NATURAL ENVIRONMENT RESEARCH COUNCIL

EVALUATION REPORT

Responsive Mode

September 2010

Contents

Acknowledgements

NERC would like to thank all those who contributed to this evaluation, including the panel members, the PIs who took the time to respond to requests for information, and the many consultees who gave their time to discuss cases of Responsive Mode's influence on NERC strategy.

INTRODUCTION

1. This report presents the results of an evaluation of the quality and impact of NERC's Responsive Mode (RM)-funded research. RM is one of NERC's three main modes of funding and an important part of NERC's strategy. RM is defined as the funding stream that supports excellent research in response to unsolicited ideas from research groups, consortia or individuals, in any area relevant to NERC's remit. In 2008/09, it comprised 24% of NERC's science budget spend.

2. Responsive mode could be evaluated in many different ways. To identify NERC's current top priority evidence needs relating to RM, key stakeholders (directors, the Science and Innovation Strategy Board) were consulted prior to evaluation design. They identified an urgent need for evidence on two aspects of RM, which became the evaluation objectives:

> **Objective 1. To evaluate the extent to which RM funding delivers excellent research and research outputs through assessing the quality of research and outputs in a sample of RM standard grants.**
>
> **Objective 2. To assess how RM research has influenced NERC's strategy**.

3. They stated that the evidence would be used to:
   - Inform strategic decisions by Council and SISB, and RM policy and practice (e.g. balance of funding, implementation of NERC's RM Action Plan);
   - Provide evidence to market NERC's achievements externally (e.g. for the next Spending Review); and
   - Inform the scope and design of future evaluations of the RM portfolio.

4. The evaluation project was managed by NERC's Evaluation Team, with guidance from a Project Board comprising the customer for the evaluation (NERC Director for Science Delivery Dr Phil Newton, Chair), a representative of NERC Council (Professor Charles Godfray) and a representative of NERC's Science and Innovation Strategy Board (SISB) (Professor Paul Bishop).

Methodology

Objective 1

5. The RM portfolio was too large and diverse to evaluate in one exercise. The scope was therefore narrowed to **standard** and **consortium grants** (as these account for the majority of NERC's RM investment) that started in **2000-2004** (giving time for outputs to have arisen), and that were in the fields of **biodiversity** or **global change** (being areas which are still key to NERC's strategy, and with a large enough number of grants in the time period). After a small number of exclusions for technical reasons or panel members' conflicts of interest, this yielded a sample of 95 biodiversity grants (£22.5m awarded, in total) and 103 global change grants (£23.6m).

6. Two independent panels (one per field) were recruited to evaluate the evidence (see the panel reports' annexes for their Terms of Reference). Each panel comprised five members, whose combined expertise substantially covered the subject areas of the sample grants, and included at least one representative from a relevant user organisation, and at least one international

member. The panels each met over two days to discuss the evidence presented[1], and produced brief reports (Appendices 1 and 2). Amongst their tasks, the panels were asked to grade the sample grants, post-completion, using NERC's α-grading scale.

Objective 2

7. This objective was addressed through consultation and the development of case studies. Key NERC and science community contacts, and the evaluation panels, were asked to identify examples of research that directly influenced a change in NERC's strategy over the years. A small number of changes were then investigated further to produce brief case studies. A brief report was produced (Appendix 3).

Report and use of the report

8. This summary report draws together the evaluation findings, and was drafted by the evaluation manager with advice from the Project Board. The evaluation customer (Director for Science Delivery) will prepare a management response setting out any actions to be taken. The report and management response will be considered by SISB then Council, and published on NERC's website.

[1] Overview evidence on the performance of NERC's RM, plus for each of the sample grants: key grant information, final report, research outputs information, and, where returned, PIs' responses to a questionnaire regarding successes, problems, achievements and outputs.

OBJECTIVE 1: QUALITY OF RESEARCH AND RESEARCH OUTPUTS

Overview

9. This section synthesises and contrasts the findings of the two panels, and is presented in the order of their terms of reference. The findings are included in full at Appendices 1 and 2, each of which has a one-page summary of main findings and conclusions.

10. NERC's RM research in the areas of Biodiversity and Global Change is on a par with, and in many cases at the forefront of, research funded by competitors in the UK and internationally. RM plays a crucial role in laying the foundations for environmental research, career development and maintaining expertise in fields of study while they are not central to NERC's strategic focus, and the generation and development of novel scientific ideas.

ToR 1: The quality and international standing of the research funded, including the outputs and outcomes

The overall quality of this sample of research

11. The panel considering biodiversity grants concluded that NERC's RM research in this area is *"internationally at the very forefront … comparatively at least as good, if not better than, research in other leading countries"*. The global change panel concluded that *"the quality of NERC's RM supported research in the area of global change is on a par with other leading research countries, with some outstanding work that is clearly world-leading"*.

12. This difference in tone was also reflected in the panels' grading of their sample grants, with the biodiversity panel rating almost twice as many of their sample grants as α5 (Table 1). It should, however, be noted that beyond the use of shared definitions, the two panels were operating independently with no shared membership and were applying a novel (for NERC) exercise of retrospective assessment of grants' performance. A degree of caution should therefore be applied when contrasting the panels' conclusions.

Table 1: Sample grant grading (both pre-award, and by the Evaluation Panels)

Grade	Post-completion grading by Panel		
	Panel's definition adapted to post-completion context	Sample Grants (%)	
		Bio-diversity	Global Change
α5	Outstanding, world-leading research, including publications in leading general science journals	28	15
α4	Excellent research pushing the frontiers of the field, good number of publications in internationally competitive/high impact[2] journals	27	29
α3	Competitive science, mostly reported in peer-reviewed journals within the discipline	28	34
α2	Far from the cutting edge, with no or very few papers in peer reviewed journals	11	15
α1	Produced some outputs, but these were generally trivial, and did not significantly advance the field	3	7
β	Had not advanced the field, little to no evidence of published outputs.	2	0

[1]*For the 90 sample grants (the same number) in each panel for which this information was available. Although some of the earliest awarded grants' alpha grades are not known, it is unlikely that any awards were made for grants rated less than α4. Success rates for grant applications, using this evaluation's project's sample grants selection criteria were comparable for both areas during the period 2000 to 2004 (28% in the area of Biodiversity; 29% in Global Change).*

[2]*The biodiversity evaluation panel used the phrase* internationally*; the global change panel used* high impact*.*

13. Although few in number (one amongst the biodiversity sample; four in global change), the Consortium projects in the sample were notable as particularly high achieving in terms of research quality, output productivity, international collaboration and influence on NERC strategy.

The quality of international collaboration, where reported

14. The panels noted that the frequency of international collaboration was low, but neither considered this a cause for concern, as although collaborations were sometimes very fruitful, on other occasions they were disappointing. Both panels found evidence of under-reporting of collaborations, noting that NERC does not request details of collaboration as part of its routine reporting requirements.

'Heroic' and 'dismal' failures

15. The two panels differed in their attitudes toward grants which they deemed to have failed; each panel was asked to consider whether failures had been heroic or dismal, where heroic failure was defined as 'where the research took a different and fruitful direction or was knowingly risky'. For the biodiversity panel, 'dismal' failures fell into the α1 and β grades (5 grants), and lack of success could be attributed to mismanagement within the projects. In contrast, their 'heroic' failures suffered more from unforeseen scientific or technical problems which prevented them achieving cutting edge results. The global change panel were reluctant to qualify underperformance as either 'heroic' or 'dismal', but noted that there were many identifiable reasons; this panel were also of the opinion that NERC had funded some projects in the sample which were flawed in design, risk-averse and/or incremental in nature. Both panels and the Project Management Board felt that NERC should carefully consider what it means by RM success, and make clear that it expects that some RM grants will not succeed for technical or other reasons (i.e., heroic failures). Both panels discussed this issue, and agreed that some failure is to be expected when funding adventurous and risk-taking research.

ToR 2: Highlights, both research achievements and economic and social impact of RM supported research

16. The Panels identified a number of clear highlights in the categories of research achievements, economic/social impact, and public engagement. These are included in the panel reports (Appendices 1 & 2, Annexes C).

ToR 3: The level of interaction between RM supported research and research users, including government and the private sector

17. Both panels were conscious of, and welcomed, NERC and RCUK's enhanced expectations for user engagement by PIs since the time of the sample grants (for example, the current requirement from PIs for 'Pathways to Impact'). PIs had reported variable-to-low details of user engagement, apparently due to a combination of under-reporting and lack of enthusiasm. Nevertheless, both panels identified some instances of excellent examples of user uptake, both nationally and internationally.

ToR 4: The level and quality of public engagement by RM grant holders

18. Reported levels of public engagement were low, especially interaction with schools, although most grants did report some public engagement activity. This outcome was not unexpected by panel members and, as with user engagement, levels could be expected to have increased since the time of the sample grants owing to NERC and RCUK's encouragement and facilitation initiatives. There were examples of successful and high profile user engagement in both sets of grants, including examples of 'citizen science'. Both Panels felt that NERC should continue to encourage public engagement by researchers, but should be wary of making such activity too demanding and to the detriment of research activities.

ToR 5: Cases where the outputs of the sample grants have helped to shape NERC strategy

This topic relates to Objective 2; see Appendix 3 for report.

Proposals

19. The Panels made a number of proposals based on their findings, as summarised below:

ROD & Reporting	Grants Policy / Management	Communication & KE	Strategy & Evaluation	Proposal	Panel (proposal number in brackets)
				NERC should consider ways to improve their collection of performance metrics about RM grants, including: • requiring PIs to complete evaluation questionnaires as a condition of the grant; • asking for additional information through ROD; • encouraging PIs to cite supporting grant numbers in publications, to improve accountability; • asking PIs to provide brief supporting statements when ascribing publications to grants.	Biodiversity (1)
				To improve awareness of researchers' international collaborations, NERC should request details of such activities as part of its reporting requirements.	Global Change (2)
				NERC should consider short-period, end-of-award, funding as a mechanism to allow post-doctoral staff time to prepare manuscripts for publication.	Biodiversity (2)
				NERC should consider providing management skills training for inexperienced PIs and/or all New Investigators, to be undertaken as a condition of the award.	Biodiversity (5)
				NERC should use its influence to try to improve the recognition, credit and sense of responsibility for post-doctoral researchers, to improve their retention and commitment to projects.	Biodiversity (6)
				In order to help inform and guide the grant-awarding process in future, NERC should consider conducting regular systematic comparisons of pre-award and post-reporting alpha gradings.	Global Change (1)

	■			NERC should carefully consider contingency plans for grant holders in the event that NERC facilities fail to deliver as agreed.	Global Change (6)
		■		NERC should consider ways to improve the communication of RM research outputs to research users. This should include ways to encourage the use of open access publishing, and events, meetings and other means of dissemination.	Biodiversity (3)
		■	■	NERC should do more to ensure that Theme Leaders are rapidly provided with details of research outcomes.	Biodiversity (4)
		■		NERC could consider offering post docs and/or graduate students the opportunity to get involved in outreach from a related group of projects.	Biodiversity (8)
		■		NERC should investigate means by which researchers can be encouraged to consider and make suggestions concerning how their work fits into the bigger picture of policy development and private sector uptake.	Global Change (3)
		■	■	The means by which information flows from RM research into the NERC strategy-development process could be improved. NERC should consider how it can better communicate and explain the method(s) by which it develops strategy. Researchers could be encouraged to propose how their work might be significant for strategy development, either as part of their final reporting, and/or through engaging more proactively with the appropriate Theme Leaders.	Global Change (4)
			■	NERC should consider a specific funding stream to support database archiving and monitoring (not hypothesis testing) of long term projects which have a proven track record of producing very high quality science.	Biodiversity (7)
			■	If NERC wishes to increase the influence of RM research on its future strategy, it could consider means by which it could increase the number of Consortium grants it awards (without reducing support for other RM research streams).	Global Change (5)
			■	NERC may wish to investigate the performances of Standard and Consortium grants, and if so should consider undertaking a comparative analysis of the two schemes.	Global Change (7)

OBJECTIVE 2: INFLUENCE ON NERC STRATEGY

Sample Grant PIs' and Evaluation Panels' Findings

A few of the sample grant PIs claimed that their grants had had some influence on NERC strategy, and the global change panel were able to identify specific instances within the sample grants. However, most PIs demonstrated little understanding of how NERC strategy is developed and how they, as RM-funded researchers, could help to steer it. The Panels encouraged NERC to consider means by which RM research outputs can be incorporated into strategy development.

See Appendix 3 for report and case studies.

NATURAL ENVIRONMENT RESEARCH COUNCIL

EVALUATION PANEL REPORT

Responsive Mode Evaluation

Biodiversity Panel Report

May 2010

Report of an independent Panel convened to conduct the evaluation

This document represents the conclusions of an independent Panel of experts. The views expressed are entirely those of the Panel.

MAIN FINDINGS & CONCLUSIONS

Main Findings

Overall: A retrospective analysis of a broad portfolio of sample grants awarded during 2000-04 identified an overall high quality of research in the field of Biodiversity. The Panel concluded that NERC's Responsive Mode biodiversity science is:

- Internationally at the very forefront (28% of the grants outputs and findings were graded α5 on NERC's grading scale);
- Clearly laying the foundations for excellent research in the UK, including areas of strategic focus;
- Comparatively at least as good, if not better than, research in other leading countries.

Outputs: There were an impressive number of publications in Nature, Science and other leading general science journals.

User Engagement: Some very good examples of user engagement and application, but this was variable between workers and could be improved, considering the high rate of potentially influential research outputs.

Public Engagement: Some notable high profile public engagement, but once again highly variable between workers and with room for improvement given the high number of interesting science stories.

Strategy: The research is contributing to the general international pool of knowledge and skills on which NERC's biodiversity strategy is built.

Proposals

Based on their findings, the panel propose the following:

1. NERC should consider ways to improve their collection of performance metrics about RM grants, including (paragraphs 9 & 26):
   a. requiring PIs to complete evaluation questionnaires as a condition of the grant;
   b. asking for additional information through ROD;
   c. encouraging PIs to cite supporting grant numbers in publications, to improve accountability
   d. asking PIs to provide brief supporting statements when ascribing publications to grants.
2. NERC should consider short-period, end-of award, funding as a mechanism to allow post-doctoral staff time to prepare manuscripts for publication (para. 12).
3. NERC should consider ways to improve the communication of RM research outputs to research users. This should include ways to encourage the use of open access publishing, and events, meetings and other means of dissemination (paras. 17 & 18).
4. NERC should do more to ensure that Theme Leaders are rapidly provided with details of research outcomes (para. 25).
5. NERC should consider providing management skills training for inexperienced PIs and/or all New Investigators, to be undertaken as a condition of the award (para. 12).
6. NERC should use its influence to try to improve the recognition, credit and sense of responsibility for post-doctoral researchers, to improve their retention and commitment to projects (para. 12).
7. NERC should consider a specific funding stream to support database archiving and monitoring (not hypothesis testing) of long term projects which have a proven track record of producing very high quality science (para. 4).
8. NERC could consider offering post docs and/or graduate students the opportunity to get involved in outreach from a related group of projects (paras. 19 – 22).

Introduction

1. This document represents the views of a specialist Panel convened in May 2010 to conduct an independent evaluation of a sample of 95 NERC's Responsive Mode grants in the area of biodiversity (Annex A lists Panel members). The Panel was asked to evaluate the quality of the grants and their outputs, and the extent to which the outputs had helped to shape NERC strategy. The sample comprised grants that were funded between 2000 and 2004, totalling an investment of £22.5m. The sample grants were divided between Panel members based on their expertise.

2. The report is organised according to the Panel's Terms of Reference (Annex 2). Note that ToR 2, identifying highlights, and ToR 6, proposing ways to build on successes and to address issues, are covered under each of the other ToR points as appropriate.

ToR 1: Assess the quality and international standing of the research funded, including the outputs and outcomes.

Overview

3. This was a very strong sample of grants, showing that the research supported by NERC responsive mode in the field of biodiversity is:
   - Internationally outstanding science at the forefront of the field;
   - Clearly laying the foundations for excellent research in the UK and included areas of strategic focus
   - Comparatively at least as good, if not better than, research undertaken in other leading countries in Europe, Australia and North America.

4. The portfolio was broad. The sample grants performed particularly well in the fields of applied macroecology, palaeoecology, and social and evolutionary ecology. Grants relating to long-term studies were often very productive, since they built on a foundation of research undertaken over many years - indeed many of these long term studies (meerkats, great tits, Soay sheep, red deer etc.) should be considered National Treasures, and care be taken to archive these data, as well as to ensure continued support. In the same vein, grants that built on previous responsive mode grants were also generally highly productive.

Proposal: To safeguard their future, NERC should consider a specific funding stream to support database archiving and monitoring (not hypothesis testing) of long term projects which have a proven track record of producing very high quality science.

Grading the quality of each grant using NERC's α grading system

5. The Panel was asked to grade the sample grants on the basis of the quality of the research conducted, and they applied a derivation of NERC's grading system for grant proposals. Grants were graded on the basis of the research conducted rather than success at meeting the original objectives. It was necessary to slightly amend the descriptions for each grade to suit the ad-hoc situation. Following detailed discussion of the scale and of grants at either end of the scale, members were confident that they had applied the scale to their set of grants in a comparable way. Table 1 shows the definitions agreed, and the results of the grading exercise.

Table 1: Sample grant grading (both pre-award, and by the Evaluation Panel)

Grade	**Pre-award grading** (for information and comparison)		**Post-completion grading by Panel**	
	Standard NERC pre-award definition	**Sample Grants (%)[1]**	**Post-completion definition agreed by Panel**	**Sample Grants (%)**
α5	Outstanding: exceptional scientific merit and originality; expected to have major scientific impact; top 5%	4	Outstanding, world-leading research, including publications in leading general science journals	28
α4	Excellent: at the forefront of field; will advance understanding; top 25%	96	Excellent research pushing the frontiers of the field, good number of publications in internationally[2] competitive journals	27
α3	Very good: generally competitive science; top 60%		Competitive science, mostly reported in peer-reviewed journals within the discipline	28
α2	Good: quality science, but not leading edge		Far from the cutting edge, with no or very few papers in peer reviewed journals	11
α1	Of merit: modest advance in the field		Produced some outputs, but these were generally trivial, and did not significantly advance the field	3
β	Probably not advancing the field; new, useful knowledge		Had not advanced the field, little to no evidence of published outputs.	2

[1]*For the 90 sample grants for which this information was available. Although some of the earliest awarded grants' alpha grades are not known, it is unlikely that any awards were made for grants rated less than α4.*
[2]*The Global Change evaluation panel used the phrase* high impact *in place of* internationally.

6. The panel made the following comments on the grading results:
   - This was a very strong sample of grants, with some outstanding work, as illustrated by the figures: 28% of grants were in the category defined by NERC as the top 5% internationally; 55% were in the top two.
   - The wide spread of grades, including five grants rated α1 or β, reflects NERC's willingness to invest in adventurous science, with an implicit acceptance of some degree of failure.
   - There was no obvious correlation between the standing of the PI (track record) and the grade awarded, reflecting the influence of the quality of the PDRA and the risky nature of research;
   - A small number of grants scored fairly low in terms of research quality, but had led to significant and important advances in policy.

7. The Panel compared pre-assessment grades with their post-completion grades. Of the four grants which were rated α5 in pre-award assessment, two maintained their grade in retrospect, one dropped to α4, and one to α3.

8. Publications were used as a key and tractable factor in determining the quality of a research grant through its outputs. The sample grants had generated an impressive number of publications in the highest impact journals, both generalist and field-specific. Of particular note were the high number of publications in the top general journals, including:

Table 2 Publications in high impact general science journals

Journal	Number of Publications
Proceedings of the Royal Society B	47
American Naturalist	35
Science	27
Nature	23
Proceedings of the Natural Academy of Science	12
Public Library of Science Biology	11

9. These figures should, however, be interpreted with caution as it was clear that there were several cases of 'double counting' publications, where investigators attributed publications that had a minor, or even non-existent link to the work funded by the grant. In some instances papers were cited even though they had come from another grant by another PI.

Proposal: To improve accountability and reporting, NERC should insist PIs cite supporting grants numbers in their publications and provide very brief supporting statements in reports to NERC. This is routinely done in the US with NIH and NSF.

The overall quality of this sample of research with similar research conducted in other leading research countries

10. As reflected in the high quality grading, NERC's RM Biodiversity grants compared favourably with similar research conducted in other leading research countries, both in terms of the ambition of the proposed science and the quality of outputs. On average the sample grants produced outputs that were on a par with, or above, leading international standards. The best performing grants were considered internationally competitive compared with the UK's research peers. Of particular note, the sample grants pushed the boundaries of existing knowledge to a greater degree than comparable work in the USA, where a greater amount of supporting preparatory work or data is normally required before grant applications are likely to receive funding. The Panel also felt the proposals compared favorably with those that the panel had reviewed from Sweden, Finland, Switzerland, Australia and Italy. There was a notable lack of 'filling-in' or 'padding' type projects in the sample.

The quality of international collaboration, where reported

11. The sample grants provided little in the way of evidence of formal international collaborations, and where these occurred the outcomes were not always successful for a variety of reasons. More evidence of collaboration is evident from shared authorship of publications than is declared in reporting to NERC. It is apparent that some collaborations were occasionally initiated serendipitously, for example derived from personnel moves between labs during and after projects, or were established during grant periods with a view to more formal collaboration in future projects. Collaborations are to be welcomed but recognized as posing certain risks. Two notable examples of successful and fruitful international collaboration were those conducted by Mace and Clutton-Brock.

'Heroic' and 'dismal' failures (heroic - where the research took a different and fruitful direction or was knowingly risky)

12. The five sample grants with retrospective grades of $\alpha 1$ or β had not achieved their objectives to a minimal acceptable standard and were considered to be failures. They all did so for reasons associated with mismanagement (post-doctoral research personnel were the most common factor associated with project underachievement, although at least part of this was PI

mismanagement), and therefore were considered to be 'dismal' failures. While management skills will improve following the massive improvement in training provided to PhD students, NERC should encourage universities to increase their support for the development of management skills in postdoctoral researchers.

Proposal: Short-period end-of award funding should be considered as a mechanism to allow post-doctoral staff time to prepare manuscripts for publication and a relatively low-cost way of improving publication outputs.

Proposal: In order to reduce grants' underperformance due to personnel management problems, NERC should consider providing management skills training for inexperienced PIs and/or all New Investigators, to be undertaken as a condition of the award.

Proposal: NERC should use its influence to try to improve the recognition, credit and sense of responsibility for post-doctoral researchers, in an effort to improve their retention and commitment to projects. In cases where a grant apparently fails because of post doctoral mis-management, some feedback from the post doctoral worker – rather than just the PI - could be informative.

13. The 11 grants graded α2 were considered to have achieved satisfactory results, albeit not at the cutting edge of their field. Although a number had suffered from mismanagement, the majority did not achieve their potential due to unforeseen scientific or technical problems, and were thus categorized as 'heroic' failures.

Research outputs and impacts

14. For summary details of the research and economic impact highlights within the sample grants, see Annex C.

ToR 3: The level of interaction between RM supported research and research users, including government and the private sector

15. In considering user engagement, the Panel was conscious of the fact that this type of activity is now given a much higher priority than at the time the sample grants were awarded. Although the research conducted through the sample grants included much that was of potential use to end users, levels of engagement were highly variable. The majority of grants reported other academics as the only end users. Although it must be acknowledged that much good quality RM research lacks direct and obvious end users, some potentially high impact research showed little to no evidence of user engagement. However there were some excellent achievements where researchers had made significant efforts to engage with end users. This was often where researchers had a pre-existing network of contacts. For government and public sector interaction highlights, see Annex C.

16. NERC's efforts to encourage knowledge exchange activities have been productive and are welcomed. Levels of user engagement would be expected to be higher in more recent grants, as impact has been given a higher priority by NERC in recent years. NERC has engaged well with many users through liaison and collaborations, for example to avoid research effort duplication and through management of partnered research programmes.

17. There remains an ongoing risk of the outputs of RM-funded research not being communicated to end users. A comparative review of the levels of public engagement of RM and RP would be

informative. Relative to RP, RM user engagement activities tend to be low profile. However, RM should not be considered secondary in terms of usefulness to end users. It can be difficult for PIs to keep up with policy developments, and to maintain contacts. NERC is in an ideal position to act as a conduit between its researchers and end users, and should consider means by which RM outputs can be disseminated. This could be, for example, through research area-themed public events or the release of periodic digests summarizing outputs in a format that can be readily accessed by interested users.

18. As a priority, NERC should address the issue of accessibility of research publications, as many potential research users (including NERC itself) do not have access to the traditional scientific media without paying often prohibitively expensive subscription fees. Open Access Publication reaches the widest possible audience, and should be actively promoted by NERC. This should include offering additional funding for paper fees at publication as opposed to time of grant writing; ultimately Research Councils will pay for the publications but this could be done retrospectively rather than at the time of award. Researchers should also be encouraged to make more use of departmental web sites to enhance dissemination and awareness of work being undertaken. Alternatively, NERC could consider expanding NORA to include final manuscript versions of NERC-funded research.

Proposal: NERC should urgently consider ways to improve the communication of RM research outputs to research users. This should include ways to encourage the use of open access publishing, and events, meetings and other means of dissemination to bring information to end users.

ToR 4: The level and quality of public engagement by RM grant holders

19. There were some clear highlights in this section (see table, below), where PIs and their teams had achieved major successes in sharing their research with the public. However, levels of public engagement overall were generally poor, despite there being some good stories to tell. Some projects seemed to have experienced a 'snowball effect' of increasing media attention, but it is not clear whether this is predominantly due to research outputs, publication profiles or the personality and inclination of the researchers involved. As is the case with end-user engagement, it is assumed that public engagement had improved in the years since the sample grants were initiated owing to the higher profile of public engagement, and NERC's efforts to enhance such activities. While the benefits of public engagement are clear, NERC should be careful to avoid making unachievable demands on researchers regarding public engagement. For summary details of the public engagement highlights within the sample grants, see Annex C.

20. Long-term studies of wild populations were notably successful in generating public interest (e.g. the work of Clutton-Brock on meerkat societies). 'Citizen Science', involving the public in a participatory or otherwise interactive manner, is increasingly popular and should be encouraged; some sample grants engaged with the public in this way (e.g. Sutherland).

21. NERC's Communicating Science to the Public training course, and similar courses provided by universities to researchers and students are particularly beneficial in terms of improving researchers' ability to engage with the public, and should continue to be supported. The course should include ways to mitigate the risk of negative media coverage. NERC could consider intensive specialist training of individual researchers as science ambassadors, as is the case through certain fellowship programmes in the USA.

22. Although there was a lack of information and was not considered a prerequisite of grants at the time these were reviewed, it appeared that there had been weak engagement with schools, both directly to children and through their teachers. This is crucial, and should be encouraged more strongly.

Proposal: NERC could consider offering post doctoral researchers and and/or post-graduate students the opportunity to get involved in outreach from a group of projects. This could be an effective and efficient means of improving public engagement for RM projects.

ToR 5: Cases where the outputs of the sample grants have helped to shape NERC strategy

23. To contribute to the evidence base on the value of RM research, the Panel were asked to identify cases where the outputs of sample grants had helped to shape NERC strategy. Although a couple of PIs felt that they had contributed through workshops, few of the responding PIs demonstrated an appreciation of NERC strategy or of the role that their research could, or should, contribute towards determining NERC strategy. PIs generally seemed to feel very distant from NERC strategy and did not see a process that allowed them to link to strategy development boards' deliberations.

24. NERC's strategy for biodiversity is broad and inclusive. While much RM research naturally falls within the strategy, it is NERC's policy that RM grants do not need to be relevant to or contribute to the delivery of the strategy. It was very clear that the research is contributing to the general international pool of biodiversity knowledge and skills on which NERC's biodiversity strategy is built.

25. Theme Leaders should be encouraged to consider carefully and make the best possible use of RM research when helping to develop NERC's strategy. It is therefore imperative that NERC ensures that the Theme Leaders are provided with the maximum possible exposure to RM research and its outcomes.

Proposal: In order to assist its Theme Leaders in making the best possible use of RM research, NERC should do more to ensure that they are provided with details of its outcomes.

Additional comments

26. The Panel was asked to base their discussions on the evidence presented. This was in places patchy, for example public engagement entries to NERC's Research Outputs Database did not contain sufficient detail, and only two thirds of PIs had returned their evaluation questionnaires despite prompting.

Proposal: To improve its ability to measure performance, NERC should consider ways to improve their collection of performance information about RM grants, including requiring PIs to complete evaluation questionnaires as a condition of the grant, and asking for slightly more information through ROD (in particular, details of engagement activities rather than providing tick-box options).

ANNEX A: PANEL MEMBERSHIP

Name	Affiliation
Professor Peter Hudson (Chair)	Director, Huck Institutes of the Life Sciences and Willaman Professor of Biology, Pennsylvania State University
Dr David Gibbons	Head of Conservation Science Department, RSPB
Professor Andy Hector	Associate Professor, Institute of Evolutionary Biology and Environmental Studies, University of Zurich
Dr Mel Kershaw	Programme Manager – Biodiversity Evidence, Natural Environment Science Team, Defra
Professor Ben Sheldon	Director, EGI, Department of Zoology, University of Oxford

ANNEX B: TERMS OF REFERENCE

Purpose

To carry out an independent scientific evaluation of the quality of standard responsive mode grants awarded by NERC between 2000 and 2004 in the area of biodiversity.

Responsibilities

Based on the evidence presented, the Panel is asked to:

1. Assess the quality and international standing of the research funded, including the outputs and outcomes. This should include:
   - Grading the quality of each grant using NERC's α grading system;
   - Comparing the overall quality of this sample of research with similar research conducted in other leading research countries;
   - Considering the quality of international collaboration, where reported; and
   - For grants that did not meet their original objectives, differentiating between 'heroic' and 'dismal' failure (heroic - where the research took a different and fruitful direction or was knowingly risky)

2. Identify highlights, both research achievements and economic and social impact of RM supported research;

3. Comment on the level of interaction between RM supported research and research users, including government and the private sector;

4. Comment on the level and quality of public engagement by RM grant holders;

5. Identify cases where the sample grants have led to changes in NERC's strategy;

6. Suggest ways in which NERC might build on successes and address identified gaps and issues.

ANNEX C: HIGHLIGHTS

Table 1: Science Highlights

Principal Investigator	Title	Comments
Prof TH Clutton-Brock (University of Cambridge)	Intrasexual selection and reproductive strategies in cooperative mammals	Meerkat society and the evolution of co-operative mammals. Very high media profile and influential on the public psyche. An example of the success of long-term projects, and also international collaboration.
Prof L Dolan (John Innes Centre)	Genetic basis of morphological evolution in land plants	A study of long-term plant evolution and a remarkable conservation of genes through time and across plant phyla.
Dr BJ Glover (University of Cambridge)	Dissecting the interaction between pollinator behaviour and a single plant gene controlling floral morphology	Interactions between bees and flowers, and pollination. Resulted in Nature & Science publications, and high profile media coverage.
Prof M Hassell (Imperial College London)	Apparent competition in a metapopulation microcosm	Metapopulation and apparent competition studies. Demonstrated that the metapopulation affects life history strategies. Intriguing, complex and not intuitive, and produced novel statistical methods. They show how connectivity influences persistence. Should have implications for pest management but the reporting doesn't mention this.
Prof CP Kyriacou (University of Leicester)	Population genetics, ecology, and function of clock gene variation in *Drosophila*	Uncovered the functional and ecological genetics of clines in the period gene of fruit flies. A study of remarkable scope, ranging from functional genetics to continental-scale population genetics; from molecular biology to ecology.
Prof GM Mace (Zoological Society of London)	Threatening processes and the conservation status of contemporary mammals	Conservation and biodiversity. Led to successful international collaboration with groups in Germany and the USA, and generated a large number of collaborative, high profile papers, substantial new datasets and methodological approaches.
Prof I Owens (Imperial College London)	Global biodiversity hotspots: evolution, ecology and extinction	Discovered that species richness is not congruent with endemism or threat, and that the distribution of rare or threatened species in different taxa are not congruent. Useful, if challenging, outputs for policymakers and those trying to identify the best areas to target for conservation. High level of international collaboration. Good engagement with the media. World-leading work.
Prof RDM Page (University of Glasgow)	Ancient mariners or recent stowaways? Tempo and mode of evolution of seabird lice	A study of the extensive co-speciation among seabirds (gannets, cormorants etc.) and their lice. World-leading in its field.
Prof G Parker (University of Liverpool)	Evolution of complex life cycle strategies in parasites	An investigation of the driving forces in the evolution of complex life cycles of parasites. May help with parasite control and developments of resistance to drugs.
Prof JM Pemberton (University of Edinburgh)	Quantifying inbreeding depression in the wild	Advances in evolutionary biology though long-term population studies

Principal Investigator	Title	Comments
Dr M Purnell (University of Leicester)	Bridging the gap between ecological and evolutionary timescales: tooth wear, niche differentiation and speciation in living and fossil fishes	Development of a new technique for analysing microscopic tooth wear patterns in fossils, in relation to feeding ecology. The work has since been applied to other taxa and picked up by many other researchers. Of use to fisheries, policymakers and conservation bodies. High impact publications. Short-listed for the Times higher Research Project of the Year award.
Prof AJ Purvis (imperial College London)	Phylogenetic imbalance and species-area relationships : unifying macroevolution with macroecology	Attempts to unify macroevolution and macroecology. Brave and exciting, and meeting with some success, showing that biodiversity depends on geographic area, and can explain phylogenetic imbalance.
Prof DJ Scanlan (University of Warwick)	Molecular ecology and physiological diversity of marine *Synechococcus*	Provided the first data on spatial separation of lineages of marine photosynthetic microbes across large spatial scales in ocean ecosystems and evidence that basin-scale and seasonal variations in vertical stratification provide a basis for understanding large-scale patterns in the distribution of marine microbial communities responsible for CO2 fixation and carbon cycling.
Dr N Wedell (University of Exeter; University of Leeds)	Co-evolutionary interactions between female mating frequency and selfish genetic elements	Uncovered the link between selfish genetic elements and population dynamics in Drosophila.
Prof S West (University of Edinburgh)	Competition between relatives and kin selection	A study which revealed that where there is local competition, relatives evolve lower levels of cooperation (in bacteria). World leading work.
Prof S West (University of Edinburgh)	How does mechanism constrain adaptation?	Reverse engineering sex ratios; fundamental understanding about the interactions between population structure and evolution
Prof GA Wolff (University of Liverpool)	CROZET - Surface water productivity, variability in export flux and deep-sea diversity - how are they linked?	Geoengineering: looking at the uptake of carbon in marine ecosystems and the effect on biodiversity, using natural systems.

Table 2: Economic and Social Impact Highlights

Principal Investigator	Grant title	Comments
Prof AFG Bourke (Institute of Zoology)	Relatedness and information in reproductive conflicts in social groups	The discovery of widespread intra-specific social parasitism by male producing workers in a social insect (cited as a key contribution to life-history evolution in Science Perspective. Has the potential to benefit commercial rearers of bumble bees and have implications in the agricultural sector in relation to changing understanding of pollination and disease transmission of wild bees – but there is no evidence that, as yet, an economic impact has been realised.

Principal Investigator	Grant title	Comments
Prof MD Brasier (University of Oxford)	Critical testing of suggested occurrences of early (3500Ma year old) life	Looking at microtubules in rocks, which are possibly evidence of some of the earliest forms of life. Of interest to space agencies looking for extraterrestrial life. World-leading research, with some good international collaboration. Produced a popular book for a general audience.
Dr T Chapman (University College London; University of East Anglia)	Costing reproduction: resource allocation and molecular signalling in male and female *Drosophila melanogaster* Determining the genetic basis of sexual conflict in *Drosophila melanogaster*: the role of the sex peptide	Studies of sex peptides and sexual conflict, examining how reproductive traits evolve in Drosophila. Male fruit flies produce a sex peptide which reduces female fitness and reproduction rates. Is being studied for potential as a pest control tool. Led to subsequent CASE awards with an industrial partner to investigate possible implications for pest control.
Prof AS Clare (University of Newcastle)	The chemical basis of barnacle settlement: discrimination between species and the evolution of associative settlement	Looking at the chemical cues associated with barnacle settlement. The panel presumed that this work could have important applications re boat fouling.
Prof L Dolan (John Innes Centre)	Genetic basis of morphological evolution in land plants	The only sample grant to report filing a patent, but the details are unknown.
Dr M Purnell (University of Leicester)	Bridging the gap between ecological and evolutionary timescales: tooth wear, niche differentiation and speciation in living and fossil fishes	Development of a new technique for analysing microscopic tooth wear patterns in fossils, in relation to feeding ecology. The work has since been applied to other taxa and picked up by many other researchers. Of potential use to fisheries management and conservation. High impact publications. Short-listed for the Times higher Research Project of the Year award. Has the potential, as yet unrealised, for economic impacts.
Prof DJ Scanlan (University of Warwick)	Molecular ecology and physiological diversity of marine *Synechococcus*	Provided the first data on spatial separation of lineages of marine photosynthetic microbes across large spatial scales in ocean ecosystems and evidence that basin-scale and seasonal variations in vertical stratification provide a basis for understanding large-scale patterns in the distribution of marine microbial communities responsible for CO2 fixation and carbon cycling.
Prof AP Vogler (Imperial College London)	Species-level phylogenies to explain global diversification rates in a lineage of tiger beetles	DNA barcoding of tiger beetles, but applicable to other species for their identification. Possible pest biocontrol applications.

Table 3: Government and Public Sector Impact Highlights

Principal Investigator	Title	Comments – mention who they worked with (the main ones) and what it led to where info exists
Dr S Jenkins (Marine Biological Association)	Biodiversity and ecosystem functioning: tests using rockpools as natural mesocosms	Biodiversity and ecosystem function. Instigated workshops, and a biodiversity action group, amongst other activities; very productive engagement activities
Prof GM Mace (Zoological Society of London)	Threatening processes and the conservation status of contemporary mammals	Conservation and biodiversity. Led to successful international collaboration with groups in Germany and the USA, and generated a large number of shared high profile papers, substantial new datasets and methodological approaches.
Prof WJ Sutherland (University of Cambridge)	Seasonal connectivity in settlement decision of migratory birds	Citizen science: an exceptionally impressive engagement of volunteer birdwatchers, in the UK and many other countries, with rapid feedback of ring resightings as a reward for participants who in return provided essential data about the study population.

Table 4: Public Engagement Highlights

Principal Investigator	Title	Comments
Prof MD Brasier (University of Oxford)	Critical testing of suggested occurrences of early (3500Ma year old) life	Looking at microtubules in rocks, which are possibly evidence of some of the earliest forms of life. Of interest to space agencies looking for extraterrestrial life. World-leading research, with some good international collaboration. Produced a popular book for a general audience.
Prof JM Bullock (NERC Centre for Ecology & Hydrology)	Can Metapopulation Theory describe the Regional Dynamics of Plants	A great deal of user engagement effort, done well. A role model re engagement for other NERC researchers.
Prof TH Clutton-Brock (University of Cambridge)	Intrasexual selection and reproductive strategies in cooperative mammals	Meerkat society and the evolution of co-operative mammals. Very high media profile and influential on the public psyche. An example of the success of long-term projects, and also international collaboration.
Prof I Owens (Imperial College London)	Global biodiversity hotspots: evolution, ecology and extinction	Discovered that species richness is not congruent with endemism or threat, and that the distribution of rare or threatened species in different taxa are not congruent. Useful, if challenging, outputs for policymakers and those trying to identify the best areas to target for conservation. High level of international collaboration. Good engagement with the media. World-leading work.

NATURAL ENVIRONMENT RESEARCH COUNCIL

EVALUATION PANEL REPORT

Responsive Mode Evaluation

Global Change Panel Report

May 2010

Report of an independent Panel convened to conduct the evaluation

This document represents the conclusions of an independent Panel of experts. The views expressed are entirely those of the Panel.

MAIN FINDINGS & CONCLUSIONS

Main Findings

- NERC's responsive mode (RM) is a vitally important source of funding underpinning environmental research in the UK. It plays a crucial role in career development, particularly of early career researchers, and thus also contributes significantly to the generation and development of new ideas. For some areas of environmental research, it remains the major source of UK funding (e.g. areas that are not targeted by directed research programmes or industry funding).
- The quality of NERC's RM supported research in the area of global change is on a par with other leading research countries, with some outstanding work that is clearly world-leading.
- The consortium grants stood out as particularly high achievers in terms of research quality, output productivity, international collaboration and influence on NERC's strategy.
- The sample did not include some of the best research being undertaken in the UK in this area at the time. This may partly be due to availability of alternative NERC directed research programmes in this area at the time, and the availability of funding from other organisations.
- It was evident from the reporting that NERC strategy, policy development, or the private sector uptake of outputs was not a priority for most of the RM sample grant holders. RM is seen typically as unfettered and adventurous blue-skies research with the goal of enhancing knowledge or understanding and so may, or may not, lead to direct application in the future. NERC needs to be conscious of this when placing expectations of engagement.
- The outputs of some of the grants had contributed to the evolution of NERC strategy.

Proposals

1. In order to help inform and guide the grant-awarding process in future, NERC should consider conducting regular systematic comparisons of pre-award and post-reporting alpha gradings (paragraph 16).
2. To improve awareness of researchers' international collaborations, NERC should request details of such activities as part of its reporting requirements (para. 10).
3. NERC should investigate means by which researchers can be encouraged to consider and make suggestions concerning how their work fits into the bigger picture of policy development and private sector uptake (para. 18).
4. The means by which information flows from RM research into the NERC strategy-development process could be improved. NERC should consider how it can better communicate and explain the method(s) by which it develops strategy. Researchers could be encouraged to propose how their work might be significant for strategy development, either as part of their final reporting, and/or through engaging more proactively with the appropriate Theme Leaders (para. 21).
5. If NERC wishes to increase the influence of RM research on its future strategy, it could consider means by which it could increase the number of Consortium grants it awards (without reducing support for other RM research streams) (para. 6).
6. NERC should carefully consider contingency plans for grant holders in the event that NERC facilities fail to deliver as agreed (para. 13).
7. NERC may wish to investigate the performances of Standard and Consortium grants, and if so should consider undertaking a comparative analysis of the two schemes (para. 23).

Introduction

1. This document sets out the views of a specialist Panel convened in May 2010 to conduct an independent evaluation of a sample of NERC's Responsive Mode grants in the area of global change (Annex A lists Panel members). The Panel was asked to evaluate the quality of the grants and their outputs, and the extent to which the outputs had helped to shape NERC strategy. The sample comprised 103 grants that were funded between 2000 and 2004, totalling an investment of £23.6m. The sample grants were divided between Panel members based on their expertise.

2. The report is organised according to the Panel's Terms of Reference (ToR) (Annex B). Note that ToR 2, identifying highlights, and ToR 6, proposing ways to build on successes and to address issues, are covered under each of the other ToR points as appropriate.

ToR 1: The quality and international standing of the research funded, including the outputs and outcomes.

Overview

3. The Panel's overall conclusions regarding the quality of the Global Change research portfolio (i.e. the sample grants that were made available to the Panel) were that:
   - The quality of the portfolio was on a par with leading international competitors, including the USA and leading European states;
   - The highest achieving research was world leading;
   - The portfolio did not include some of the best research being undertaken in the UK in this area at the time.

4. The 'global change' research portfolio was extremely broad. The sample performed particularly strongly in the areas of atmospheric chemistry, biogeochemistry, glacier and ice sheet dynamics, deep Earth dynamics, geochemical fluxes and satellite-based remote sensing.

Grading the quality of each grant using NERC's α grading system

5. The Panel was asked to grade the sample grants on the basis of the quality of the research conducted, using NERC's grading system for grant proposals. Grants were assessed on the basis of the research that was actually conducted rather than success at meeting the original objectives. The Panel used the revised scale that had been defined by the Biodiversity Evaluation Panel, as shown below. Following discussion of the scale and of the merits of grants at either end, members were confident that they had applied the scale to their set of grants consistently. Table 1 shows the post-hoc alpha definitions agreed, and the results of the Panel's grading exercise.

Table 1: Sample grant grading (both pre-award, and by the Evaluation Panel)

Grade	**Pre-award grading** (for information and comparison)		**Post-completion grading by Panel**	
	Standard NERC pre-award definition	**Sample Grants (%)[1]**	**Post-completion definition agreed by Panel**	**Sample Grants (%)**
α5	Outstanding: exceptional scientific merit and originality; expected to have major scientific impact; top 5%	9	Outstanding, world-leading research, including publications in leading general science journals	15
α4	Excellent: at the forefront of field; will advance understanding; top 25%	91	Excellent research pushing the frontiers of the field, good number of publications in high impact[2] competitive journals	29
α3	Very good: generally competitive science; top 60%		Competitive science, mostly reported in peer-reviewed journals within the discipline	34
α2	Good: quality science, but not leading edge		Far from the cutting edge, with no or very few papers in peer reviewed journals	15
α1	Of merit: modest advance in the field		Produced some outputs, but these were generally trivial, and did not significantly advance the field	7
β	Probably not advancing the field; new, useful knowledge		Had not advanced the field, little to no evidence of published outputs.	0

[1]*For the 90 sample grants for which this information was available. Although some of the earliest awarded grants' alpha grades are not known, it is unlikely that any awards were made for grants rated less than α4.*
[2]*The Biodiversity evaluation panel used the phrase* internationally *in place of* high impact*.*

6. The Panel made the following comments on the grading results:
   - This was a good sample of grants, with some outstanding work included, as illustrated by the retrospective assessments by the Panel: 15% of grants were put in the category α5, defined as "world-leading"; 44% were in the top two alpha grades. The proportion of α5 grades had increased significantly compared to the pre-award assessment. Annex C lists research highlights that were identified by the Panel.
   - The Panel found the systematic comparison of pre-award and post-reporting rankings to be novel, interesting and of potential value for informing and guiding the peer-review and award-granting process in the future.
   - The four Consortium grants in the sample performed particularly well, being more highly rated on average than the Standard grants, and typically having more substantial international relevance and more influence on NERC strategy.

Proposal: In order to help inform and guide the grant-awarding process in future, NERC should consider conducting regular systematic comparisons of pre-award and post-reporting alpha gradings.

7. The Panel compared the pre-award α5 rated grants with their retrospective (post-reporting) assessments. Of the eight grants rated α5 in pre-award assessment, two maintained their grade,

and two each dropped to α4, α3 and α2. Overall, the post-reporting (retrospective) ranking was noticeably lower than the pre-award ranking. Possible reasons for this are discussed below.

8. Although of a good standard on average, the Panel considered that the portfolio did not include some of the very best research being undertaken in the UK in this area at the time, and nor were all of the global change-relevant science areas that the Panel would have expected to find represented. This is likely to be partly due to the volume of research being supported through NERC's directed Research Programmes at the time, and the availability of funding from other sources (at least for some areas covered by the portfolio). A few of the projects were judged to have been uninspiring in concept, leading some members of the Panel to suggest that NERC could do more to attract and/or support the more innovative and adventurous, or even 'left field', research projects.

The overall quality of this sample of research compared with similar research conducted in other leading research countries

9. The sample grants were judged to be broadly competitive compared with similar research conducted in other leading research countries, in terms of the quality of both research and outputs. The best performing grants were world-leading in their fields, but there was also evidence of mediocrity, particularly some in the area of palaeoclimate research. Notable areas of strength included: atmospheric chemistry, biogeochemistry, marine biology and oceanography, glacier and ice sheet dynamics, deep Earth dynamics, geochemical cycles and satellite-based remote sensing.

The quality of international collaboration, where reported

10. There were a few outstanding examples of international collaboration, where researchers had worked closely with, and gained considerable added value through working with other leading international teams (highlights listed at Annex C). However, the majority of sample grants reported little in the way of international collaboration. While this could partly be explained by under-reporting (NERC does not specifically ask for information on international collaborations), it may reflect the UK focus of some parts of the community, and a reluctance amongst some to apply for international funding due to the perceived bureaucratic burden.

Proposal: To enhance its awareness of researchers' international activities, NERC should request details of such collaborations as part of its standard reporting requirements.

'Heroic' and 'dismal' failures (and reasons for under-performance)

11. The Panel were reluctant to apply the categories of 'heroic' and 'dismal' failure, being of the opinion that failure cannot be qualified.

12. NERC could perhaps expect a measure of underperformance or even failure of some of its funded projects, if it is committed to funding adventurous and risk-taking research. However, based on the evidence available from this portfolio, the Panel did not conclude that cases of under-performance were due, primarily, to inherent scientific challenges. Notably, there were several examples of projects that encountered unexpected difficulties and where efforts were redirected successfully.

13. Due to lack of information, it was often difficult to judge why a grant failed or under-performed. In some cases, problems stemmed partly or entirely from issues with NERC services and facilities, particularly delays. A small number of the projects appeared to have

been flawed in design from the outset, and so may reflect, also, a deficiency at the time of peer-review or the award process. In other cases, the project's performance problems may have been due to over-ambition at the proposal-writing stage, personnel issues, or mismanagement.

Proposal: NERC should consider establishing contingency plans for grant holders in the event that NERC facilities fail to deliver as agreed.

Research outputs and impacts

14. The grading results were generally influenced by the publications reported by PIs. The journals in which the sample grant results were published most frequently were good, appropriate, and in many cases represented the leading high impact journals in the field. The publication figures provided by the PIs should, however, be interpreted with caution, as there were several cases identified where investigators appear to have reported publications that had only a minor, or even non-existent link to the work actually funded by the grant.

15. NERC's RM funding and the prestige it brings clearly plays a vital role in career development, particularly for early career researchers, and thus also contributes significantly to the generation and development of new ideas.

ToR 3: The level of interaction between RM supported research and research users, including government and the private sector

16. PIs reported few interactions with potential or actual users, although there were a few clear highlights (see Annex C). Generally, there seemed to be a lack of interest in pursuing or reporting this, reflected by the fact that Panel members were aware of some instances of user uptake both in the UK and internationally (for example, contributions to the IPCC) that had not been reported by the PIs. It is acknowledged that general awareness of the importance of identifying economic and other impacts has increased considerably since these sample grants were awarded.

17. RM grant recipients, in general, may not be as interested in NERC strategy, policy development and private sector uptake of research results as NERC would like them to be. Notwithstanding the considerable pressures on NERC to deliver valuable solutions for society, RM grant holders typically view their projects as unfettered, adventurous research that might, but might not, result in valuable applications or breakthroughs. Arguably, this is consistent with the philosophy of RM funding.

18. The Panel firmly supports the contention that RM research should not have an expectation of policy or private sector impact, and is wary of increasing pressures on researchers to identify or promise such impacts for their RM projects. Nevertheless, the Panel agreed that NERC has a role both to improve researchers' awareness of how their work can influence policy, and to facilitate the exchange of knowledge between researchers and research users. NERC is applauded for its existing mechanisms such as the excellent Planet Earth publication, but is encouraged to consider how this exchange can be further strengthened for RM research.

Proposal: NERC should work to strengthen both RM researchers' awareness of how their work can influence policy, and the exchange of knowledge between RM researchers and research users, without putting the "blue-skies" nature of RM at risk.

ToR 4: The level and quality of public engagement by RM grant holders

19. The level of public engagement reported by the sample grants was lower than desirable, but close to what the Panel would have expected based on their experience of researchers' typical participation in such activity. There were some clear highlights where PIs and their teams had put considerable effort into engaging with the public (see Annex C). Most grants undertook some form of public engagement but there was no clear evidence of general enthusiasm amongst the PIs for such activities. NERC's efforts to encourage public engagement are welcomed, and it is acknowledged that in the period since the sample grants were awarded, engagement activities are likely to have increased.

20. Universities have varying levels of skill and commitment to public engagement and NERC is neither in a good position, nor resourced sufficiently, to organize public engagement for projects as diverse and numerous as those funded under RM. Nevertheless, NERC should consider means by which it, or RCUK, could better assist its sponsored researchers and their host institutes in publicizing the outcomes of RM research. Such activity should not, however, be funded to the detriment of research.

Proposal: In order to improve the level of public engagement, NERC should consider means by which it, or RCUK, could better assist its sponsored researchers and their host institutes in publicizing the outcomes of RM research.

ToR 5: Cases where the outputs of the sample grants have helped to shape NERC strategy

21. A few PIs felt that their work may have directly or indirectly affected NERC strategy, including influencing NERC's partnership with the Met Office, and contributing to the design and scope of new Research Programmes (see Annex C). The consortium grants had been particularly influential. However, the Panel was surprised that so few researchers had considered how their work could influence, or has influenced, NERC strategy. Some PIs stated that they were unaware of how NERC strategy was developed. NERC's thematic approach to strategy is welcomed as enhancing the opportunities for researchers to influence NERC's strategy. NERC should, however, consider ways to strengthen awareness concerning the influence that RM-supported research can have on its strategy.

Proposal: NERC should consider how it can further encourage RM-supported scientists to engage with and influence its strategy development. When inviting the final report, PIs could, for example, be invited to engage with Theme Leaders if they wish to influence NERC's strategy development.

Additional comments

22. The Panel was asked to base its discussions on the evidence presented. This was patchy in places, for example entries to NERC's Research Outputs Database did not always contain sufficient detail to allow informed judgement of performance, and only two thirds of PIs returned their evaluation questionnaires, despite prompting.

23. A retrospective evaluation such as this would benefit from periodic repetition in order to track trends and the effects of changing funding policies, over time. It would also be valuable to explore ways of assessing value for money, for example when comparing the standard and consortium grant schemes.

ANNEX A: PANEL MEMBERSHIP

Name	Affiliation
Professor Doug Wallace (Chair)	Professor of Marine Chemistry, Leibniz Institute for Marine Science (IFM-GEOMAR), Marine Biogeochemistry & Chemical Oceanography
Professor Philip Allen	Chair in Earth Science, Department of Earth Science and Engineering, Imperial College London
Professor Erland Källén	Head of Research, European Centre for Medium-Range Weather Forecasts
Professor John Lee	Emeritus Professor, Department of Animal and Plant Sciences, University of Sheffield
Dr Chris Sear	Head of Climate Science, Climate and Energy, Science and Analysis, DECC

ANNEX B: TERMS OF REFERENCE

Purpose

To carry out an independent scientific evaluation of the quality of standard responsive mode grants awarded by NERC between 2000 and 2004 in the area of global change.

Responsibilities

Based on the evidence presented, the Panel is asked to:

1. Assess the quality and international standing of the research funded, including the outputs and outcomes. This should include:
- Grading the quality of each grant using NERC's α grading system;
- Comparing the overall quality of this sample of research with similar research conducted in other leading research countries;
- Considering the quality of international collaboration, where reported; and
- For grants that did not meet their original objectives, differentiating between 'heroic' and 'dismal' failure (heroic - where the research took a different and fruitful direction or was knowingly risky)

2. Identify highlights, both research achievements and economic and social impact of RM supported research;

3. Comment on the level of interaction between RM supported research and research users, including government and the private sector;

4. Comment on the level and quality of public engagement by RM grant holders;

5. Identify cases where the sample grants have led to changes in NERC's strategy;

6. Suggest ways in which NERC might build on successes and address identified gaps and issues.

ANNEX C: HIGHLIGHTS

Table 1. Science.Highlights

Principal Investigator	Title	Comments
Professor MJ Bickle (University of Cambridge)	Unravelling the Ca isotope curve: shoring up global budgets and identifying responses to long- and short-term climatic perturbations.	This project studied the isotopic ratio of dissolved Ca in seawater based on measurements in marine carbonate, which reveals perturbations to the global calcium cycle caused by climatic impacts on weathering. Innovative work which established new methodology and published high impact papers establishing a new Ca isotope record for the last 15 Ma.
Professor MJ Bickle (University of Cambridge)	Weathering inputs in Himalayan flood plains and the oceanic Sr flux from Himalayan rivers.	This work established the investigating team as world leaders in riverine hydrochemistry. Determined the sources of Sr contributing to the high 87Sr/86Sr ratios of rivers flowing into the Indian Ocean by quantifying floodplain processes. The results are critical to the interpretation of climatic drivers for the strontium isotope composition of marine carbonates - commonly used as a chemical weathering proxy. Follow-up funding followed, and the project developed close collaborations with Indian scientists and undertook significant outreach (including a summer school).
Professor MJ Collins (University of York)	Palaeoproteomics: a revolution in ancient biomolecular studies?	This grant led to a novel method for the identification of bone and bone fragments, with potentially great importance to archaeology. Good international co-operation with a group in Copenhagen extended the investigation. Applications of the techniques developed are of interest to Defra and, the Food Standards Authority the Central Science Laboratories. Excellent public engagement activities, including featuring on BBC TV.
Professor R Geider (University of Essex)	Assessing limitation of photosynthesis and nitrogen fixation by N, P and Fe in the tropical North Atlantic.	Provided the first evidence for airborne Saharan dust enabling oceanic nitrogen fixation. High impact publications resulted from the work.
Professor LJ Gray (University of Reading)	The Role of the Stratosphere in Climate Change Atmospheric teleconnections with the tropical stratosphere	Very influential projects that have helped the Hadley Centre to develop new climate models; outputs core to climate science.
Professor D Gubbins (University of Leeds)	Deep Earth System - understanding composition, chemistry & dynamics of the deep Earth through an interdisciplinary study of core-mantle & inner-outer core interfaces	This consortium project produced a fundamental improvement of knowledge of core-mantle and inner-outer core dynamics. A very large number of papers resulted, comprising an authoritative body of work, and the collaborating groups won several prizes.

Principal Investigator	Title	Comments
Professor DE Heard (University of Leeds)	The North Atlantic marine boundary layer experiment (NAMBLEX).	The NAMBLEX consortium led to a remarkable scientific output, including a number of papers detailing a range of important new findings. The project was multidisciplinary in character and involved a good level of international collaboration. Directly influenced NERC strategy, and may have contributed to the UK thematic programme SOLAS. There were policy-relevant aspects to the project based on improvements to the Master Chemical Mechanism policy tool.
Professor DP Mattey (Royal Holloway)	Greenhouse-icehouse transitions: testing the use of oxygen isotopes in associated mammal tooth phosphate and freshwater carbonate as an Eocene-Oligocene climate proxy	
Professor P Moore (Newcastle University)	Derivation of ocean bottom pressure and land hydrological signals from satellite gravity measurements.	The project developed a new model for satellite-based gravity measurement, and generated many outputs and papers. Good collaborations used and follow-up activity.
Dr DJ Parker (University of Leeds)	African Monsoon Multidisciplinary Analyses - UK (AMMA-UK).	A very successful (consortium) project, with an impressive list of publications with a good citation rate. Clear evidence of influencing policymakers and government departments (Defra, DfID, Met Office, WMO and EA), if not NERC strategy. Appreciable follow-on through NERC and EU grant support. Much evidence of public engagement.
Professor AJ Payne (University of Bristol)	Pine Island Glacier flow and dynamics.	A leading project which helped provide the next generation of ice dynamics models. Influenced the IPCC reports and led directly to the major European initiative Ice2Sea.
Professor O Phillips (University of Leeds)	Changing Tropical Forest Dynamics: a critical evaluation of physical, chemical and biological drivers.	Big impacts for a relatively low investment. Some high impact publications and follow-on funding. Also participated in to international collaborations.
Professor JMC Plane (UEA)	Photoelectric emission from mesospheric ice particles.	A very successful project examining mesospheric noctilucent clouds and their climate influence through the radiation balance. Very good to excellent publications.
Professor J Scourse (Bangor University)	Sequencing ocean-ice-climate interaction in the North East Atlantic.	Produced a high number of papers and resulted in follow-up projects. Influenced NERC's strategy.
Professor MJ Siegert (University of Bristol)	Calculation of ice accumulation rates in Antarctica over the last glacial cycle.	Similar reasons to Payne, 61
Professor JM Slingo (University of Reading)	Indian Ocean variability and its role in the global climate.	
Professor JM Slingo (University of Reading)	UK-HIGEM: a national programme in 'Grand Challenge' high resolution modelling of the global environment.	Instrumental in the development of the latest Earth system models. Led to very important international collaborations

Principal Investigator	Title	Comments
Professor J Tennyson (UCL)	Absorption by water at near infrared and visible wavelengths.	Tennyson's projects have performed very well in an important area of research, contributing to our knowledge of climate change through radiation modelling in climate models. Very high impact and high quality application-orientated basic research.
Professor J Tennyson (UCL)	Calculated absorption by water vapour at near infrared and optical wavelengths.	
Dr CH Wellman (University of Sheffield)	Development of a novel palaeo-proxy for terrestrial solar ultraviolet-B fluxes.	Influential publications, leading the field.

Table 2. Economic and Social Impact Highlights

Principal Investigator	Grant title	Comments
Professor PJ Clarke (Newcastle University)	Elastic and inelastic ocean tide loading response in the British Isles from long-term GPS observations.	Results from this and follow-on work contributed significantly to the development of UK industry guidelines for the use of network real time kinematic (RTK) GPS, developed by Newcastle University for The Survey Association (in conjunction with RICS, Ordnance Survey, and two of the major equipment manufacturers)
Professor MJ Collins (University of York)	Palaeoproteomics: a revolution in ancient biomolecular studies?	A procedure to detect animal-specific bone fragments in food and animal feed has been picked up by Defra, the FSA and CSA, and others. The work has led to follow-on CASE funding.
Professor R Geider (University of Essex)	Assessing limitation of photosynthesis and nitrogen fixation by N, P and Fe in the tropical North Atlantic.	Fisheries management should benefit from an improved understanding of nutrient loading and ocean fertilisation.
Professor AJ Goddard (Imperial College)	Large-scale ocean circulation modelling: studying the influence of topography using a new three-dimensional finite element model.	Collaboration with companies such as BP and Fujitsu.
Professor AP Jephcoat (University of Oxford)	Partitioning of noble gases and siderophile elements between Fe-rich alloys and silicates at ultrahigh pressures and temperatures.	Research was pure and non-applied, though there is considerable materials science potential based on the methods developed. The role of "Extreme Conditions" work sponsored here by NERC is transferred directly to the national interest through Jephcoat's presence at Diamond Light Source Ltd., and Principal Scientist at the Extreme Conditions beamline for which substantial government resources are allocated through the Spending Reviews
Dr DJ Parker (University of Leeds)	African Monsoon Multidisciplinary Analyses - UK (AMMA-UK).	Economic impacts should have arisen through the numerous policy effects the project has led to (with Defra, DfID, EA, WMO, EU etc.)

Professor JMC Plane (University of Leeds)	Calcium Chemistry in the Upper Atmosphere.	The results have been used by an SME, Lidar Technology, as the basis for a proposal to ESA to build a space-borne lidar.
Professor JM Slingo (University of Reading)	Indian Ocean variability and its role in the global climate.	Will be of economic benefit to the Indian subcontinent through improving understanding of the South Asian monsoon.
Professor J Tennyson (UCL)	Absorption by water at near infrared and visible wavelengths.	Tennyson's projects have performed very well in an important area of research, contributing to our knowledge of climate change through radiation modelling in climate models. Very high impact and high quality application-orientated basic research.

Table 3. Government and Public Sector Impact Highlights

Principal Investigator	Title	Comments
Professor HL Bryden University of Southampton)	Meridional overturning in the Indian Ocean.	This grant produced results concerning ocean circulation and water mass property changes that represent world-leading research, as evidenced by the large number of publications in top journals that resulted. The PIs made a genuine attempt to support interdisciplinary activities on their research cruise. There was useful international collaboration, and the work has been cited in the IPCC 4th Assessment report.
Professor AJ Payne (University of Bristol)	Pine Island Glacier flow and dynamics.	A leading project which helped provide the next generation of ice dynamics models. Influenced the IPCC reports and led directly to the major European initiative Ice2Sea.
Professor P Pearson (Cardiff University)	Paleoclimatic study of cored intervals of major environmental change, Tanzania.	On publication of Nature paper, the PI was asked to present a briefing lecture at the Welsh Assembly Government on climate change prior to the Copenhagen climate summit. He has also been nominated by DECC to be a lead author on the UN-Intergovernmental Panel on Climate Change. This work was among the science he listed as relevant publications.

Table 4. Public Engagement Highlights

Principal Investigator	Title	Comments
Professor G Foulger (Durham University)	The Iceland HOTSPOT Project Phase 2: structure and flow in the plume beneath Iceland	A controversial study which has challenged existing paradigms regarding mantle plumes. An exemplary record of outreach and communication (including books, websites, countless media items), backed up by a very high level of publication in top journals.

Dr DJ Parker (University of Leeds)	African Monsoon Multidisciplinary Analyses - UK (AMMA-UK).	A very successful (consortium) project, with an impressive list of publications with a good citation rate. Clear evidence of influencing policymakers and government departments (Defra, DfID, Met Office, WMO and EA), if not NERC strategy. Appreciable follow-on through NERC and EU grant support. Much evidence of public engagement.

Table 5. Influences on strategy

Principal Investigator	Title	Comments
Dr R Baxter (Durham University)	Climate, snow and hydrology in tundra ecosystems interactions, feedbacks and scaling issues.	This grant involved international collaboration and led to good publications in strong journals. It influenced the Norwegian Meteorological Office Numerical Weather Predictor, and has had some influence on NERC's arctic research priorities.
Dr LJ Carpenter (University of York)	Global marine sources of reactive halogen species.	This grant, along with others, contributed to prioritisation of research towards the UK-SOLAS programme, which included a specific call on reactive halogens.
Professor TW Choularton (The University of Manchester)	Investigation of the effects of Aerosol on mixed phase cloud at an alpine mountain site.	Influenced CEH Strategy
Professor AJ Payne (University of Bristol)	Pine Island Glacier flow and dynamics.	A leading project which helped provide the next generation of ice dynamics models. Influenced the IPCC reports and led directly to the major European initiative Ice2Sea. The work has had some influence on NERC policy and its focus within recent theme actions on icesheet-ocean interactions.
Professor JM Slingo (University of Reading)	Indian Ocean variability and its role in the global climate. The role of an interactive upper ocean in determining tropical variability on diurnal to intraseasonal timescales. UK-HIGEM: a national programme in 'Grand Challenge' high resolution modelling of the global environment.	These grants led to the Joint Climate and Weather Programme

NATURAL ENVIRONMENT RESEARCH COUNCIL

EVALUATION REPORT

Responsive Mode Evaluation

Objective 2 Report

Impacts of Responsive Mode on NERC Strategy

September 2010

Summary

24. There is little doubt within the community that the outputs of Responsive Mode (RM) research influence NERC strategy. However, establishing causal links between grants and specific elements of strategy is difficult, owing to the complex path of research progression and its varied sources of funding, and the processes of strategy development itself. Nevertheless, examples where the outputs of RM-funded research have contributed to NERC's strategy can be identified, and the results have been significant. RM is valued by the strategy development community as pioneering, capacity building, and as an essential complement to NERC's strategically-driven research.

Introduction

25. This document described the findings of Objective 2 of the Responsive Mode (RM) Evaluation: *to assess how RM research outputs have helped to influence the development of NERC strategy*. It comprises a brief summary of the results of a consultation process, and a number of appended case study examples.

Methodology

26. The many interacting factors involved in strategy development make it difficult to separate the influences systematically. With advice from the Project Board and the Chair of SISB, it was decided to consult key individuals involved in strategy development, and to prepare a number of case studies illustrating key examples of influential RM research based on the suggestions.
27. Initially, consultees were asked whether they could identify one, or a group of, RM grants, the outputs of which had resulted in changes to NERC strategy. After consultation with the project board, it was decided to focus on cases where the outputs had influenced strategy at the *challenge* level or above.
28. A broad range of consultees were approached, including:
    - Theme Leaders;
    - Science and Innovation Managers (SIMs);
    - Chairs of the theme strategy development panels;
    - Science and Innovation Strategy Board (SISB) members;
    - Council members from the academic community;
    - The current and former Chief Executive;
    - The Chairs of the last Peer Review Committees; and
    - The two Objective 1 Panels

Overview of responses

29. An overwhelming majority of respondents stressed the importance of RM in NERC's portfolio of activities and agreed with the notion that RM work feeds in to the development of NERC's strategy. The primary mechanisms by which RM influences NERC strategy are:
    - NERC-supported research contributes to the general worldwide intellectual melting pot. Changes to NERC strategy then come in reaction to this overall progress, not as a result of particular grants;
    - The training and development of skilled individuals, and maintaining a research capability in all areas of science within NERC's remit. This enables rapid reaction to

emerging areas of strategic need and maintains strategic flexibility. Skilled individuals contribute to strategy development through helping to identify priorities; and
- Funding exploratory and innovative research in new areas, in the process creating and helping to identify new strategic priorities.

30. Most of the respondents found it difficult to identify specific cases of RM research which had influenced NERC's strategy at the challenge level. The question concerned some respondents, e.g.: *"it is very naïve to think that RM support leads to impacts in a simple direct or linear way, and I hope that NERC will not make such a simplistic analysis"*. A few were sceptical that the question could be answered: *"the problem is that science emerges in very diffuse forms – at meetings, in the literature and in formal and informal discussions … I'm unable to point to what was RM funded versus other funding streams", and: "because science is so interdependent I wonder whether the question you ask can be answered at all – a successful RM project will have an impact on the scientific community which may influence NERC strategy down the line but by then the project in general will be only one of many influences in the field"*.

RM influences on the development of NERC strategy

31. The majority of potential cases identified by respondents were at the level of strategy implementation, e.g. where a grant or grants had influenced the scope of a Research Programme. After consultation with the Project Board and Chair of SISB, the Evaluation team focussed on the small number of suggestions where a grant or grants had influenced one or more of the strategy challenges. Leading examples were developed into case studies (table below; Appendices A to D). Further suggestions could be developed into case studies if considered a priority.

Case	Research Area	Lead & institution	Strategic influence
1.	Polar ice sheet mass balance	Prof Duncan Wingham, UCL	Fundamentally altered the way that NERC and other agencies conduct monitoring of the polar regions.
2	Solar Terrestrial Physics (Space Weather)	Prof Jo Haigh; Imperial College	Led to specific challenges in NERC's 2002-2007 strategy due to new insights into the influence of solar radiation on the Earth's climate.
3	IronEx / SOIREE (marine iron fertilization experiments)	Prof Andrew Watson, UEA	NERC redressed its appreciation of the role of biogeochemistry in the Earth system. Helped to demonstrate the efficiency of the multi-institution consortium model for research projects.
4	Montserrat's Soufrière Hills Volcano (SHV) studies	Various volcanologists and collaborating disciplines	RM funding has enabled the exploitation of the SHV event to advance and maintain UK expertise in the area of volcanic eruptions. This work influenced the inclusion of natural hazards as a theme in NERC's strategy.

Conclusions

Examples of RM research influencing NERC policy can be identified, but definitive cases are difficult to isolate. Research breakthroughs are often the result of many sub-projects, with a combination of RM and other sources of funding.. The strategy development community support RM as a valuable underpinning activity which sustains and enables NERC's strategic priorities.

How the outputs of RM research has helped to shape NERC strategy: documenting some recent instances

CASE STUDY 1: UCL-LED ICE SHEET MASS BALANCE STUDIES 1990 to 2001

Summary
In the late 1990s monitoring of Polar ice was transformed by work undertaken by a small team of independent researchers at UCL, funded primarily through NERC's Responsive Mode (RM). Their research was pioneering in the use of satellite-based Earth observation, and instrumental in demonstrating that the ice sheets are more dynamic than had previously been thought, and in regions previously neglected as study sites. The team's work was a major influence on NERC strategy, firmly placing the need to better understand ice sheet dynamics at the heart of climate change science, and helped change attitudes world-wide regarding polar monitoring.

Science area

In the late 1990s, UCL's Polar observation group, led by Professor Duncan Wingham, undertook a series of satellite studies of Arctic and Antarctic ice mass, which amounted to unprecedented continental-scale mapping. Key outcomes of this were the revelations that the rate of ice flow is greater than had previously been appreciated, and that the area of the Antarctic undergoing the most rapid change in ice balance (The Pine Island Glacier) had until that time been overlooked as a study site[2]. These discoveries led to a major strategic re-think of Polar monitoring, in the UK and internationally, both in the methods used and the sites of greatest importance. Prior to the UCL team's work in the 1990s the prevailing opinion was that polar EO missions were required only occasionally, and, erroneously, that traditionally monitored sites were representative of the Polar regions as a whole.

Influence on NERC strategy

NERC came to recognise the importance and value of satellite-based Earth observation in part through the successes and impact of the UCL team's work. The commitment to support satellite Earth observation was a significant shift of resources and emphasis for NERC, and represents one of the most dramatic influences of RM-funded work on NERC strategy. National Capability support for satellite EO from NERC came partly through the establishment of the Centres of Excellence in Earth Observation (CEO), through which the UCL team won the status of a NERC collaborative centre as the Centre for Polar Observation and Monitoring (CPOM[3]). CPOM's continued work has helped to show that ice sheet mass changes are accelerating.

[2] Wingham, D.J., Shepherd, A., Muir, A. and Marshall, G.J. (2006) Mass balance of the Antarctic ice sheet. Philosophical Trans-actions of the Royal Society A Mathematical Physical and Engineering Sciences, 364 (1844). pp. 1627-1635. ISSN 1364503X.

[3] http://www.cpom.org/

The importance of NERC's (RM) funding

RM funding allowed the UCL researchers test the concept of satellite-based Earth observation of the Polar regions. Specifically, the funding allowed them to:

- Address the problem of sea ice thickness using the satellite instruments currently available
- Bring the latest technical skills and abilities to the UK
- Build the technical infrastructure (part technical, part personnel) required for further work.

Wider influences

The first ESA Earth Explorer mission competition was won by the UCL team's-led CryoSat proposal, for a dedicated low-orbit ice monitoring satellite. This project would not have been feasible without the experience and technical capabilities the UCL team had built up through its RM funding. The UCL team's track record of RM-funded projects helped to demonstrate that it had the capability to make the CryoSat project work.

Current situation

CPOM remains part of a NERC collaborative centre, having being incorporated into the National Centre for Earth Observation (NCEO) upon the NCEO's creation in 2009[4]. CPOM studies processes in the Earth's Polar latitudes that may affect the Earth's albedo, polar atmosphere and ocean circulation, and global sea level. With research groups in the Department of Earth Sciences at University College London, at the Bristol Glaciology Centre at the University of Bristol and in the School of Earth and Environment at the University of Leeds, CPOM continues to model and test predictions of ice, ocean and atmosphere interactions and climate models.

[4] http://www.nceo.ac.uk/

Funding from NERC which supported the UCL polar Earth observation team

Dates	NERC Reference	PI	Co-Is	Project Title	Award Value (£)	Award Type
1992 – 1994	GST020880	DJ Wingham		The correction & verification of global digital elevation maps using ERS-1 altimeter, long repeat data	£25,055	Earth Observation (LINK)
1992 – 1995	GST020927	SW Laxon		Geoid determination over sea-ice covered oceans using satellite radar altimetry	£32,955	Earth Observation (LINK)
1993 – 1995	GST020919	DJ Wingham		Topographic mapping of the south-west Vatnajökull icecap	£54,988	Earth Observation (LINK)
1993 – 1996	GR3/08748	DJ Wingham		Initiating the monitoring of the mass-balance of the Antartica ice-sheet with the ERS-1 radar altimeter.	£97,436	Standard
1993 – 1994	GR3/09587	CG Rapley		Infrastructure funding for the Mullard space science laboratory remote sensing group	£21,000	Standard
1993 – 1994	GR3/09584	CG Rapley		EOS initiative post startup grants	£10,000	Standard
1994 – 1997	GR3/09600	DJ Wingham		Ice sheet and climate interactions	£618,647	Standard
1995 – 1996	GR9/01832	DJ Wingham		Recovering the ERS-1 radar altimeter historical data 1991-1993 for ice sheet research.	£19,273	CONNECT B
1996 – 1999	GR3/10498	DJ Wingham	JA Dowdeswell - University of Cambridge	Synthetic aperture radar interferograms to investigate ice dynamics in Svalbard	£172,776	Standard
1997 – 2000	GR3/11186	DJ Wingham	PJ Valdes - University of Bristol	Mass balance fluctuations of the Greenland ice sheet 1991-1998 by radar altimetry and modelling	£178,472	Standard
1998 – 2002	GST022196	SW Laxon		Arctic Ocean circulation and ice freeboard through space-borne altimetry	£124,833	Arctic Ice Environment Variability (ARCICE)
1999 – 2003	GST022195	DJ Wingham	JA Dowdeswell - University of Cambridge	Ice dynamics and mass flux of Arctic Ice Caps and the Greenland Ice Sheet using satellite radar interferometry	£119,376	Arctic Ice Environment Variability (ARCICE)
2001 – 2004	NER/T/S/2000/00306	SW Laxon	DL Feltham - University College London	Optimisation of an Arctic sea ice model using spaceborne estimates of ice thickness.	£141,624	Coupled Ocean Atmospheric Processes & European Climate (COAPEC)
2001 – 2004	NER/A/S/2000/00419	AJ Payne - University of Bristol	OW Jones - Bournemouth University; Wingham	Pine Island Glacier flow and dynamics.	£81,258	Standard
Total					£1,697,693	

***NB** Grant holders were staff at UCL unless specified.*

How RM research has helped to shape NERC strategy: documenting some recent instances

CASE STUDY 2: SOLAR-TERRESTRIAL PHYSICS (PROF JO HAIGH, IMPERIAL COLLEGE LONDON)

Summary

Pioneering studies on the sun's influence on Earth's climate were undertaken by Professor Jo Haigh at Imperial College from the mid-1990s, supported primarily through NERC RM-type funding. Her work, on the influence of solar radiation on terrestrial weather, has had influences throughout the world. The importance of the work was recognised by the inclusion of this area in NERC's previous strategy, Science for a Sustainable Future.

Science area

Prof Haigh's research interests have been concerned with aspects of radiative transfer in the Earth's atmosphere. This includes investigating how atmospheric constituents (gases and clouds) absorb and scatter radiation emitted by the Sun and also absorb and emit thermal radiation. A fundamental understanding of these mechanisms is important because the Earth's climate depends on a balance between incoming solar, and outgoing thermal, radiation. Prof Haigh's RM-funded observational studies over many years suggested that various meteorological parameters vary in phase with solar activity but the problem in explaining these observations is that the measured magnitude of the variation in total solar irradiance appears to be too small to account for the apparent response. She received international attention when suggesting that the effects may be amplified due to the response of stratospheric ozone to variations in solar ultraviolet output. A 1996 Science paper, authored by Professor Haigh, is considered seminal in creating an acceptance of the need to be informed about processes in the stratosphere in order to understand the behaviour of the troposphere.

Influence on NERC strategy

Professor Haigh's work was influential in the development of NERC's 2002 – 2007 strategy *Next Generation Science for Planet Earth.* One of this strategy's three priority areas, Climate Change, included the fundamental research question: "*what is the influence of solar cycles on Earth's atmosphere"*? In spite of this, there has been no NERC thematic funding in the area of solar effects on climate.

NERC took responsibility for funding Solar Terrestrial Physics from STFC in 2009, as a result of the recommendation made in the 2008 RCUK Review of UK Physics (The Wakeham Review). At the time Professor Alan Thorpe, NERC's Chief Executive stated: *"I welcome the transfer of responsibility for Earth-oriented solar terrestrial physics, which will strengthen the delivery of NERC's strategy. This area of physics includes, for example, studies of space weather impacts on technological systems, ionospheric effects on communications and global positioning, and solar influences on global climate change. We look forward to working with the new members of our community"*.

The importance of NERC's (RM) funding

In supporting Professor Haigh's research the Responsive Mode awards have resulted in influential outputs which have informed the strategy of NERC and several international organisations.

RM funding received

In 1993 Professor Haigh was awarded a SERC (later transferred to NERC) Advanced Fellowship. Since then she has received RM-type funding and, as a result of her studies, has succeeded in raising the profile of the solar effects on Earth's climate, a previously underappreciated aspect of meteorology. She is PI for the current NERC RM Consortium project Solar Influences on Climate (SOLCLI).

Wider influences

There has been a growing international interest in solar variability and its effects on climate, largely as a result of Professor Haigh's work. She has been involved in numerous panels, projects and working groups, including:

- Panel membership of NASA's 'Living with a Star' programme
- The International Council for Science's Climate and Weather of the Sun-Earth System programme
- Coordinator of EC Framework Programme 5 project 'Solar Influences on Climate and the Environment'

Current situation

Although NERC has assumed RC responsibility for funding solar-terrestrial physics, there are currently no research programmes or other targeted funding in this area.

Prof Haigh is now Head of the Physics Department, at Imperial College London.

Relevant funding received by Prof Haigh

Dates	Funder & Reference	PI	Co-Is	Project Title	Award Value (£)	Award type (if NERC)
1993 – 1998	SERC & NERC; GT59402EO	JD Haigh		Potential solar-terrestrial links investigated using satellite data and numerical models o	£73,343	Postdoctoral Fellow
1999 – 2001	NERC; GST022438	JD Haigh	J Austin - Meteorological Office	The response of lower stratospheric ozone to solar variability and its impact on radiative forcing and climate	£130,887	Directed
2002 – 2003	NERC; NER/T/S/2000/01035	LJ Gray - University of Reading	MR Allen - University of Oxford JD Haigh - Imperial College London WA Norton - University of Reading	The role of ozone in determining the response of the coupled ocean-atmosphere climate system to solar forcing.	£37,107	Directed
2003 – 2003	EC		Imperial College London Rutherford Appleton Lab UK Met Office CNRS, Jussieu, Paris Free University of Berlin University of Oslo Aristotle University, Thessaloniki	Solar Influences on Climate and the Environment	£1,022,955	
2004 – 2006	ESA		Danish National Space Centre Swedish Institute of Space Physics Imperial College London	ISAC	£46,883	
2004	International Space Science Institute		Reading University Stony Brook University, New York Swiss Federal Inst. for Environmental S&T Free University of Berlin Rutherford Appleton Lab Imperial College London	Solar-climate team	Workshop and meeting costs	
2005	Met Office		Reading University Imperial College	Consultancy on solar variability	£10,000	
2005 – 2008	NERC; NER/A/S/2003/00370	LJ Gray - University of Reading	JD Haigh	Atmospheric teleconnections with the tropical stratosphere.	£168,458	Standard Grant
2006 – 2011	NERC; NE/D002753/1	JD Haigh	M Blackburn - University of Reading M Chipperfield - University of Leeds LJ Gray - University of Reading PH Haynes - University of Cambridge MJ Jarvis - NERC British Antarctic Survey Y Unruh - Imperial College London	Solar Influences on Climate	£1,267,417	Consortium Grant
2009 – 2012	NERC; NE/G00367X/1	JD Haigh		Impact of the representation of ozone on tropospheric weather forecasts	£261,353	Partnership Research

How the outputs of RM research has helped to shape NERC strategy: documenting some recent instances

CASE STUDY 3: OCEAN IRON FERTILIZATION EXPERIMENTS (PROF ANDREW WATSON, UEA)

Summary

Responsive Mode (RM)-funded experiments investigating marine plankton productivity, led by researchers at the University of East Anglia (UEA), have influenced NERC's strategy through several cycles. The current *Next Generation Science for Planet Earth*'s Earth System Science challenges, *to understand the biogeochemical forces and feedbacks that drive the Earth system,* and *to understand the long-term development of the Earth and its habitability*, both owe their prominence, in part, to this work. These RM studies proved that iron is the limiting nutrient in some ocean systems, and that its addition can significantly increases the rates of biogeochemical processes and phytoplankton growth; this has had far-reaching ramifications for our understanding of global carbon cycling, and the ability of the oceans to absorb and sequester CO_2.

Science area

Which factors determine ocean productivity was once on of the greatest unanswered questions of marine science. In the 1930s, it was demonstrated that nitrates and phosphates were the limiting trace nutrients in most, but not all, of the seas, including the Southern Ocean. This became known as the 'Antarctic paradox'. In the 1990s Professor Andrew Watson and his colleagues at the UEA, funded primarily through NERC's RM, conclusively demonstrated that the limiting nutrient in these regions was iron, with the artificial fertilization experiments IronEx and SOIREE. These studies were made feasible through the use of a novel aquatic tracer technology, which had also been developed through a NERC RM award.

Influence on NERC strategy and wider influences

While ultimately not demonstrating the utility of anthropogenic iron fertilization as a means of carbon sequestration (much of the carbon assimilated by phytoplankton due to the iron addition quickly leaks back into the atmosphere as CO_2), the outcomes of IronEx and SOIREE influenced NERC's strategy in a number of ways. The importance of natural iron fertilization (for example Saharan dust storms depositing iron-rich sand far out to sea), has been better appreciated and the investigation of biogeochemical cycles remain a key component of NERC's strategy, e.g. the current Earth System Science theme's challenge, *to understand the biogeochemical forces and feedbacks that drive the Earth system*. Work by Prof Watson and others have demonstrated the importance of understanding biogeochemical cycles in order to predict changes to the Earth system as a whole; particularly important in predicting the consequences of increased concentrations of CO_2 in the atmosphere.

IronEx and SOIREE demonstrated to NERC the power and efficacy of consortium-model research projects in tackling discrete science questions. NERC's current strategy implementation programme makes particular use of consortium projects, in part thanks to the success of RM consortium-type projects such as those of IronEx and SOIREE.

The importance of NERC's (RM) funding

Strategic funding was not available in this field at the time.

Current situation

While the experiments did indicate that ocean biogeochemistry is high on NERC and other, international, agencies' priorities for strategic funding, the experiments ultimately did not prove the practicality of carbon sequestration using iron as a marine fertiliser. Prof Watson and his UEA colleagues continue to work on observations of the ocean carbon system and ocean physics using tracers, funded by EU and NERC grants. They have received funding for further studies, including:

- Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES)[1]
- An award through the Strategic Oceans Funding Initiative (SOFI)[2]

Prof Watson was elected FRS in 2003 and awarded the EGU's Nansen Medal for "fundamental contributions to the understanding of the integrated oceanic system" in 2004.

NERC grants awarded to support IronEx & SOIREE

Dates	Grant reference	PI	Co-Is	Project title	Total award value	Award type (if NERC)
[Tracer development award details not obtained.]						
[IronEx award details not obtained.]						
1998 - 2001	GR3/A1431	A Watson	PS Liss C Law – PML P Nightingale - PML	Southern ocean iron fertilisation experiments (soiree)	£264,259	Standard Grant

[1] http://dimes.ucsd.edu/
[2] http://www.oceans2025.org/funding.php

How RM research has helped to shape NERC strategy: documenting some recent instances

CASE STUDY 4: MONTSERRAT VOLCANIC ERUPTIONS

Summary

NERC has provided the resources for a generation of researchers to study the ongoing eruption of the Soufrière Hills Volcano on the Caribbean island of Montserrat. The mainly Responsive Mode (RM)-funded work using this rare opportunity on UK territory influenced the development of the current NERC Natural Hazards theme challenge 2: *to enable better forecasting and mitigation of the risks of geohazards*; the work also contributed to the inclusion of the theme itself, as a new component of NERC strategy. This case also demonstrates how one of the inherent strengths of RM research – flexibility – can be harnessed by the NERC community to effectively exploit emerging opportunities.

Influence on NERC strategy

The Soufrière Hills Volcano (SHV), on the British Overseas Territory of Montserrat, has been erupting continuously since July 1995. Alongside other UK natural hazards research strengths, the successful and highly-cited portfolio of work already undertaken by NERC's researchers on and around Montserrat, and the continuing opportunity to study an eruption on UK territory, influenced NERC's decision to include Natural Hazards as a dedicated theme within the new strategy *Next Generation Science for Planet Earth*. The Natural Hazards theme's scope includes development of the science associated with the forecasting and mitigation of volcanoes, and effects of volcanic emissions on the atmosphere.

RM funding received

To date, at least 112 grant applications have been submitted to NERC proposing to study the SHV and its environmental impacts[7]. Of these, 34 have been funded (see table, below), of which 29 (85%) have been unequivocally RM. The value of these awarded grants has been £4.4m, of which £4.1m (93%) has been RM.

The importance of NERC's (RM) funding

Since the latest eruptions began in 1995, the SHV has been one of the most closely monitored and studied volcanoes in the world. This work has been funded, primarily by NERC, using a combination of NC monitoring and RM research awards. The Montserrat Volcano Observatory (MVO)[8], part-run by BGS, has maintained a presence on the island since the eruption began, and has participated in the RM projects, but the great majority of research projects studying the SHV have been undertaken through RM.

Science area

[7] Data collected by searching NERC's MANTRA grants database with terms "Montserrat" and "Soufrière".
[8] http://www.mvo.ms/

The eruption has presented a rare opportunity for a wide range of UK researchers, mostly within the NERC-supported science community, and it is now one of the most intensely studied volcanic events in history. Besides its obvious interest to the geological, volcanological and atmospheric sciences, the island's rich biodiversity and maritime location present opportunities for other disciplines to study the effects of eruptions.

Wider influences

NERC's volcanology and atmospheric sciences community drew on their expertise, honed partly as a result of work carried out analysing the SHV eruption plume, to advise the Met Office during the 2010 Eyjafjallajökull eruptions, in Iceland. Their cutting edge knowledge of volcanic ash generation and its spread in the atmosphere helped inform and improve the Met Office's predictions, and limit necessary disruption to flights.

Current situation

BGS continue to operate at the MVO, and NERC continues to receive RM grant applications pertaining to the island. The Natural Hazards theme has recently announced a new interdisciplinary programme of research on resilience and vulnerability to seismic and volcanic-related natural hazards[9].

[9] http://www.nerc.ac.uk/research/programmes/resilience/events/ao.asp

NERC grants awarded for studies of the Soufrière Hills eruption. Where split awards, lead grants only are shown.

Dates	NERC Reference [10]	PI	Co-Is	Project Title	Award Value	Award Type
1995 - 1996	GR3/10412	D Cronan (Imperial College)		A study of hydrothermal fluids and precipitates from Montserrat, British West Indies, whilst in eruption	£13,759	Standard
1996 - 1998	GR3/10679	MR Carroll (University of Bristol)	R Macdonald (Lancaster University); R Sparks (University of Bristol)	Characterisation of the Montserrat magma system and magma properties applications to eruption forecasting and hazards mitigation	£117,318	Standard
1996 - 1999	GR3/10714	PW Francis (Open University)		Purchase of Montserrat cospec	£27,000	Standard
1997 - 1998	GR9/02633	R Macdonald (Lancaster University)		Experimental studies of the evolution of the Soufrière St Vincent magmatic system	£3,401	CONNECT B
1997 - 1997	GR9/02668	PR Norris (University of Warwick)		Characterization of novel, mineral sulphide-oxidizing acidophiles (Montserrat survey)	£13,034	CONNECT B
1997 - 1998	GR3/11020	RS Sparks (University of Bristol)	A Woods (University of Cambridge); M Carroll (University of Bristol)	Characterisation and dynamics of the andesite dome eruption of the Soufrière hills volcano, Montserrat applications to eruption forecasting and hazard	£84,215	Standard
1998 - 2001	GR3/11683	RS Sparks (University of Bristol)	A Woods (University of Cambridge); M Carroll (University of Bristol)	Dynamics of the eruption of the Soufrière Hills Volcano, Montserrat	£145,970	Standard
1998 - 2000	GR9/03608	C Oppen-heimer (University of Cambridge)	P Francis (Open University)	Chemical evolution of the Soufrière Hills volcanic plume, Montserrat	£15,449	CONNECT B
1998 - 1999	GR3/11685	DA Rothery (Open University)	G Wadge (University of Reading); S Blake (Open University)	Growth and stability of lava domes monitoring and modelling	£96,858	Standard
2000 - 2005	NER/M/S/2000/00272	J Barclay (UEA)		Experimental and textural investigation of degassing induced crystallisation relevant to the pressurisation of silicic magmas	£18,545	New Invest-igators
2000 - 2004	NER/A/S/1999/00077	RS Sparks (University of Bristol)	H Huppert (University of Cambridge)	Non-linear dynamics of volcanic systems	£110,951	Standard
2000 - 2003	NER/A/S/1999/00030	J Neuberg (University of Leeds)	B Baptie (BGS)	Models of seismo-volcanic sources for long-period earthquakes on Montserrat	£112,553	Standard
2001 - 2005	NER/A/S/2000/00421	RS Sparks (University of Bristol)	J Neuberg (University of Leeds)	Magma reservoir-conduit dynamics as revealed by a borehole Geophysical Observatory system	£150,564	Standard

[10] *NB Split awards are amalgamated. Reference for leads only shown; values of splits are combined.*

2002 - 2005	NER/A/S/2001/01001 (3 awards)	G Wadge (University of Reading)	G Smith (University of St Andrews); H Pinkerton (Lancaster University)	Measuring and modelling the collapse of volcanic domes	£578,325	Standard
2004 - 2008	NER/A/S/2002/00963	RS Sparks (University of Bristol)	P Talling (National Oceanography Centre)	The dispersal and chronology of tephra in the sea during eruptions of the Soufrière Hills volcano, Montserrat	£207,182	Standard
2004 - 2007	NER/A/S/2003/00512	J Neuberg (University of Leeds)		Understanding the origin of low-frequency earthquakes - the key to forecasting volcanic hazard	£180,359	Standard
2004 - 2006	NE/B500107/1	DC Roman (University of Leeds)		Development of new volcano monitoring technique: relationship of stress field orientation to magmatic processes at Soufrière Hills Volcano, Montserrat	£113,565	Post-doctoral Fellowship
2004 - 2008	NE/B504614/1 (2 awards)	J Barclay (UEA)	C Oppenheimer & R Cox (University of Cambridge)	Volcanogenic bromine and iodine: petrology, atmospheric chemistry and global emission rate	£482,910	Standard
2005 - 2008	NE/C509958/1	RS Sparks (University of Bristol)		Dynamics of magma chambers and conduit flows during volcanic eruptions using the Soufrière Hills Volcano, Montserrat as a natural laboratory	£186,714	Standard
2005 - 2005	NE/D00859X/1	G Wadge (University of Reading)	G Smith (University of St Andrews); H Pinkerton (Lancaster University)	Measuring the growth of the new lava dome at Soufrière Hills Volcano, Montserrat	£28,017	Standard
2006 - 2006	NE/E001734/1 (2 awards)	G Wadge (University of Reading)	H Pinkerton (Lancaster University); D MacFarlane & G Smith (University of St Andrews)	A time series of measurements of magma flux at the lava dome of Soufrière Hills Volcano, Montserrat	£46,018	Standard
2006 - 2007	NE/E002900/1	J Barclay (UEA)	J Alexander (UEA)	Rapid response survey of the 20th May 2006 Montserrat lahar deposits: a snapshot of lahar system dynamics and associated hazard	£20,148	Small Grants
2007 - 2009	NE/E007961/1	J Gottsmann (University of Bristol)		Investigating cyclic changes in the potential field at Soufrière Hills volcano, Montserrat	£20,503	Small Grants
2007 - 2011	NE/E015093/1 (3 awards)	G Wadge (University of Reading)	H Pinkerton (Lancaster University); D MacFarlane, D Robertson & G Smith (University of St Andrews)	Measuring incipient lava dome collapse	£1,234,379	Standard
2008 - 2009	NE/F000936/1	R Gertisser (Keele University)		New insights into the deposit architecture and emplacement mechanisms of block-and-ash flows using ground penetrating radar	£69,694	New Invest-igators
2008 - 2009	NE/F010478/1	P Talling (NOC)		How is ash dispersed in the ocean around volcanoes?	£46,301	Small Grants

2010 - 2011	NE/G00764 0/1 (2 awards)	P Talling (NOC)	C Berndt (Geomar Research Centre); T Henstock (University of Southampton)	Emplacement process and timing of large volcanic debris avalanches, Montserrat, Lesser Antilles: implications for volcanic and tsunami hazards	£257,267	Integrated Ocean Drilling Programme (IODP)
Total					£4,380,999	