FY 2000

COMMITTEE OF VISITORS REPORT

ON

POLAR SCIENCES

OFFICE OF POLAR PROGRAMS
NATIONAL SCIENCE FOUNDATION

25-27 JULY, 2000

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THE ORGANIZATION OF THE REVIEW BY THE COMMITTEE OF VISITORS

The Committee of Visitors (COV), which reports to the Office of Polar Programs Advisory Committee, met at the National Science Foundation on 25-27 July 2000. Dr. Karl Erb, the Director of the Office of Polar Programs (OPP), charged the COV to address and prepare a report on:

A. Integrity and Efficiency of the Sections' Processes and Management

- *the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions*
- *programmatic priorities within each of the two Sections*

B. Results: Outputs and Outcomes of NSF Investments

- *the quality and significance of the results of the Sections' programmatic investments*
- *the degree to which the award outcomes have met the NSF's GPRA Performance Plan objectives*
- *programmatic balance and future directions within each of the two Sections*

C. Any other issues that the COV feels are relevant to the review.

A review of the OPP is made particularly difficult because this office funds polar projects that cut across the entire spectrum of NSF's scientific and educational activities. A 10-person COV cannot possibly include all of the expertise required for this spectrum. Accordingly, we chose to review the nine specific programs of OPP in the aggregate rather than to attempt a separate evaluation of each program. Some 82 funded and declined jackets, with actions during the relevant three years (1997-1999), were chosen by the simple method of picking every 20th jacket. Additional jackets were pulled for the committee during the meeting (e.g., LTO awards). All nine programs, both Antarctic and Arctic, were represented, but the review did not include Polar Logistics.

SUMMARY OF FINDINGS

The COV was impressed with the progress made since the last COV, especially in the implementation of the logistics program for the Arctic and the addition of permanent staff to the Arctic Section. Overall the program is very effective at using merit review procedures; the documentation of contacts with PI's, of the reviews, and of decisions is superb. At the present time, however, proposers, reviewers and program managers need to pay more attention to

presenting and commenting upon the second review criterion, which takes up "the broader impacts of the proposed activity."

The portfolio of research projects carried by OPP is very good indeed. There are strong projects in every possible field of science and exciting examples of innovation. The Arctic System Science is a model for the entire NSF in how to carry out interdisciplinary research and synthesis.

Some projects, such as the use of the *in situ* ice at the South Pole to detect neutrinos, can only be carried out at the poles. Other projects add to the fund of knowledge of the polar regions and many of these are having an impact on our understanding of global processes such as climate change. However, in order to put together the resources needed to carry out many of the projects the COV reviewed, scientists spent a great deal of time in obtaining other research grants with related goals. It would be much more efficient and effective for NSF to provide adequate funding in the first place. Despite deliberate efforts by OPP, the participation of underrepresented groups is small; this is typical of the whole of NSF.

Overall, the outcomes of the OPP awards are meeting the objectives of the NSF's GPRA Performance Plan. An internationally oriented scientific workforce is making important discoveries that cut across disciplines; these discoveries are being put to societal service. OPP participates effectively in a wide variety of activities and programs within NSF.

Finally, the COV made special mention of directorate-wide planning that promises to be both forward looking and wide-ranging.

A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES & MANAGEMENT

1. Effectiveness of the program's use of merit review procedures:

a. Overall design, including appropriateness of review mechanism (panels, ad hoc reviews, site visits);

b. Effectiveness of program's review process;

c. Efficiency; time to decision;

d. Completeness of documentation making recommendations;

e. Consistency with priorities and criteria stated in the program's solicitations, announcements, and guidelines.

1a. Overall the program is very effective at using merit review procedures. Both panel and mail reviews are used appropriately and the COV encourages making use of both in general. Program managers are sensitive to the needs of the scientific community in the review process. In addition, program managers also need to regularly attend scientific meetings and visit field sites and institutions as a necessary component of the review processes. It is important for OPP to prioritize and financially support these activities.

1b. The review process successfully evaluates quality of prior work, importance of proposed research, and originality of approach.

1c. Reducing the time to decision is a recognized priority of NSF. Over the past three years, OPP has reduced the average dwell time from 7 months in 1997 to 5.7 months in 1999. The program managers are to be commended for their efforts in achieving this reduction. Managers at all levels should ensure that the infrastructure is in place to maintain dwell times of less than 6 months.

1d. Proposal documentation is superb. Files are well organized in a systematic fashion. Program managers do an excellent job of communicating with PI's both verbally and through written comments. We commend the Program's strong commitment to accountability that is demonstrated by the completeness of the documentation provided.

1e. Proposal evaluations are consistent with the priorities and criteria stated in the program's solicitations, announcements, and guidelines. Because of this it is important that these documents clearly highlight OPP and NSF priorities and evaluation criteria.

2. The program's use of the new NSF Merit Review Criteria:

a. The program is successful when reviewers address the elements of both generic review criteria appropriate to the proposal at hand and when program officers take the information provided into account in their decisions on awards.

b. Identify possible reasons for dissatisfaction with NSF's merit review system.

2a. The NSF review criteria were in a transition state during the period covered by the COV review. For the early proposals in this review cycle only the first criterion (intellectual merit) was addressed. This is the traditional criterion for rating the scientific merit of a proposal. By the end of this review period a second criterion was added to the review process. The new, or second, criterion involves "the broader impacts of the proposed activity." We found few of the mail reviews or the panel summaries specifically addressed this second issue. Indeed, even in program manager's comments to awardees and to those proposers who were declined, the second criterion was rarely mentioned.

The COV spent considerable time discussing the second criterion in evaluating proposals. From our discussion, it appears that this criterion is not being addressed by either proposers or reviewers for the following reasons:

- There is ambiguity in interpreting what is asked in criterion 2. Our discussion did not lead to a consensus about what is asked in criterion 2, and because of this, it is not clear how to evaluate activities related to this criterion.
- Proposers do not realize the importance of criterion 2. In the OPP program announcement the evaluation criteria are mentioned on page 13 under directions to reviewers. Similarly, in the NSF general guide to proposal writers, information about the evaluation criteria is mentioned in a rather obscure paragraph on page 8. This is particularly a problem for PI's who have been submitting proposals for a long time, and may not read the guidelines.

Recommendations:

- *To help clarify the intent of criterion 2 and to raise awareness of PI's about its importance, NSF should provide examples of suitable criterion 2 activities and results in progress and final reports.*
- NSF/OPP should highlight both criteria and have them be explicit parts of the form that needs to be filled out by PI's, just as prior support is part of the form. This could be done easily with Fastlane submissions. Reviewers would be more likely to comment on both criteria if they were addressed independently in the proposal.
- Where appropriate, OPP program managers and educational liaisons should help PI's link up with program managers in EHR to assist them in developing meaningful education efforts.
- OPP should continue to request PI's to better highlight and document educational activities.

2b. Overall the COV was impressed with how well the review system works. However, there might be reasons for dissatisfaction because of differences in review procedures -- e.g., some programs have review panels while some rely solely on mail reviews, there are instances of differences in relative ranking between programs, and there are real or perceived conflicts of interest. The key in this area is communication between the PI and program manager. The COV thinks that instructions to PI's should make clear how the review process will proceed and how the outcome was determined.

In cases where a PI has expressed dissatisfaction with the results, NSF has a reconsideration process. In our review of proposals, we found that both formal and informal processes were used. Again the key is communication. Here, it is up to the program manager to clearly explain the reasons for a declination, especially when there is a perceived or real bias. The COV found no instances of bias.

3. Reviewer selection:

a. Use of adequate number for balanced review;
b. Use of reviewers having appropriate expertise/qualifications;
c. Use of reviewers reflecting balance among characteristics such as geography, type of institution, and underrepresented groups;
d. Recognition and resolution of conflicts of interest.

In general reviewer selection was handled extremely well throughout OPP, and was judged to be successful by the COV.

3a. In the randomly selected jackets examined, at least three peer reviews were available, and often the number of reviews significantly exceeded the required minimum of three. Over the 1997-1999 time frame 60% of the solicited mail reviews were obtained, comparable to the overall NSF mean. In the cases where panels were convened, the number of participants was appropriate for covering both the depth and breadth of the subject matter.

3b. OPP program managers have done an outstanding job identifying reviewers of appropriate expertise and qualifications.

3c. The information available to address this question was incomplete. The COV's response is based on reviewing a random sampling of the jackets and compiled statistics for gender, disciplines represented, institutional classification and geographical location. The COV recommends that NSF collect more complete information from reviewers regarding underrepresented groups. One possible mechanism would be to acquire this information via Fastlane in an automated fashion. The data available show that selected reviewers represented a

wide range of geographic locations and institution types. The involvement of the international community in the review process appears to be particularly effective in OPP. The COV considers international reviewers to be highly desirable given the nature of Arctic and Antarctic science. The proportion of female reviewers in OPP appears to be in accord with NSF-wide averages (approximately 15% of the reviews were by women, and a comparable percentage of reviews were solicited from women). Finally, we note that OPP program managers appear to be making a concerted effort to offer underrepresented groups the opportunity to serve as reviewers. However, concern was expressed that the size of the underrepresented community is small and care must be taken to avoid a disproportionate burden upon this community while attempting to entrain it into the system.

3d. OPP program managers appear to be exercising good judgment in their *a priori* selection of reviewers such that percentages of conflicts has been limited to about 3% (the NSF overall average is 2%). In the cases where conflicts were identified, the conflicts were satisfactorily resolved and amply documented.

4. Resulting portfolio of awards:

e. Overall quality of science/engineering;

f. Appropriateness of award scope, size, and duration;

g. Effective identification of and support for emerging opportunities;

h. Appropriate attention to maintaining openness in the system, for example, through the support of new investigators;

i. Evidence that proposers have addressed the integration of research and education in proposals;

j. Evidence of increased numbers of applications from underrepresented groups;

k. Balance of projects characterized as

- *High-risk*
- *Interdisciplinary*
- *Innovative*

4a). The overall quality of science is very good.

4b. The scope of awards, their size, and duration appear reasonable and appropriate. There seem to be no significant outliers. However, in some cases the size of the grant is not adequate for the research proposed. In order to assemble the resources needed to carry out some of the projects the COV reviewed, scientists spent time obtaining other research grants with related goals. Such leveraging and bundling of projects is, unfortunately, not uncommon for polar research at NSF. While the COV applauds the entrepreneurial skill of these scientists, it would be more efficient and effective for NSF to provide adequate funding in the first place. To accomplish this, the average size and duration of grants would have to be significantly increased and the number of

OPP awards decreased assuming no increase in OPP's budget. Clearly this trade-off requires careful thought on the part of OPP.

4c. There appears to be considerable openness on the part of program managers to new ideas and initiatives from investigators, the OAC, and the PRB. ARCSS has made an excellent effort to support new and emerging opportunities. For example, SHEBA involved innovative technologies, cross agency, interdisciplinary, and international cooperation. Innovations included technology for the NOAA very light aircraft and over-wintering a ship in the ice. Another example is the new technology that allows the Antarctic ice to be used as a detector of high-energy particles (e.g., AMANDA" and "IceCube").

4d. OPP pays attention to the openness of the proposal process. There is excellent support for new investigators and the success rate of underrepresented proposers seems appropriate. The program is attracting young scientists and new investigators to both polar regions. One highlight of the efforts to bring in new investigators is the excellent course titled "Integrative Biology and Adaptation of Antarctic Marine Organisms" run at the McMurdo research facility.

4e. Successful proposers often have not addressed education specifically in their proposals. While the COV notes that education of graduate and undergraduate students is a component of most OPP proposals, it often appears only on the budget pages. As noted in section 2a above, more emphasis placed on criterion 2 should encourage proposers, reviewers, and even program managers to highlight achievements in this area.

4f. There is no evidence for increased participation over the last few years by PI's from underrepresented groups. The success rate for those who do apply appears appropriate. However, proposal pressure from underrepresented groups is still low. The COV applauds the use of REU's and SGER's for providing opportunities to and enhancing retention rates of underrepresented groups. Additional site visits by program managers to field sites and home institutions to interact with young scientists might further assist in this endeavor. Support of the Alaska Native Science Commission and Barrow Arctic Science Consortium (BASC, a native organization) is a positive action on the part of OPP to increase involvement of native Americans in polar science. Science educational initiatives supported by OPP that impact underrepresented groups, including Alaska natives, are particularly noteworthy.

4g. OPP successfully funds projects characterized as high-risk, interdisciplinary, and innovative. The Arctic Section, and particularly ARCSS and the Arctic Social Sciences programs, have been especially proactive and innovative in promoting interdisciplinary science and innovative approaches. The ARCSS model should be considered for adoption by the Antarctic Section. Having said that, it is noted that within the Antarctic Section there have been successful multidisciplinary programs in Oceanography, Glaciology, and Atmospheric Sciences. Finally, the COV recommends establishing a conduit for promoting bi-polar research, especially in those

areas where such an approach would lead to unique insights or capitalize on the resources of OPP. Early efforts in this regard have been fruitful and should be expanded beyond instrumentation to intellectual activity.

B. RESULTS: OUTPUTS AND OUTCOMES OF NSF INVESTMENTS

This section is to be based on the COV's study of awardee results that are direct and indirect accomplishments of projects supported by the program *that are currently active or were closed out during the previous three fiscal years.*

NSF investments produce results which appear over time. For each Outcome Goal, the COV should look carefully at and comment on (1) noteworthy achievements of the year based on NSF awards; (2) the ways in which funded projects have collectively affected progress; and (3) expectations for future performance based on the current set of awards.

GPRA OUTCOME: Discoveries at and across the frontier of science and engineering that result from NSF investments.

Goal 1: Performance is successful when NSF awards lead to important discoveries; new knowledge and techniques, both expected and unexpected, within and across traditional disciplinary boundaries; and identification of high potential links across these boundaries.

5. Is the program's performance successful for this outcome?
Provide NSF-supported examples and explain why they are relevant or important for this outcome. If performance is not successful, comment on steps that the program should take to improve performance.

5. This outcome is successful. OPP has excellent program performance in terms of discoveries at and across the frontiers of science and engineering. The breadth and scientific impact of the discoveries are outstanding. Discoveries range from enhancing our understanding of the behavior of the earth system, to cosmological insights, to documenting the biological response of tundra to climate change. Significant discoveries have been made in both disciplinary and interdisciplinary studies. The availability of long-term datasets has contributed directly to major discoveries and the COV encourages the continued support of such projects. Some important recent discoveries are as follows:

- Greenland ice core studies have produced evidence that rapid climate change (8 ^{o}C in less than a decade) has occurred. (9614503)
- Studies at the South Pole measuring the cosmic microwave background radiation left over from the creation of the universe strongly support the model of a geometrically

"flat" universe and provide a hint that structure of the universe may not correspond to presently favored theories. (9729121)

- Sea ice cover of the Arctic Ocean has undergone a major decrease in the past decade as a result of melting and redistribution due to atmospheric circulation changes. (9617343, 9634513, 9728837, 9728825)
- Fossil bones of Hadrosaurs (dinosaurs) and mosasaurs (marine reptiles) were discovered on the Antarctic Peninsula – a finding so exciting it was awarded a share of the "Discovery of the Year" by the Royal Geographic Society of London. (9815231)
- The first modern bathymetric maps of the Arctic Ocean have been completed.
- Investigations of the Antarctic troposphere indicate that the oxidation capacity for sulfur is greater by a factor of 4 to 8 than previously thought; this has led to major changes in our understanding of atmospheric sulfur chemistry. (9809962, 9809164, 9812246, 9725465, 9809162)
- Previously unknown large, ancient volcanic eruptions in the Ross Sea of Antarctic and recent lava flows on the Gakkel ridge in the central Arctic have been identified. (9619251)
- Studies on the accretion ice of Lake Vostok have led to predictions of a large and diverse population of bacteria within the permanently frozen lake itself, and large interdisciplinary studies of Lake Vostok are planned for the near future. These investigations have implications for life on Earth, and serve as models for future interplanetary investigations to places like Europa. (9714339, 9632763, 9820596)

OPP awards have directly resulted in new knowledge and techniques, both expected and unexpected, within and across traditional boundaries including:

- Studies of trace gases and isotopes of oxygen in polar firn and ice that have allowed previously unimagined information on global scale productivity. Quoting Joe Barry in a 1999 Nature News and Views piece, "I do not think even the strongest proponents of these programs foresaw the depth of knowledge about the Earth system that has been gleaned from this investment". (9814634, 9796268, 9615333, 9615292, 9419396)
- Results from the interdisciplinary SHEBA program that indicate that clouds play a greater role in atmospheric warming and melting of sea ice than previously predicted by models. (9702025, 9703127, 9720144, 9701592)
- Discovery of a fish antifreeze gene that links evolution with climate history and showing independent, yet convergent, evolution in response to cooling events in both polar regions. (9615023)
- Tundra regions on the Alaskan North Slope that have switched from a sink to a source of greenhouse gases. The winter production of these gases is surprisingly important. This is an example of a payoff from long term observations. (9318532, 9318529, 9318535, 9318527, 9318531, 9415386, 9318530, 9732105, 9730004)

- New technology that allows the Antarctic ice to be used as detector of high energy particles such as neutrinos. The high tech "AMANDA" and "IceCube" projects are the direct result of a high risk SGER grant awarded by OPP in 1990. (9528559)
- A series of interdisciplinary social and physical studies that have determined that interactions between rapid climate shifts and human settlement and resource use have followed identifiable patterns that can help predict human response to future environmental change. (9515380, 9523529)

GPRA OUTCOME: Connections between discoveries and their use in service to society that result from NSF investments.

Goal 2: The program is successful when the results of NSF awards are rapidly and readily available and feed, as appropriate, into education, policy development, or use by other federal agencies or the private sector.

6. Is the program's performance successful for this outcome?
Provide NSF-supported examples and explain why they are relevant or important to the outcome. If performance is not successful, comment on the steps that the program should take to improve performance.

The performance of OPP under this goal is generally successful. There is, however, room for improvement with respect to the delivery of scientific research results to society, or more specifically, to end-user communities. While acknowledging that meeting the goals set up by criterion 1 remains the overriding goal for OPP, the COV identified a variety of end users of OPP scientific results who will benefit from more attention to criterion 2. Examples include other scientists, policy makers and regulatory agencies, professionals in business and industry, the media and general public, educators, and Native peoples. The following are examples of some ways in which polar research has reached various end-users (note: the balance of examples is tipped somewhat toward the Arctic):

- The number and scope of press releases on polar science is noteworthy, and OPP should be commended for their efforts in reaching the general public through the media.
- OPP programs to directly expose artists, writers, and teachers to polar regions and polar research (e.g., Artists and Writers in Antarctica, and TEA) are proving to be excellent ways to impact the educational process and reach the general public. "Blue Ice: Focus on Antarctica," "Glacier," polar LTER Schoolyard Sites, and the Children's Television Workshop booklet "Antarctica" are other examples of OPP's educational outreach.
- OPP Program Officers traveling to Alaska have met with Native groups and other Alaskan residents to inform them of NSF opportunities.
- OPP researchers are developing instrumentation and techniques including autonomous underwater vehicles and Radarsat, reference standards such as isotopically light water,

and data archives (e.g., ARCSS data products to the University of Colorado) that can be used by other scientists.

- Instrumental records, observations of environmental change, and computer simulations of climate, ocean systems, and ecosystems by NSF-OPP's Arctic System Science program are providing policy makers with improved insights into issues of global warming, and better predictive capability of climate-induced changes in the environment. As one example, the science input to the IPCC has been greatly appreciated and resulted in significant conclusions. For another, OPP is taking a leading role in organizing and supporting an international evaluation of the impacts of global change on the Arctic through ACIA (Arctic Climate Impacts Assessment) a regional IPCC-like assessment. IARPC and the Arctic Research Commission are further examples of policy-level entities and activities in which OPP contributes strongly and plays a societally important role.
- The Arctic Social Sciences program involves frequent collaborations between scientists and Native American communities. Arctic residents participate in the discovery, synthesis, and use of knowledge about their own societies. Examples include the Beringian Yup'ik Heritage project and the Whale Hunting Societies of the Western Arctic project.
- Results from a large, long-term interdisciplinary study in the Arctic have provided a combined assessment of the effects of a predicted global warming, oil development, tourism, and governmental cutbacks on the sustainability of Arctic villages in the range of the Porcupine Caribou Herd.
- Briefings to Alaska Department of Fish and Game, BLM, North Slope Borough, and National Park Service have been appreciated and have resulted in new policy development (including the NSB and ADF&G)

Although as noted, many scientific results are available to feed appropriate end-users, there is little evidence of mechanisms, other than the media, that are used to deliver the information (e.g., through special user workshops, joint task forces and working groups, special publications, and other training activities). Knowledge transfer cannot rely on research publications or random efforts alone. Rather it should be programmatic in nature. Also, there is only modest evidence of effective partnerships between the scientific and end-user communities that might help guide what information is actually needed. One modest success is the informal technology transfer achieved when OPP scientists support U.S. industry as consultants and contractors.

Recommendations:

- OPP needs to better document examples of the transfer of Arctic/Antarctic knowledge to the users of this knowledge in the private economy and government. If little transfer is taking place, then better efforts must be initiated, including scientist/end-user partnerships. NSF-STC programs may have well-developed examples and vehicles that OPP can draw upon. ARCUS may be an appropriate forum to lead these efforts for Arctic knowledge. It is likely that a different type of forum may be needed for this transfer for Antarctic research results.

- OPP should develop a comprehensive policy, based upon input from the OAC, on the digital archival of appropriate science results for both Arctic and Antarctic programs.
- The Polar Information Program is presently serving only the Antarctic section. OPP should apply sustainable resources to both the Arctic and Antarctic sections for outreach to the media.
- Knowledge transfer to non-polar scientists needs to be enhanced. For example, a recent development has been the linking of the SEARCH initiative with the WCRP CLIVAR program.

GPRA OUTCOME: A diverse, globally-oriented workforce of scientists and engineers resulting from NSF investments.

Goal 3: The program is successful when participants in NSF activities experience world-class professional practices in research and education, using modern technologies and incorporating international points of reference; when academia, government, business, and industry recognize their quality; and when the science and engineering workforce shows increased participation of underrepresented groups.

7. Is the program's performance successful for this outcome?

Provide NSF-supported examples and explain why they are relevant or important to the outcome. If performance is not successful, comment on the steps that the program should take to improve performance.

OPP has been very successful in providing world-class professional experiences in research and education. Modern technologies are employed that are often on the cutting edge of those used anywhere, and in many cases lead the nation and the world (e.g., ARCSS). The multidisciplinary, cross cutting nature of OPP has incubated interdisciplinary and innovative approaches to understanding earth system functioning. The challenging polar conditions have encouraged development of state of the art autonomous, remote, and automated instrumentation (e.g., Sky Arrow Flux aircraft, 9604793). However, there is little evidence yet of any significant success in the recruitment of underrepresented groups to the scientific workforce.

The nature of polar research allows participating students and scientists to experience an advanced level of international interaction. This is facilitated by international research programs (e.g., SHEBA, SCICEX, AMANDA, ITASE, JGOFS), organizations (e.g., SCAR, IASC, etc.), and meetings (e.g., Trømso IASC, IUGG Polar Meteorology Section) and OPP support of ARCUS and PRB for international meetings and databases.

OPP has been proactive in training a globally-oriented workforce through its support of TEA (Teachers Experiencing the Antarctic and Arctic), Research Experiences for Undergraduates (REU), and support of graduate student involvement in polar research. These programs have been aggressively promoted by OPP.

OPP has been proactive in involving underrepresented students in research programs through active support for REU supplements, and support of educational activities in K-12, especially in rural and North Slope Alaska. OPP is involved in funding a number of projects and organizations that should result in improved Native American interest in and awareness of the value of science and technology in their lives, and could be expected to lead to an increased involvement of these groups in the scientific workforce. OPP has funded indigenous organizations such as the Alaska Native Science Commission (9979679), Association of Village Council Presidents (9615086), Calista Elders' Council (9909945), and Kodiak Tribal Council (9907099) to conduct research relevant to their lifestyle, and BASC (Barrow Arctic Science Consortium) to provide technical and logistical support in the Barrow region. Other Arctic Social Science Program funded projects, while not awarded to indigenous organizations, have significant involvement of local Native peoples (OPP-9812881 Krupnik; OPP-9806516 Harritt and McCartney). These projects have resulted in partnerships with other NSF funded scientists, and provide a potential for collaboration with both social and natural scientists.

Despite these excellent efforts, there does not yet appear to have been an increased participation of underrepresented groups in the scientific workforce. The overall statistics for women and minorities serving as PI's also do not reveal high involvement. Of the 588 OPP awards made during the period evaluated, only 91 (15%) had women PI's and only 17 (3%) had minority PI's. The reasons for this remain elusive and may include time lags between intervention and effect. However, this complex area may offer a basis for cooperative programs between OPP and EHR.

Formal Education. Several commendable efforts in the realm of formal education have been supported thorough OPP. As one example, OPP supported an EHR GK-12 K-6 project to bring hands-on science education to classrooms in the Barrow and Atqasuk communities. Graduate students are working shoulder to shoulder with elementary teachers to improve inquiry-based science education in K-6 classrooms. The intent is to increase the quality of science education and the number of Alaskan Natives entering careers in science. Alaskan Native undergraduate and graduate students in science are provided an opportunity to travel to San Diego to assist K-8 teachers and students. This will increase the science education in San Diego and provide Alaskan Native science majors and graduate students with increased global experiences. In the Antarctic program, one investigator developed a partnership with high school students around the topic of El Niño-Southern Oscillation (ENSO) and how it affects the climate of the southern ocean. Students learned how to use software such as ArcView GIS and Excel spreadsheets. High school students attended the Spring AGU meeting in Boston and gave talks to middle

school students about El Niño. The education and outreach program for the NSF Center for Astrophysical Research in the Antarctic (CARA) targets African-American students at inner-city high schools in Chicago. Space Explorers Program enhances student abilities before they enter college during a week-long summer institute at Yerkes Observatory. The Space Explorers present programs with astronomers to 30 schools (3,000 students) annually.

International points of reference. Polar science by its very nature should be international. OPP has been a leader in education and in sponsoring international involvement, collaboration, and participation of its scientists and staff. NSF has supported and encouraged participation of its investigators and their students in international and circumpolar activities such as SCAR and IASC. OPP is taking a leading role in organizing and supporting an international evaluation of the impacts of global change on the Arctic through ACIA (Arctic Climate Impacts Assessment) a regional IPCC like assessment. OPP has supported research by its investigators and their students in all polar regions and countries including Russia, Svalbard, Greenland and Canada in the face of often daunting logistics. OPP has provided educational experiences beyond REUs, e.g., study in the UNIS at Svalbard. In the Antarctic, collaborative work between the University of Maine, the Chinese Antarctic Research Expedition, and the State Oceanic Administration of the People's Republic of China studied the biological production and export flux of biogenic material in intermediate and deep-water masses within the Polar Front zone. Perhaps the largest international project in the Antarctic is the Antarctic Muon and Neutrino Detector Array (AMANDA) at the South Pole. At the present time the collaboration includes 111 scientists from 16 institutions in the U.S., Sweden, Germany, and Belgium, and is funded by U.S. and international agencies. In summary, OPP has provided exceptional international, interdisciplinary, multidisciplinary, and multicultural experiences for its investigators and students. This makes the OPP science community one of the most globally aware science communities in the country. OPP should be commended for being proactive in fostering global awareness and encouraged to continue.

Recognition by academia, government, business, and industry. News articles (as evidenced in the 1999 press clippings for SHEBA and the Antarctic) and other media coverage indicate a significant interest in results from the Arctic and Antarctic. The science input to the IPCC has been greatly appreciated and resulted in significant conclusions. Briefings to Alaska Department of Fish and Game, BLM, North Slope Borough, and National Park Service have been appreciated and have resulted in new policy development (including the NSB and ADF&G). OPP scientists have often supported U.S. industry as consultants and contractors, forming an informal technology transfer. OPP researchers are assisting the NSB’s Heritage Museum in updating its informal education on global change in the arctic and in the creation of large outdoor panels and take-home brochures at the Worthington Glacier State Park affecting 1,200 visitors per day.

GPRA OUTCOME: Improved achievement in mathematics and science skills needed by all Americans

Goal 4: The program is successful if NSF awards lead to the development, adoption, adaptation, and implementation of effective models, products, and practices that address the needs of all students; well-trained teachers who implement standards-based approaches in their classrooms; and improved student performance in participating schools and districts.

8. Is the program's performance successful for this outcome?

Provide NSF-supported examples and explain why they are relevant or important to the outcome. If performance is not successful, comment on the steps that the program should take to improve performance.

There are insufficient data to completely evaluate this goal. The COV could not readily locate data on actual effectiveness and widespread adoption of materials that have been produced and activities that have been undertaken. We are aware that cooperative programs between EHR and OPP aimed at large audiences such as TEA and the Glacier programs are undertaking extensive evaluation and publicity efforts. We recommend that the outcome of such joint efforts be summarized by the cognizant OPP program manager for the benefit of future COV's.

To both acknowledge and enhance the success of all education and outreach efforts, it is suggested that:

- OPP encourage and consolidate explicit documentation of project impacts and outcomes, including, for example, feedback from users of educational materials such as compact discs, follow-ups with teachers who have received training, and numbers of schools that have adopted modules.
- OPP foster publicity for educational projects at meetings of professional groups such as the National Science Teachers Association (NSTA), National Association of Geoscience Teachers (NAGT), American Geophysical Union (AGU) and Geological Society of America (GSA). We note that participants in the TEA program are already encouraged and supported to attend NSTA meetings.

The following suggests the types of activities, which, if properly documented, could represent a successful outcome for this goal:

- Eighteen teachers from rural school districts in Alaska representing the five distinct Native cultures will be trained annually in GLOBE program procedures, and will be guided in expanding these studies to include locally significant observations and

traditional knowledge. This has the potential for high impact in Alaskan school districts. The outcomes over the short and long terms should be well documented.

- "Blue Ice: Focus on Antarctica" meets the National Science Education Standards for grades 5-8 in physical science, life science, earth science, science and technology, science in personal and social perspectives, and history and nature of science. The module consists of two concurrent 10-week units in which participants virtually visit Antarctica via the Internet. The California Technology Clearinghouse named "Blue Ice" one of the top ten science education products in May 1998. Documentation needs to be collected about the impact of this activity.
- "Glacier" is a collaborative Antarctic curriculum for grade 8 and involved participants of the highly successful TEA program. The project has piloted an eighth grade supplementary module for the Earth Science curriculum. During three months in 1997 the Glacier site received 300,000 hits with 12,000 unique hosts, but it is not known how many schools formally adopted all or parts of this module.
- Both Arctic and Antarctic sites are part of the Long Term Ecological Research (LTER) Schoolyard program. These sites include Bonanza Creek, McMurdo Dry Valley and Palmer Station. At least six schools (Joy Elementary and West Valley High, Fairbanks, AK, Lakeside School, Seattle, WA, Tuscaloosa Academy, AL, and Santa Barbara and San Diego schools) are participating, as well as museums and aquariums. Again the impact of the program has not been documented.

Several other educational products are under development. In part, this is being accomplished through the efforts of a designated liaison for Arctic Education and Outreach who coordinates with EHR. This collaboration has the potential to be highly effective. For example:

- ACD game on compact disc emphasizing sea-ice and climate is being developed under ARCSS-SHEBA.
- In conjunction with ESIE/EHR, ARCSS is developing "Arctic Connections," an interactive CD ROM to stimulate interest in science among Alaska Native middle-school students.
- "On-Line Expeditions", an interactive Antarctic website has been developed in conjunction with Scholastic Inc.
- "Live from Antarctica 2", a video focusing on peninsula Antarctica was produced in conjunction with PBS and NASA. A website and teachers' guide were developed to accompany the program.

9. For each area of emphasis shown below, do the investments and available results demonstrate the likelihood of strong performance in the future?

Explain and provide NSF-supported examples, which relate to or demonstrate the above outcomes.

The Office of Polar Programs participates in a wide variety of activities and programs within NSF. The results and information available indicate that the OPP participation will result in strong results. Not all of the areas of emphasis mentioned in the report template apply to OPP. Relevant areas are explained below.

Life in Extreme Environments (LExEN) is particularly suited to OPP participation and a total of 13 projects are currently funded. In one project (9713990), OPP-funded researchers have discovered evidence of microscopic life at the South Pole. During the austral summer, bacteria were discovered to be actively metabolizing (synthesizing DNA and protein) at local temperatures of –12 to –17^{o}C. Based upon the strong representation of polar scientists in the LExEN program, and the exciting potential results from the biology of the under-ice Lake Vostok, the COV concludes that there is an excellent likelihood of a strong performance in the future.

Research on global change. The COV notes that research on global change is going on in many parts of OPP. The Arctic System Science program (ARCSS), for one example, is a major program with 30 to 40 awards per year. Its fundamental goal is the description of global change, past and present, and the prediction of the future results of global change on peoples and ecosystems of the Arctic. We believe that this outstanding program is just about the best in global change at NSF in that it includes observations, experiments, analysis, and predictive modeling. The gaps identified in the knowledge through the predictive modeling exercises have resulted in further funding; this interaction of research and modeling adds tremendous strength to ARCSS. Projects funded include SHEBA (ice-atmosphere interactions) and the Arctic Flux Study (material and energy fluxes between land and atmosphere).

Other parts of OPP, such as the program on Antarctic Glaciology, fund several global change-related projects. For example, past climates are being studied through collections of firn air samples and gas enclosed in ice cores (9796268). Antarctic Oceans and Climate Systems helped support 13 projects that made up the Joint Global Ocean flux Study – Southern Ocean Experiment.

Science and Technology Centers: **Integrative Partnerships**; OPP hosts one of the STC's, the Center for Astrophysical Research in Antarctica (CARA), which is dedicated to exploiting the atmospheric conditions at South Pole to do astronomy and cosmology. CARA also has an active program of education and outreach. The core program, Space Explorers, targets African-American students at inner-city high school students in Chicago to enhance their science abilities before they enter college. Thirty students each August attend a week-long summer residential institute at Yerkes Observatory; a 2-day version is given each December. The Space Explorers teach in grammar schools during the academic year. Space Explorers with Adler Planetarium

astronomers present programs using a portable planetarium to 30 schools (3,000 students) annually.

CARA is reaching its sunset under the STC program and the COV knows of no new applications for STC's in polar regions at this time. The interdisciplinary, integrative nature of polar research and its focus on such topics as global change, ice sheet dynamics, air-sea-ice interactions, and extreme environments lends itself to center modes of research. OPP program managers may want to encourage appropriate polar research groups to consider developing STC proposals for the next round of solicitations.

Integrative research and education opportunities at all levels:

CAREER. OPP has one funded project that investigates genetic variations and diversity in a freshwater crustacean, *Bosmina*.

POWRE. There have been two awards in this category but none in 1999. One (9752998) studied the influence of El Nino Southern Oscillation on the Polar Ocean regions. The other (9805909) involved a high-resolution chronology of millennial-scale lake-level fluctuations in the Dry Valleys of Antarctica. The COV endorses strongly OPP's efforts in helping to develop the new program called ADVANCE, which seeks to increase the participation and advancement of women in science and engineering.

Research Experiences for Undergraduates (REU). OPP has supported the REU program despite the high costs of taking undergraduates to the field for research. The number of awards, each of which covers a number of students, was 18 in 1997, 10 in 1998, and 18 in 1999.

Integrative Graduate Education and Research Training (IGERT). Two IGERT projects are associated with OPP. One is on the carbon cycle and the other is on possible life forms outside the Earth.

Graduate teaching fellows in K-12 education. OPP is funding one project (9979741) for a graduate fellow to teach in a school on the North Slope of Alaska.

> *In summary, there has been extensive participation of polar scientists in various activities and programs within NSF. From the evidence reviewed, the COV concludes that the participation has resulted in excellent science and the improvement of education. There is a very good likelihood of strong performance in the future.*

10. Other Issues addressed by the COV

Funding of "non competitive" travel, meetings, supplements and REU's

The previous COV suggested that "future COV's should examine non-competitive funding of travel, meetings, supplements, and REU's". They could not assess how important in a dollar sense such funding was in comparison to the funding of peer-reviewed proposals. They suggested that the balance in size, age, sex and race of reviewed versus non-reviewed funding be examined. Lack of data and time obviated a thorough appraisal of this issue by this COV. While the proportion of funding in this category appears to be small, we were unable to document this quantitatively. This is an instance of the unavailability of aggregated data (e.g., total amount spent on supplements, etc.) requested by the COV during the course of the meeting. It is recommended that NSF improve its networked data handling programs to allow NSF staff – particularly those without specific expertise in programming – to readily access reliable data on proposals and awards. One problem that should be addressed is how to identify a research project that addresses a number of NSF goals. For example, within one OPP project the REU supplement provided a mechanism to include underrepresented groups in research.

Proportion of ARCSS funds awarded to workshops, ARCUS and science management offices

The previous COV suggested that future COV's looking at ARCSS should make a point of looking at grants funding the science management offices (SMO's), ARCUS, and planning meetings.

ARCUS: The budget situation for the Arctic division has changed markedly since the last COV such that a separate logistics program has now been established. Since ARCUS now services the Arctic division beyond just ARCSS, its funding has been shifted to the logistics program. Examination of the jacket revealed that the cooperative agreement with ARCUS was reviewed by external examiners directly after the last COV report and will be reviewed again when the renewal proposal (now for 5 years) is submitted in the near future. At a funding level of approximately one million dollars per year, ARCUS is not an insignificant fraction of the logistics expenditure. The review documents showed that the community values ARCUS services as necessary and well executed. If the renewal proposal is successful, the COV strongly supports continuing review of the annual operating budget by the program officer, and review of performance every three years by external reviewers.

Workshops: The COV commends OPP for establishing a web page where a listing of all OPP workshops, reports and notes on associated activities are available. In this context, the number of workshops conducted in the ARCSS sphere over the past three years does not appear inappropriate or disproportionate. The situation seems a healthy one in that these workshops have expanded community participation and resulted in a number of successful science outcomes. No jackets were examined for workshop support.

SMO's: Several jackets were examined for ARCSS SMO support including both thematic (PALE, LAII, OAII, SEARCH, PARCS/ESH) and project specific (SHEBA, SBI, RAISE) ones. In all cases, the SMO's performed essential functions with defensible budgets. The total support in this category comprised less than 5% of the annual ARCSS operating budget. The SMO funding ramped up and down as the projects/themes were phased in and out as would be expected. The duration of SMO's varied from that anticipated at the outset and renewal was appropriately flexible to account for changed circumstances as the projects evolved. The COV suggests that it may be desirable to evaluate SMO performance at appropriate intervals (project/theme dependent but at least every three years), particularly in the cases where SMO support is being renewed beyond the length of time for which it was initiated. Such independent feedback should be aimed at optimizing SMO function and providing the program manager with information pertinent to continuing funding decisions. As in the case of workshop support, the general health of the research portfolio does not indicate any particular problem with SMO support at present.

OPP Staffing Issues

The previous COV identified the need for permanent science program managers in the Arctic division as one of two pressing issues to address. In the intervening three years, NSF has made substantial improvements in this arena. The number of permanent science management positions has increased from 3 (1 ARCSS, 1 research policy, 1 social scientist) to 7 (now including the division director, 2 ANS and 1 logistics). In addition, a rotating science manager has been assisting with the ARCSS program, and a recent agreement has been made for sharing a rotating Arctic science manager with ONR for a total of 1.5 temporary positions. These changes go a long way toward strengthening OPP's position of world leadership in research and education in both polar regions. To maintain this position, it is important that workload distributions across the directorate be evaluated on an ongoing basis. It is also important to strike a healthy balance between permanent and temporary positions. On this note, the COV recommends that the number of temporary positions in the Arctic division not be decreased. The COV recognizes that a fair assessment of the workload issue involves a wide range of factors, and that our examination of this issue is necessarily incomplete. Nonetheless, it is worthwhile to note the following:

- Based on statistical summaries of the number of proposal actions (reviewed, continuing awards, supplements, contracts and pre-proposals) handled in each of the OPP programs, it appears that ANS handles substantially more per manager than any other program. Furthermore, the ANS portfolio is extraordinarily diverse and could benefit from broadened managerial expertise.
- The COV was not charged with evaluating the Antarctic logistics program and so information was limited. However, the budget to personnel ratio in the Arctic versus Antarctic suggests that there might be cause for reconsideration of logistics staffing.

- There appear to be numerous cross-directorate, cross-NSF activities undertaken by the program mangers. It would be helpful to future COV's, if information on this is presented in some consolidated form.

Long-Term Planning

The COV noted that OPP appears to be carrying out a healthy amount of planning that is both forward looking and wide-ranging. Establishment by the director of in-house retreats to promote communication across the directorate is commended. At present, there seems to be a good balance among future planning activities, the need to respond to new scientific developments, and careful attention to programs at hand. The COV notes that it would be helpful for future COV's to be afforded a comprehensive overview of long-term planning efforts across the directorate.

IARC Funding

The COV notes that a cooperative agreement has been signed to support certain aspects of the International Arctic Research Center (IARC) at the University of Alaska, Fairbanks. Since the IARC budget can be a significant fraction of the Arctic logistics funding, it is recommended that future COV's examine this jacket in the context of the cooperative agreement and comment upon the success of IARC's programs.

The Format of the COV Review

As noted earlier, in this review the jackets of awards and declines for the entire three-years of OPP operation were randomly sampled by pulling every 20th jacket. Because some of the OPP programs had a relatively small number of jackets, this procedure meant that some programs were not well represented in the sample. Some members of the COV would have liked to look at a statistically significant number of jackets from each of the nine programs. One suggestion was to have jackets available representing 10 awards and 20 declines for each program; NSF personnel pointed out that this procedure would result in choosing 270 jackets and would represent nearly all the awards/declines in some small programs and only a fraction of the awards/declines in the larger programs. Another alternative would be to provide a list of awards/declines — with titles, award amounts, etc. — to the COV and let the committee select specific jackets to be read. Before the format for the next COV is decided, these alternatives should be carefully considered and weighed in view of the goals of the COV and of the time limitation of the COV review.

A Review of the Long Term Observatories.

This present COV membership contained so many persons that had submitted proposals to the Long Term Observatory competition that no review of the jackets could be carried out by the committee as a whole. It would be appropriate for the next COV to carry out such a review.

Signatures of COV members: _____

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