 COV that the program's goals, and strategy for increasing long-term observation programs amidst a relatively flat budget, remain diffuse. Without a clear articulation of its mission and funding strategy, it is unclear how and why AON selects proposals in the Arctic disciplines. Approximately half of the funding in 2013-2015 went to Oceanography, without a compelling case as to why. Similarly, there were eight awards in Oceanography, but two or fewer in all other disciplines/sub-disciplines (AON COV presentation, slide 5).

The COV supports the Arctic Science program sponsoring an Arctic LTER site. There is potential synergy between AON and LTER that could help both AON and the new LTER site.

4. 2. Are awards appropriate in size and duration for the scope of the projects?

As with 4.1, the size and duration of awards was appropriate for all programs except AON. A good example of appropriate award amount is that of Arctic Social Science, where approximately 45 awards were less than $50K (many social scientists need less funding for research than physical scientists), but large investments were also made, including one award over $1M that supported integrated and multidisciplinary research. Moreover, the COV emphasizes that the vast majority of awards for ARCSS and ANS received full funding, indicating that there are sufficient funds for each of these grants to reach their scientific goals.

In contrast, all awards by AON had reduced funding. The average amount requested was $1,097,829, while the average amount awarded was $709,651, an approximately 36% cut. This raises the question of whether AON is grossly undercapitalized, given its mission. The COV noted that the average award duration was 60 months, which is appropriate for long-term observations.

We concur with the 2013 COV report's statement on the weaknesses of AON, with the update that AON has more challenges now than in 2013. The program has suffered from management difficulties (the current PO inherited outyear commitments of approximately 85% that have strained the ability to fund new proposals). The program is woefully underfunded when compared to other long-term observational programs at NSF such as LTER and CZO.

While it is outside the scope of the COV to make programmatic recommendations, the COV review process has underscored the difficult path that AON has taken and continues to traverse. A current goal is to provide long-term datasets, but there is no long-term funding mechanism. The current grants show little synergy with each other and so the rationale for the disparate data sets is not clear. The COV has the following overarching recommendations for strengthening AON and providing a smoother evolution to a fully functioning network. These include an increase in funding for AON and development of a strategy for targeting the type of datasets collected, including a mechanism for long term funding, where LTER, CZO, and LTREB are reasonable models.

The COV applauds the efforts of the new PO to reinvigorate AON. However, if the suggestions above cannot be implemented, future AON funds may be better utilized elsewhere in Arctic Science.

IV. 3. Does the program include awards for projects that are innovative or potentially transformative?

The COV affirms that all programs in Arctic Sciences encourage and fund projects that are potentially innovative and transformative. POs pointed to several examples in their own portfolios that that fall into this group. The COV encourages programs to continue in these efforts-- that while such projects carry "high risk", they also potentially produce "great rewards", that could contribute to paradigm shifts in the disciplinary and multi-disciplinary research process and to society overall. The COV considered the potential value of developing a metric to gauge the transformative quality of funded research in the Division. Programs can assert that their projects have the potential to be transformative, but is it possible to measure the impact of research projects, at least on the academic community? Simple measures might be the number of articles/books resulting from funded research, but quantity of papers is

probably less relevant than frequency of citations of articles and books that were produced by funded NSF projects.

IV.4. Does the program portfolio include inter- and multi-disciplinary projects?

The Arctic system is complex and past experience clearly suggests that inter-disciplinary and multi-disciplinary research will be required to address these complex systems. The COV finds that the programs in the Arctic Section include a number of inter- and multi-disciplinary projects. The ANS and ARCSS programs each fund projects that typically include 2-3 disciplines and sub-disciplines, with some projects including as many as 6 or 7 sub-disciplines. The Arctic Social Sciences program reports that 22 of 101 projects (22%) were inter- or multi-disciplinary in nature while the AON program reported that 4 of 22 projects (18%) included another sub-discipline and only 1 of 22 (5%) included another major discipline. That the Social Sciences and AON programs support a lower percentage of inter- or multi-disciplinary projects is understandable. The Social Sciences program tends to fund smaller projects that are managed by one or a few closely related PIs who are addressing a fairly focused question. This is not a rule, but a generalization. The AON program is – by definition – focused on the generation of data streams that can be used immediately by the community. While it is likely that an AON project will produce several closely related data streams, it seems less likely that one AON project would produce widely disparate data streams and so the disciplinary focus in this program is expected. In summary, the COV concludes that the program portfolios in the Arctic section include a healthy proportion of inter- and multi-disciplinary projects.

However, the COV notes that there is a relationship between disciplinary diversity and project costs; specifically, multi-disciplinary projects are expensive. Thus, to achieve the level and pace of discovery that is desirable in Arctic research, will require substantial investments; especially given the remote and difficult nature or work in the Arctic. This presents challenges in a programmatic environment in which funds are limited. Either fewer projects can be funded at adequate levels or more projects funded at a lower levels. Neither of these options will allow us to make good progress on "big questions" identified in the policy documents supplied to the COV in the eJacket documents. The COV suggests that the Arctic section needs to consider how to best operationalize strong, integrated projects that require mid-scale funding levels; *i.e.*, more than the funding for typical 1-3 PI standard project but less than large (MRI) projects.

IV 5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators?

Yes, the program has an appropriate geographical distribution of PIs. We say this given that an unusual number of PIs are from Alaska. In addition to Alaska, PIs come from a broad geographical distribution including the southeast, southwest, northeast, mid-west and west.

IV 6. Does the program portfolio have an appropriate balance of awards to different types of institutions?

The majority of awards are made to Carnegie Research Intensive (R1) institutions (doctoral universities with highest research activity), and at least two to R2 institutions (doctoral universities with higher research activity). Among the R1 awards there is a balance to different

types of institutions from the most prestigious Ivy League schools to private and public research universities. There are two awards to an institution not listed as R1, 2, 3. No proposals were submitted from predominately minority colleges and universities.

IV 7. Does the program portfolio have an appropriate balance of awards to new and early-career investigators?

With one exception, the data by program show that the success rates for new and early career proposals are about the same as for proposals from other PIs. Far fewer AON proposals are received from new or early career scientists and AON awards go predominantly to experienced PIs. This pattern is likely related to the administratively intensive job of being a lead AON PI. It makes sense not to burden new and early career PIs with these large administrative loads.

IV 8. Does the program portfolio include projects that integrate research and education?

Integrating education into research can take several forms. Sometimes it involves graduate education, undergraduate education, general public, etc. The COV agrees that the award portfolio contains compelling examples of educational activities that are deeply integrated into research in all of the programs.

IV 9. Does the program portfolio have appropriate participation of underrepresented groups?

NSF does not have the legal authority to require principal investigators or reviewers to provide demographic data. Since provision of such data is voluntary, the demographic data available are incomplete. This may make it difficult to answer this question for small programs. However, experience suggests that even with the limited data available, COVs are able to provide a meaningful response to this question for most programs.

Here we are concentrating on underrepresented minorities. The main issue appears to be the few number of underrepresented minority scientists submitting proposals. Their success rates are comparable to other scientists – except for AON, again because it is a different type of program. Note that there is an award of ~$1 million which funds REUs for underrepresented students.

IV 10. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs?

The COV reviewed the Program portfolio presentations and the extensive list of reports, national priorities, and agency goals and vision statements provided. The COV noted the Section's leadership of the Interagency Arctic Research Policy Committee (IARPC) as well as its role in guiding the IARPC 5-year plan. The COV recognizes that ARC generally is guided by proposals from the community (a bottom-up approach) rather than directing research (a top-down approach) (see also Section 3, Question 3; the community interaction of the ASSP and AON programs is noted). As such, the responsiveness to such guidance could be viewed as circular. However, as noted earlier in this report, the COV encourages the Programs to advocate for input from the research community that then informs strategies like the IARPC 5-year plan, which then guides future research. In reviewing the program solicitations, some Programs could be more proactive in making these connections explicit and are encouraged to do so. POs did

not generally comment on these connections or the role of other reports such as the National Academy of Sciences *Arctic in the Anthropocene* report and the SEARCH research priorities. The COV suggests such connections be described in PO reports to future COVs.