The Role of the Southern Ocean in the Earth System (RoSES)

Announcement of Opportunity

Issued on 7 October 2016
Full Proposals deadline: 16.00 GMT on 15 December 2016

1 Summary

Proposals are invited for a new Research Programme on the Role of the Southern Ocean in the Earth System.

The outcome of this Research Programme will be the provision of the scientific basis to inform international climate policy on the role of the Southern Ocean carbon system in 21^{st} century climate change.

It is expected that this announcement will lead to the funding of up to 3 proposals that address the programme's objectives. Up to £5.2m is available for this call according to a pre-determined distribution of funding between the programme's Challenges.

A workshop will be held on the **14 October 2016** in London, to ensure the research community is aware of the NERC National Capability available to support this research, such as the recently awarded National Capability programme ORCHESTRA field campaigns and modelling, facilities and infrastructure. The event will also provide a forum for discussion of the science challenges and possible approaches to undertaking the research. It will also provide an opportunity to identify potential collaborations and partnerships.

Whilst attendance at the workshop is encouraged, it is not a prerequisite for submitting a proposal to this call.

Proposals for this call are invited from eligible UK researchers (see NERC Grants Handbook for standard eligibility criteria.

The closing date for proposals is 16:00 on 15 December 2016.

2 Background

The Southern Ocean (SO) is one of the most important and poorly understood components of the global carbon cycle that profoundly shapes Earth's climate. It is the primary hot spot for the oceanic sink of anthropogenic CO_2, having captured half of all human-related carbon that has entered the ocean to date[1 2]. This vast anthropogenic perturbation to the SO carbon system is activating a range of complex climate feedbacks (e.g. a rising atmospheric CO_2-induced acceleration of the westerly winds over the SO, which may in turn be driving increased SO outgassing and raising atmospheric CO_2 concentrations further[3]) that are likely to exert a decisive control on the evolution of oceanic carbon uptake, atmospheric CO_2 and global climate over the 21st century[4 5]. Many of these climate feedbacks are poorly understood and quantified, yet evidence from our planet's past global climatic transitions (e.g. the end of the last glacial period) suggests that they can induce changes in atmospheric CO_2 as large as those caused by human activities since the industrial revolution[6 7]. As the focus of major knowledge gaps and a central player in global carbon and climate dynamics, the SO carbon system is regularly singled out as the 'Achilles heel' of the Earth system models upon which humankind relies to understand contemporary climate change, predict its future evolution, and define international climate policy[8 9].

Inadequate understanding and unconstrained model representation of the SO carbon system constitute a critical uncertainty in climate projections for the 21st century. Investigations of the present magnitude of the SO carbon sink and its recent decadal variability yield wildly different estimates, yet unanimously show that the regional budget is the sum of large, uncertain outgassing and uptake terms that are both comparable in magnitude to the CO_2 emissions from the world's most polluting economies and highly sensitive to climate change[8 10]. In the recent Paris Agreement, 195 nations committed to undertaking rapid reductions in their greenhouse gas emissions to hold the global-mean temperature to well below 2°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change. The effectiveness of this Agreement is, however, acutely vulnerable to future changes in the SO carbon system that are not captured by rudimentary representations in the present generation of Earth system models. Even modest variations in the SO's outgassing or uptake terms may lead to a significant shift in the reduction of global anthropogenic CO_2 emissions required to meet long-term temperature goals, and produce a geopolitically challenging imbalance between the integral of national sources and the desired evolution of atmospheric carbon.

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[1] Mikaloff Fletcher, S. & twelve others, 2006: Inverse estimates of anthropogenic CO2 uptake, transport, and storage by the ocean. Glob. Biogeochem. Cyc. 20, doi:10.1029/2005GB002530.
[2] Frölicher, T. & five others, 2015: Dominance of the Southern Ocean in anthropogenic carbon and heat uptake in CMIP5 models. J. Clim. 28, 862-886.
[3] Le Quéré & eleven others, 2007: Saturation of the Southern Ocean CO2 sink due to recent climate change. Science 316, 1735-1738.
[4] Schwinger, J. & eleven others, 2014: Nonlinearity of ocean carbon cycle feedbacks in CMIP5 Earth system models. J. Clim. 27, 3869-3888.
[5] Kessler, A. & J. Tjiputra, 2016: The Southern Ocean as a constraint to reduce uncertainty in future ocean carbon sinks. Earth Syst. Dyn. 7, 295-312.
[6] Martínez-García, A. & eight others, 2014: Iron fertilization of the Subantarctic Ocean during the last ice age. Science 343, 1347-1350.
[7] Watson, A. & two others, 2015: Southern Ocean buoyancy forcing of ocean ventilation and glacial atmospheric CO2. Nature Geosci. 8, 861-864.
[8] Lenton, A. & sixteen others, 2013: Sea-air CO2 fluxes in the Southern Ocean for the period 1990-2009. Biogeosci. 10, 4037-4054.
[9] Heinze, C. & seven others, 2015: The ocean carbon sink – impacts, vulnerabilities and challenges. Earth Syst. Dyn. 6, 327-358.
[10] Landschützer, P. & eleven others, 2015: The reinvigoration of the Southern Ocean carbon sink. Science 349, 1221-1224.

The evolution of the SO carbon sink over the 21st century has been the subject of a persistent, heated debate in the scientific literature[3 8 10 11 12]. This is reflected in the SO accounting for most of the uncertainty in Earth system model predictions of global oceanic carbon uptake, which differ by up to approximately 2 Pg C yr-1 (i.e. the present net global oceanic carbon uptake) by 2050. The debate is fuelled by a paucity of essential carbon system observations in the SO, which makes the region the most glaring biogeochemical 'data desert' in the world ocean; and by a damaging lack of understanding of the fundamental processes controlling the size of the SO carbon sink, which raises large uncertainties in the nature and magnitude of associated climate feedbacks – particularly as global emissions start to decline toward zero. Now, the advent of novel autonomous robotic platforms and biogeochemical micro-sensor technologies, in which the UK has played a world-leading role, makes it possible to tackle these issues directly for the first time, and settle the debate once and for all.

3 Scope of Call

3.1 Programme Objectives

The overarching objective of RoSES is to provide the scientific basis to inform international climate policy on the role of the SO carbon system in 21st century global climate change. By substantially reducing uncertainty in 21st century global climate change projections through improved assessment of the SO carbon sink, RoSES will bolster the UK's capacity to credibly encourage other nations to strengthen their emission reduction ambitions through the 5-year review and 'ratchet' mechanism. This is a stated diplomatic priority for the UK (Prime Minister's speech to COP21 summit in Paris, 30 November 2015).

The exceptional significance of the SO in the global carbon cycle stems from the region hosting most of the vertical flow between the surface and deep layers of the world ocean[13]. Deep waters enriched in carbon and nutrients upwell to the surface in the Antarctic Circumpolar Current, powered by the strong westerly winds that blow incessantly over the SO. Some of these waters flow southward, cool, form sea ice and sink to the abyss, producing northward-flowing Antarctic Bottom Water. The remainder flow northward, freshen and subduct to intermediate depths at the northern edge of the SO as Antarctic Intermediate Water and Subantarctic Mode Water. These two circulation pathways form the lower and upper limbs of the SO overturning circulation, and act to draw carbon into the ocean interior and to feed the rest of the ocean with the nutrients that sustain global primary productivity and ecosystems[14 15].

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[11] Zickfeld, K. & three others, 2008: Comment on 'Saturation of the Southern Ocean CO2 sink due to recent climate change'. Science 319, 570b.
[12] Takahashi, T. & seven others, 2012: The changing carbon cycle in the Southern Ocean. Oceanog. 25, 26-37.
[13] Rintoul, S. & A. Naveira Garabato, 2013: Dynamics of the Southern Ocean circulation. In Ocean Circulation and Climate: A 21st Century Perspective, Academic Press, Oxford, U.K.
[14] Sarmiento, J. & three others, 2004: High-latitude controls of thermocline nutrients and low-latitude biological productivity, Nature, 427, 56–60.
[15] Marinov, I. & three others, 2006: The Southern Ocean biogeochemical divide. Nature 441, 964-967.

The sign and magnitude of the SO's contribution to global atmospheric CO_2 are set by the difference between the carbon content of upwelling and downwelling waters. This difference is determined by the sum of a complex, poorly understood array of biological, chemical and physical processes that collectively modify the carbon content of water parcels during their characteristically approximate 1 year-long journey through the upper ocean. On reaching the surface, upwelled waters experience air-ice-ocean gas exchanges, which transfer CO_2 into or out of the atmosphere. The high nutrient content of those waters fuels biological carbon fixation through the growth of phytoplankton, but this growth is regulated by upper-ocean turbulent flows (which shape the light and nutrient conditions for growth) and ultimately limited by the widespread shortage of the micronutrient iron. Grazing by zooplankton stimulates biological carbon export through the sinking of organic particles, which are broken down into inorganic carbon by remineralisation processes in the deep ocean. All these processes are strongly seasonal and episodic, and their effect on carbon content is dependent on their relative phasing and interactions with other processes[5]. In the pre-industrial period, this suite of processes made the SO a strong source of carbon to the atmosphere, but in recent decades the rising concentrations of anthropogenic CO_2 in downwelling waters have likely reversed the region's contribution to a sink of unknown magnitude[8]. During the 21st century, however, the SO carbon sink could revert to a source if the local biological carbon fixation and export decreased substantially[16].

The alarming uncertainty in the contemporary size and future evolution of the SO carbon sink stems from two factors:

1. the acute sensitivity of observational estimates of the contemporary sink to methodological detail, which precludes assessment of the sink's variability and feedbacks with the wider climate system[10];
2. the existence of critical and uninformed differences in the representation of biogeochemical processes and their interaction with the overturning circulation in Earth system models[16].

Both of these factors are caused, at root, by the scarcity of biogeochemical observations. There is a fundamental mismatch between the annual time scale of upper-ocean carbon content change and the much shorter, summer-biased timing of the ship-based observations that are used to investigate its drivers. Year-round measurements of how the SO carbon system operates are key to determining the sequence of processes controlling the carbon content difference between upwelling and downwelling waters, so that an integrated view of the SO carbon sink and its vulnerability to perturbations in climatic forcing can be developed with robust analytical approaches and credible, mechanistically constrained models.

To address this requirement, the overarching objective of the programme will be addressed through the delivery of three inter-related research challenges:

***Challenge 1*:** (1 proposal to be funded at a maximum cost to NERC of £1m)

Design and implement the optimal approach to assess the <u>state, variability and climatic drivers</u> of the contemporary SO carbon sink.

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[16] Hauck, J. & seventeen others, 2015: On the Southern Ocean CO2 uptake and the role of the biological carbon pump in the 21st century. Glob. Biogeochem. Cyc. 29, 1451-1470.

The SO is widely recognised as the largest oceanic sink of anthropogenic CO_2. In contrast, the strength, variability and biogeochemical controls of the SO's cycling of 'natural' (i.e. pre-industrial) carbon are poorly observed, modelled and understood, despite its decisive role in determining the sign and magnitude of the region's net contribution to global atmospheric CO_2 change[17]. Estimates of the size and recent variability of the regional carbon sink from atmospheric and oceanic observations differ wildly, are highly approach-dependent, and fail to constrain the system's climatic drivers[3 10]. Climate-scale models indicate a much more modest response of the SO carbon sink to climatic forcing perturbations than is suggested by observations, and provide no consensus on the sink's evolution over coming decades[8 17]. This points to serious structural deficiencies in the models, and opens up a fundamental and dangerous gap in our ability to predict and understand 21st century global climate change.

Challenge 1 will address this gap by developing, formally contrasting, and reconciling multiple approaches to the estimation of the SO carbon sink from diverse atmospheric and oceanic observations. This groundwork will lead to an assessment of the size, variability and climatic drivers of the contemporary SO carbon sink, and to the design and implementation of the optimal strategy to monitor the carbon sink in decades to come.

Challenge 2**:** (up to 2 proposals to be funded at a maximum cost to NERC of £2.1m per proposal)
Define, quantify and provide <u>mechanistic understanding of the key processes</u> controlling the rate of SO carbon uptake.

The rate of SO carbon uptake is set by the difference between the carbon content of upwelling and downwelling waters across both limbs of the overturning circulation. This difference is determined by a complex sequence of biological, chemical and physical processes with strong seasonality and highly episodic behaviour. These include: air-sea gas transfer, which controls the equilibration of CO_2 in upwelled waters with the atmosphere; sea ice formation and melting, which regulate gas transfer and biological production; iron supply and light levels, which influence the rate of nutrient utilisation and carbon fixation by phytoplankton; and grazing, which affects biological production and the sinking of organic carbon. Climate-scale models of the SO carbon system differ widely in their assessment of which processes are dominant in setting the system's efficiency and of how the balance between those processes is established[8 16]. The damagingly wide range of projections reflects the large uncertainties in current representations of biogeochemical processes in the models, which suffer from a critical lack of constraints by targeted, year-round observations.

Challenge 2 will tackle this fundamental weakness by:

- obtaining first-of-a-kind, systematic, year-round measurements of the processes controlling the rate of carbon uptake in each limb of the SO overturning circulation;
- using these observations to define the key processes that must be correctly characterised in models of the SO carbon system, quantify their contribution to the system's efficiency, and assess how models must represent their mechanistic operation.

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[17] Ciais, P. & fifteen others, 2013: Carbon and other biogeochemical cycles. In Climate Change 2013: The Physical Science Basis. IPCC Fifth Assessment Report. Camb. Univ. Press, Cambridge, U.K.

***Challenge 3*: (1 proposal to be funded at a maximum cost to NERC of £1m)**
Develop <u>key policy-informing metrics</u> of the integrated efficiency of the SO carbon sink and its role in 21st-century global climate change.

If international climate policy is to succeed at stabilising atmospheric CO_2 concentrations and global warming below dangerous levels, it requires a quantitative assessment of the SO carbon system's impact on 21st century climate projections and their uncertainty ranges. Specifically, determining whether the policies arising from the Paris Agreement are likely to lead to the desired outcomes demands that:

- the evolving contribution of the SO carbon system to global atmospheric CO_2 be continuously monitored, supporting Article 4's requirement of signatories to reduce emissions so as to achieve a global balance between sources and sinks of atmospheric carbon;
- the commitment to future warming associated with anthropogenic perturbations to the SO carbon system be assessed, by e.g. identifying crucial tipping points in the system or other events that may lead to irreversible change and permanent loss or damage.

To meet these policy needs, it will be critical to develop and exploit key metrics that quantify the integrated effects of the SO carbon system on Planetary Vital Signs[18]. Key metrics are to encapsulate how changes in the biological, chemical and physical elements of the SO carbon system influence global climate, and might involve, for example, the upper-ocean mixed layer depth[16], extent of sea ice[19], strength of the overturning circulation[20], rate of biological export[21], and partitioning of nutrients within the water column[22].

Challenge 3 will directly connect the step change in scientific understanding of the SO carbon system achieved by RoSES to the goals of international climate policy-makers by, first, synthesising the new major insights on the system's operation from Challenges 1 - 2; and, second, using these as a basis to develop key metrics of the system's integrated efficiency and climate impacts. Significant contributions to this Challenge may come from multiple approaches, such as analyses of available carbon system-related data and proxies, the development and application of new theoretical frameworks, or investigations with a hierarchy of models of varying complexity (ranging from conceptual models to ocean general circulation models, and extending to IPCC-class Earth system models such as UKESM). ORCHESTRA simulations using ocean circulation models will be made available to RoSES for biogeochemical development or analysis.

This Announcement of Opportunity is for proposals to address Challenges 1 and 2 only. Details of Challenge 3 have been included for information and a separate Announcement of Opportunity will be released within 18 months of this call. Successful applicants from this announcement will

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[18] Briggs, S. & two others, 2015: Planetary vital signs. Nature Clim. Change 5, 969-970.
[19] Ferrari, R. & five others, 2014: Antarctic sea ice control on ocean circulation in present and glacial climates. PNAS 111, 8753-8758.
[20] Anderson, R. & six others, 2009: Wind-driven upwelling in the Southern Ocean and the deglacial rise in atmospheric CO2. Science 323, 1443-1448.
[21] Kwon, E. & two others, 2009: The impact of reminerlization depth on the air-sea carbon balance. Nature Geosci. 2, 630-635.
[22] Ito, T., & M. Follows, 2005: Preformed phosphate, soft tissue pump and atmospheric CO2. J. Mar. Res. 63, 813-839.

be required to share their work plans with Challenge 3 applicants at that time to ensure that the outputs from Challenges 1 and 2 can be exploit in the delivery of Challenge 3.

3.2 Proposal Requirements

Proposals will be required to address the deliverables of either Challenge 1 or 2:

Challenge 1 deliverables

- State of the art observation based assessment of the size, variability and climatic drivers of the contemporary SO carbon sink.
- A legacy optimal strategy to measure the future evolution of the SO carbon sink over the 21st Century.

Significant contributions to this Challenge may come from:

- New upper-ocean carbon system observations (e.g. obtained with novel autonomous robotic platforms and biogeochemical micro-sensors deployed from ORCHESTRA cruises), particularly in winter, in ice-covered regions, and over short time scales (e.g. capturing storms); and integration of these observations into carbon system data products and SO carbon uptake estimates.
- Improved large-scale, observation-based estimates of the SO carbon sink, including atmospheric and oceanic inversions drawing on new biogeochemical observations collected via ORCHESTRA cruises or new atmospheric carbon system measurements from remote SO islands, new types of biogeochemical observations, measurements of changes in carbon inventories, regional constraints, and / or multiple carbon-related tracers.
- New simulations and analyses of hindcast climate-scale carbon cycle models (including, but not limited to, a possible extension of an ORCHESTRA ocean model with coupling to a biogeochemical module) and observation – model comparative studies (e.g. using emergent property approaches) to constrain the contemporary SO carbon sink's evolution and its response to climatic drivers.
- Analyses that integrate several or all of these strands using novel mathematical frameworks (e.g. Bayesian optimisation), to reconcile disparate approaches and define the optimal strategy to assess the SO carbon sink.

Challenge 2 deliverables

- Definition and quantification of the key processes controlling the rate of carbon uptake in each limb of the SO overturning circulation.
- Mechanistic understanding of those key processes, and a roadmap for their parameterisation in climate-scale models.

Major advances in this Challenge are expected to come from experiments exploiting innovative autonomous robotic platforms and capabilities (e.g. long-range, high-endurance autonomous vehicles; hibernating autonomous vehicles deployed under seasonal sea ice), biogeochemical micro-sensor technologies, and polar infrastructure (e.g. the RRS Sir David Attenborough) to assess the rate and controls of carbon content change in upper-ocean waters flowing from upwelling to downwelling regions of the SO.

Project proposals are only expected to consider one limb of the SO overturning, given the limbs' distinct functioning and geographical scope. Focussing of fieldwork in the South Atlantic and Southeast Pacific is strongly recommended so that scientific and logistical synergies with ORCHESTRA may be maximised – the 'upper limb' and 'lower limb' experiments might respectively focus on the Southeast Pacific and the Weddell Sea, where some of the most intense sinking of intermediate and mode waters and of Antarctic Bottom Water around the SO takes place.

Exploitation of the SOCCOM float programme is encouraged. Successful proposals will be expected to identify a clear pathway for the new observations to inform the development of the climate-scale models of the SO carbon system used to predict the system's future evolution

4 Programme Requirements

4.1 Programme Funding

Up to £5.2m is available for this call to fund up to 3 research projects, 1 to address Challenge 1 and 2 to address Challenge 2 – one for each of the limbs of the SO overturning. The maximum cost to NERC for each proposal is as follows:

Challenge 1 - £1m
Challenge 2 - £2.1m per proposal

Challenge 1:
It is expected that only modest fieldwork costs will be included within proposals to address this Challenge, some of which will involve utilising other existing or planned field campaigns, for example ORCHESTRA, SOCCOM, or RoSES Challenge 2.

All costs associated with fieldwork must be included within the total funding available for Challenge 1, including any costs associated with National Marine Facilities (NMF) support for fieldwork (e.g. for autonomous systems).

The NERC funding contribution for proposed projects will be at 80% of FEC with the exception of NMF support costs which will be paid at 100% and must be included within the £1m funding limit (for example, if the NMF costs for supporting a proposed RoSES autonomous campaign are £100k, then only £900k will be available to cover the 80% FEC costs of the proposed project). Indexation at the prevailing rate will be applied at the time of award.

Challenge2:
It is anticipated that there will be 1 or 2 dedicated cruises to aid in the delivery of Challenge 2. All costs associated with NMF support for fieldwork must be costed into proposals and will be paid at 100%. Applicants are therefore required to engage early with NMF to scope out their fieldwork so that they are aware as soon as possible of the likely scale of the NMF costs that will need to be included within their proposals.

The NERC funding contribution for proposed projects will be at 80% of FEC with the exception of NMF support costs which will be paid at 100% and must be included within the £2.1m funding limit (for example, if the NMF costs for supporting proposed RoSES cruise and autonomous campaign are £400k, then only £1.7m will be available to cover the 80% FEC costs of the proposed project). Indexation at the prevailing rate will be applied at the time of award.

All costs associated with NMF should be included within the Directly Incurred Other Costs section of the Je-S form.

Proposals should include formal requests (and access costs) for any other NERC Services and Facilities (e.g. aircraft, HPC, isotope analyses), where relevant.

Associated studentships may not be included in proposals.

4.2 Implementation and Delivery

All proposals are required to involve a minimum of 2, but preferably more, eligible institutions. Proposals will also be expected to include a range of both senior and early career scientists.

Proposals may be up to 48 months in duration. Proposals addressing Challenges 1 and 2 will be expected to start in time to coordinate with the activities being undertaken on the November 2017 ORCHESTRA cruise. Proposals addressing Challenge 3 will start later than those addressing Challenges 1 and 2 to ensure that they are able to exploit the outputs from these two challenges.

All proposals must include milestones and deliverables to ensure that NERC and the Programme Advisory Group can monitor the delivery of the science outputs.

It is highly desirable for proposal teams to be inter-disciplinary, and should also work with international project partners where appropriate.

4.3 Knowledge Exchange and Impact

Knowledge exchange (KE) is vital to ensure that environmental research has wide benefits for society, and should be an integral part of any research.

All applicants must consider how they will or might achieve impact outside the scientific community and submit this with their application as a Pathways to Impact statement, with associated delivery costs where relevant. Pathways to Impact activities do not have to be cost-incurring; it is not a requirement to include funded activities. Any funds required to carry out any proposed, outcome-driven activities identified within the Pathways to Impact **must** be fully justified within the Justification of Resources statement.
The Pathways to Impact will identify those who may benefit from or make use of the research, how they might benefit or make use of the research, and methods for disseminating data, knowledge and skills in the most effective and appropriate manner.

An acceptable Pathways to Impact is a condition of funding. Grants will not be allowed to start unless unacceptable Pathways to Impact are enhanced to an acceptable level within 2 months of notification of the panel outcome.
All funded projects may also be required to engage with programme-wide KE activities, in which case appropriate funding for which will be provided by the programme.

All funded projects may also be required to engage with programme-wide KE activities, in which case appropriate funding for which will be provided by the programme.

4.4 Data Management

The NERC Data Policy must be adhered to, and an outline data management plan produced as part of proposal development. NERC will pay the data centre directly on behalf of the programme for archival and curation services, but applicants should ensure they request sufficient resource to cover preparation of data for archiving by the research team.

4.5 NERC Facilities

Prior to submitting a proposal, applicants wishing to use a NERC service or facility must contact the facility to seek agreement that they could provide the service required. Applicants wishing to use a NERC facility will need to submit a mandatory 'technical assessment' with their proposal (including aircraft but excluding ships and HPC). For NERC, this means a quote for the work which the facility will provide. A full list of the Facilities requiring this quote can be found here on the NERC website. The costs for the service or facility (including NMF costs) must be included within the Directly Incurred Other Costs section of the Je-S form and also within the facilities section of the Je-S form. Further information on NERC services and facilities can be found on the NERC website.

4.6 Programme Management

It will be a condition of grant awards that the lead PIs of the awarded grants will work closely for the life time of the programme with the defined Programme Management arrangements.

5 Application Process

5.1 Full Proposals
Closing date: 15 December 2016

Full proposal must be submitted using the Research Councils' Joint Electronic Submission system (Je-S). Applicants should select Proposal Type - 'Standard Proposal' and then select the Scheme – 'Directed' and the Call – 'Role of Southern Ocean DEC16'.

Applicants must ensure that their proposal is received by NERC by 4pm on the closing date. The Je-S portal will not allow submissions after 4pm. Applicants should leave enough time for their proposal to pass through their organisation's Je-S submission route before this date. Any proposal that is incomplete, or does not meet NERC's eligibility criteria or follow NERC's submission rules (see NERC Grants Handbook), will be returned to the applicant and will not be considered.

All attachments, with the exception of letters of support and services/facilities/equipment quotes, submitted through the Je-S system must be completed in single-spaced typescript of minimum font size 11 point (Arial or other sans serif typeface of equivalent size to Arial 11), with margins of at least 2cm. Please note that Arial narrow, Calibri and Times New Roman are not allowable font types and any proposal which has used either of these font types within their submission will be rejected. References and footnotes should also be at least 11 point font and should be in the same font type as the rest of the document. Headers and footers should not be used for references or information relating to the scientific case. Applicants referring to websites should note that referees may choose not to use them.

Applicants should ensure that their proposal conforms to all eligibility and submission rules, otherwise their proposal may be rejected without peer review. More details on NERC's submission rules can be found in the NERC research grant and fellowships handbook and in the submission rules on the NERC website.

Proposals for this call addressing:

- **Challenge 1** - should be submitted in **standard** grant format (page limit restrictions) following the requirements outlined in Section F of the NERC research grant and fellowships handbook.
- **Challenge 2** - should be submitted in **large** grant format (page limit restrictions) following the requirements outlined in Section F of the NERC research grant and fellowships handbook.

Please note that on submission to council ALL non PDF documents are converted to PDF, the use of non-standard fonts may result in errors or font conversion, which could affect the overall length of the document.

Additionally where non-standard fonts are present, and even if the converted PDF document may look unaffected in the Je-S System, when it is imported into the Research Councils Grants System some information may be removed. We therefore recommend that where a document contains any non-standard fonts (scientific notation, diagrams, etc.), the document should be converted to PDF prior to attaching it to the proposal.

No associated studentships can be requested under this call.

5.2 Eligibility

Normal individual eligibility applies and is in Section C of the NERC research grant and fellowships handbook. Research Organisation eligibility rules are in Section C of the handbook. Independent Research Organisations (IROs) must be eligible for NERC Managed (Strategic Research) Mode.

Investigators may be involved in no more than two proposals submitted to this call and only one of these may be as the lead Principal Investigator.

6 Assessment Process

Full proposals will be internationally peer-reviewed and final funding recommendations made by a moderating panel consisting of independent experts and members of the NERC Peer Review College where possible. Applicants will be given the opportunity to provide a written response to peer review comments prior to the moderating panel. Applicants may be invited to give a presentation at the moderating panel.

The assessment criteria to be used for the full proposal stage will be as follows:

- Research Excellence
- Fit to Programme Requirements

Feedback will be provided to both successful and unsuccessful applicants.

NERC will use the recommendations of the moderating panel along with the overall call requirements and the available budget in making the final funding decision.

7 Timetable

Closing date for full proposals: 15 December 2016
Moderating panel meets: April 2017
Decision communicated to applicants: April/May 2017
Latest start date for projects: July 2017

8 Contact

For all enquiries, please contact Lisa Hole liho@nerc.ac.uk

For enquiries about ORCHESTRA please see ORCHESTRA information paper

For Marine Facilities enquiries please contact Natalie Clark natcla@nerc.ac.uk