

A.3 OCEAN BIOLOGY AND BIOGEOCHEMISTRY

NOTICE: Clarified on February 17, 2016. New text was added to Section 2.6 to clarify requirements for proposed budgets for HPLC pigment analysis and for travel to meetings. The proposal due date has not changed; proposals remain due on March 3, 2016.

NOTICE: Amended on December 3, 2015. This Amendment releases final text for this program element. Notices of intent are requested by January 7, 2016 and proposals are due by March 3, 2016. Proposers to this program will not be asked to provide a data management plan via the NSPIRES cover pages, because it must be provided in the proposal, see Section 3.4.

1. Scope of Program

NASA's Ocean Biology and Biogeochemistry program focuses on describing, understanding, and predicting the biological, ecological, and biogeochemical regimes of the upper ocean, as determined by observation of aquatic optical properties using remote sensing data, including those from space, aircraft, and other suborbital platforms.

Overarching programmatic goals include:

- Understanding and quantifying the impacts and feedbacks of Earth System processes, particularly oceanographic mechanisms, on the global and regional spatial and temporal variability of ocean biology and ecology, including phytoplankton and organisms from other trophic levels;
- Understanding and quantifying the impacts and feedbacks of Earth System processes, particularly oceanographic mechanisms, on the global and regional spatial and temporal variability of ocean biogeochemistry, including carbon sources and sinks and the fate of other chemical species or components in the ocean;
- Exploring the development of new biological, ecological, and biogeochemical observations beyond traditional ocean color (e.g., phytoplankton chlorophyll *a*) from space-based assets, as well as furthering the climate research enabled by existing time series of climate observations (Earth System Data Records); and
- Improving future climate predictions (impacts and feedbacks) by incorporating a dynamic understanding of ocean biology, ecology, and biogeochemistry into global biogeochemical and ecological models to understand the ocean's role in the Earth System.

Ocean Biology and Biogeochemistry research mainly supports the Carbon Cycle and Ecosystem Focus Area (<http://nasascience.nasa.gov/earth-science/carbon-cycle-and-ecosystems>). Each of the Earth Science Focus Areas portrays a strategy for a decade of progress through 2015, based on a suite of systematic observations, novel new Earth Science observations, and specific programmatic elements. NASA's Ocean Biology and Biogeochemistry program utilizes remotely sensed observations from land, ocean, and atmosphere, as well as field studies and campaigns, and interdisciplinary data assimilation and modeling efforts to better understand the ocean's role

in the Earth System and to predict future causes of change and feedbacks on ocean biology and biogeochemistry within the Earth System.

In support of the Carbon Cycle and Ecosystems Roadmap, scientific questions of interest to the Ocean Biology and Biogeochemistry Program include (but are not limited to):

- How are ocean ecosystems and the biodiversity they support influenced by climate and environmental variability and change, and how will these changes occur over time?
- How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do biogeochemical fluxes impact the ocean and Earth's climate over time?
- How (and why) are the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well being of human society?
- How do hazards and pollutants impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?

Appendix A.1 of ROSES ("Earth Science Research Program") provides an overview of how the Ocean Biology and Biogeochemistry program fits into the Earth Science Division within NASA's Science Mission Directorate. Program goals and objectives for the coming decades can be found in the Ocean Biology and Biogeochemistry program's advance plan (http://oceancolor.gsfc.nasa.gov/DOCS/OBB_Report_5.12.2008.pdf).

2. Description of Solicited Research

Priorities for new research within NASA's Ocean Biology and Biogeochemistry program continue to derive from the goals and objectives for Earth Science in NASA's Strategic Plan (<http://nasascience.nasa.gov/about-us/science-strategy>), the research agenda of the U.S. Global Change Research Program (USGCRP) (<http://www.globalchange.gov/>), the science priorities of the U.S. Carbon Cycle Science Program (<http://www.carboncyclescience.us/>), and the National Ocean Policy Implementation Plan (https://www.whitehouse.gov/sites/default/files/national_ocean_policy_implementation_plan.pdf) of the National Ocean Council (NOC). This solicitation calls for research on specific topics of current, strong scientific interest, and programmatic relevance. The NASA Ocean Biology and Biogeochemistry program requests the following types of research investigations:

- Research in ocean ecology, specifically to prepare scientifically for new ocean measurements from the Pre-Aerosol, Cloud, ocean Ecosystem (PACE) mission recommended by "Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space Science" (http://science.nasa.gov/media/medialibrary/2010/07/01/Climate_Architecture_Final.pdf) or to advance ocean ecology research based on data from historical, existing, and new sensors such as OCO-2;
- Global data set development and modeling activities to enable a predictive understanding of the export and fate of global ocean primary production and its implications for the Earth's carbon cycle, specifically in support of a planned field campaign in the Northeast Pacific and North Atlantic Oceans,
- Studies to support the trilateral *Galway Statement on Atlantic Ocean Cooperation* of May 2013, among the European Union (EU), Canada, and the United States (US) (available at <http://www.coopeus.eu/galway-statement/>); and

- Successor studies that offer to significantly advance the results of prior NASA Ocean Biology and Biogeochemistry research toward meaningful answers to important NASA goals, relevant USGCRP, and NOC carbon cycle and ecosystems research questions, and current and future NASA missions..

2.1 Research in Ocean Ecology

Aquatic ecosystems respond to global change in a variety of ways, but ecosystems vary in both their vulnerability (i.e., exposure, sensitivity, resilience) to and impacts from environmental and climate variability and change. Some impacts of global environmental change are major, greatly affecting the sustainability of ecosystem dynamics or functions, and/or causing large feedbacks to the climate system. Some ecosystem changes or responses to environmental or climate change are abrupt, while others take much longer (decades or even centuries) to become manifest. Research is needed to identify the most significant of these ecosystem impacts and vulnerabilities, to understand the processes controlling them, and to assess the likely magnitude of change(s) associated with them.

This research is essential if we are to anticipate the type and degree of future environmental changes and to devise strategies for mitigation and/or adaptation. Additionally, this research is critical if current and future ocean color and other satellite missions, such as the Pre-Aerosol, Cloud, ocean Ecosystem (PACE) mission's data, are to be used not only for research, but to better inform monitoring, management, and decision and policy makers. Research proposals submitted to this subelement can utilize existing ocean satellite observations and should clearly connect to future remote sensing missions or requirements, such as the PACE mission.

Integrative research is sought to apply remote sensing observations to the characterization of ocean biology and ecology impacts from and/or vulnerability to global climate and environmental variability and change. Within the domain of ocean ecology, a wide variety of aquatic ecosystem impacts and vulnerabilities could be addressed in the proposals submitted in response to this element of the solicitation, but not all will be equally important. Therefore, proposals must offer compelling rationales as to 1) the clear definition and “geographic” boundaries of the ecosystem under study, 2) why the impacts and/or vulnerabilities of a given ecosystem to be studied are expected to be highly significant, representing major perturbations to the Earth system, and 3) how the remote sensing data and data products to be utilized in the study provide unique and powerful information for addressing the ecosystem research issues/questions posed. Ecosystem in this context could be defined on any number of scales, but the ecosystem under study must be compellingly defined and justified in the global context.

Characterization of uncertainties will be essential in all analyses of potential ecosystem impacts and vulnerabilities, so for a proposal to be considered responsive to this element, it must explain how error and uncertainty will be considered, incorporated into results, and reported.

NASA is seeking research under this subelement that is centrally focused on the vulnerabilities to and response of ocean ecosystems to global environmental change. While aspects of and consequences to biogeochemical cycling may be addressed in such studies, proposers offering studies centrally focused on carbon cycle science are encouraged to respond instead to ROSES

2016 Carbon Cycle Science, in Appendix A of the 2016 ROSES omnibus solicitation (to be released February 2016).

2.2 Global Data Sets and Modeling In Support of Planned Northeast Pacific and North Atlantic Export Flux Studies

A major scientific challenge in the ocean sciences is to identify and quantify the mechanisms that determine the export of biogenic carbon from the euphotic zone and its transformation in the mesopelagic zone at regional and global scales. Observations and models at many scales will need to be combined to address the questions and challenges of understanding and quantifying export fluxes of carbon and associated materials, and the biogeochemical-ecological interactions that impact the biological pump. The quantification of the magnitude, efficiency, and variability of the biological pump is critical for understanding the ocean's carbon cycle in response to a changing environment and climate.

To address the above challenges, the NASA Ocean Biology and Biogeochemistry Program is planning the EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) field campaign (see <http://cce.nasa.gov/cce/ocean.htm> for the EXPORTS Final Science Plan, Executive Summary, and other relevant materials). The EXPORTS field campaign is focused on sampling the ocean carbon pathways over a range of contrasting ecosystem/carbon cycle states in order to formulate a predictive understanding of the export and fate of global Net Primary Production (NPP). The research to be conducted will involve data mining, observations, process-oriented analyses, scientific syntheses, and modeling. The EXPORTS field campaign will emphasize the pathways that lead to the export and fate of global NPP and will integrate and synthesize geospatial data collected by airborne and spaceborne sensors with information obtained from ship-based observations. Data mining of previous experimental *in situ* and remotely sensed data (details provided below) will expand the possible range of ecosystem states available for assessing the export and fate of global ocean NPP and for help with planning and executing the field program. Further, modeling studies are needed to help guide field campaign planning, such as an Observing System Simulation Experiments (OSSE).

The detailed study design for EXPORTS will be developed over the next year, but it is not too early to begin assembling key existing data sets within and outside the study region to support its planning and eventual synthesis. The exact location of the study region has not yet been determined. However, for the purposes of this solicitation, proposers should assume that the study region includes the North Atlantic circa the 2008 North Atlantic Bloom Experiment study area and Northeast Pacific near Station P, as defined in the EXPORTS science plan. Thus, data sets of obvious importance for the Northeast Pacific and North Atlantic biogeochemical-ecosystem research and modeling, as well as data sets that would inform study planning and preparation, are of interest. This opportunity is not for the collection of new *in situ* data, but rather to access and refine existing data for use in the future EXPORTS field campaign research.

Data mining of existing *in situ* and remotely sensed data sets, as well as modeling results from other areas of the ocean that specifically expand the dynamic range of ecosystem and carbon cycle states identified in the EXPORTS Science Plan, are also of interest. The aim is to supplement the relatively small number of ecosystem/carbon cycle states that will be directly

observed by EXPORTS by conducting an intensive data-mining effort. These additional states may not be sampled as completely as the EXPORTS observational suite is likely to be, and will likely be missing some important carbon cycling pathways or spatial/temporal scales of variability. However the data-mining exercise will ensure that the EXPORTS program will have a broad range of ecosystem and carbon cycle states needed for the development of broadly applicable remote sensing and numerical models of the export and fate of global NPP. Again, this opportunity is not for the collection of new field observations.

Numerical modeling activities may also prove to be very useful in the planning and execution of sampling strategies for the EXPORTS field campaign. In particular, physical, ecological and biogeochemical numerical models could be used as part of an Observing System Simulation Experiment (OSSE) to assess different observational strategies. Model fields can be sampled and analyzed as the observed data fields would be, to test how well the EXPORTS science questions can be answered given a particular observational strategy. This work must be conducted at the appropriate spatial and temporal scales to inform the field campaign planning. Other modeling approaches, data assimilation, process modeling of particular processes, etc. will also be considered, but again must contribute to the planning of the EXPORTS field campaign.

NASA requests proposals for investigations to assemble, prepare, develop, refine, data mine, and/or integrate data sets for use in preparing for and conducting North Atlantic or Northeast Pacific field campaign research. Research activities may involve: obtaining and compiling existing data sets not otherwise widely available; subsetting and/or custom processing of satellite data for the study region; combining related data sets in an integrated, consistent synthesis; data mining a suite of *in situ* and geospatial data sets with consistent formatting, metadata, map projections, etc., suitable for use in relevant ecosystem models. NASA also requests modeling studies to help guide field campaign planning. Proposals must explain the overall importance of the data set or numerical model simulation proposed and its anticipated use(s) for the planning and/or execution of the EXPORTS field campaign. They must also explain the relevance of the proposed data set or model to a remote sensing-oriented research program. NASA intends to select only the most obviously important, high priority data mining and numerical modeling activities for "pre-EXPORTS" investment.

All selected data mining and modeling studies will be subject to the standard Earth Science Data Policy described below.

2.3 Research In Support of the Galway Statement: North Atlantic - Arctic Oceanographic Processes

The trilateral *Galway Statement on Atlantic Ocean Cooperation* of May 2013, among the European Union (EU), Canada, and the United States (US) (available at <http://www.coopeus.eu/galway-statement/>) emphasizes the need for international cooperation in discovering and understanding processes influencing this dynamic region of the oceans. From 2013 to 2014, NASA sponsored the EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) field program science planning effort (final science plan available at <http://cce.nasa.gov/cce/ocean.htm>), which focused on identifying and quantifying the

mechanisms that determine the export of biogenic carbon from the euphotic zone and its transformation in the mesopelagic zone at regional and global scales.

NASA welcomes proposals to conduct research to address the goals and objectives of the Galway Statement and its implementation, particularly those science objectives that are in line with preliminary research to inform planning for the EXPORTS field campaign based on the final science plan. The proposed work plan's relationship and direct link to the Galway Statement and the Galway Statement's research goals and objectives must be explicitly justified within the proposal. Proposed research must clearly demonstrate a firm partnership with scientists from Canada or the European Union in support of the Galway Statement. Proposals seeking to address the goals of the EXPORTS draft science plan that are not clearly and explicitly linked to the Galway Statement research goals and objectives are not solicited at this time.

2.4 Successor Studies

This solicitation provides opportunities for integrative research relevant to the goals and objectives of the Ocean Biology and Biogeochemistry (OBB) program element that will significantly advance the results of prior research toward meaningful answers to NASA's goals, relevant USGCRP, and NOC carbon cycle and ecosystems research questions, and current and future NASA missions. Successor proposals and follow-on research from past NASA Ocean Biology and Biogeochemistry research projects will be considered. Such proposals must offer demonstrable scientific advances beyond the earlier study and explain the continuing relevance and priority of the research to be pursued to the Ocean Biology and Biogeochemistry Program. If new studies do not cite the specific prior NASA-OBB funded study, and do not document the progress made in that study, then the proposed research that remains the prompt for the present study will be considered nonresponsive under this element.

3. Additional Proposal Requirements

3.1 Requirement Regarding Remote Sensing

For proposals to develop new data sets (i.e., responding to Section 2.2 above), use of remote sensing data is strongly encouraged. However, in cases where the data set cannot be assembled from existing remote sensing data and the data set is of clear utility and priority for NASA Ocean Biology and Biogeochemistry research, use of remote sensing data will not be required. Instead, the proposal must explain how the data set will meet a priority NASA Ocean Biology and Biogeochemistry need and be used in future research to complement satellite remote sensing data analysis.

For ocean ecology (Section 2.1), Galway Statement research (Section 2.3) and successor proposals responding to Section 2.4 above, substantive use of remote sensing data is required.

3.2 Requirement Regarding Duration of Study

It is anticipated that many data set development and modeling activities that exploit existing data sources can be completed within one to two years. Also, some follow-on or successor studies that focus on remote sensing science and remote sensing methods may be achievable in less than three years. Therefore, proposers submitting in response to this program element are encouraged to consider award durations of less than three years. While proposers may request up to three years of support, they must document and carefully justify the need for the amount of time requested.

3.3 Requirement to Address Errors and Uncertainties

All proposals submitted in response to this solicitation must include a section in the statement of work describing how errors and uncertainties will be addressed. The research supported will be expected to characterize uncertainties and quantify errors associated with data, analytical approaches, model results, and scientific interpretations. This work must be described in the proposal.

3.4 Requirement for a Data Management Plan

Proposals must include a data management plan of no more than two pages that addresses the dissemination and sharing of research results and compliance with NASA Earth Science data policy (<http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/>). The data management plan should include, when relevant to the type of study being proposed, the types of data and data products or other materials to be produced in the course of the project, the standards to be used for data and metadata formats and plans for providing access to and/or archiving the data and other research products. The data sharing plan called for in Section 2.3.5 of the *Guidebook for Proposers* may be included in the data management plan. The data management plan must be included within the 15-page limit for the Scientific/Technical/Management section of the proposal. A valid data management plan may include only the statement that no detailed plan is needed, as long as a clear justification is provided.

For new data sets proposed under Section 2.2 above, the data management plan must include plans for quality assessment, timely public release, and long-term archive of the data set(s).

3.5 Requirement for Proposals Requesting Acquisition of New Airborne or Shipborne Data

Proposals requiring data from airborne sensors must detail in their cost plan all costs for acquiring the new data sets, including costs for aircraft hours, deployment costs, mission peculiar costs, data processing costs, and other costs associated with deploying the sensors and aircraft (this includes NASA sensors and platforms, as well as non-NASA sensors and platforms). In addition, for any proposed activities requiring NASA aircraft or NASA facility sensors, proposers should submit a Flight Request to the Airborne Science Flight Request system at <http://airbornescience.nasa.gov> (and then click on "FLIGHT REQUEST"). Questions regarding the flight request system or process should be addressed to Marilyn Vasques, Flight Request

Manager (Marilyn.Vasques@nasa.gov or 650-604-6120). If the instrument or aircraft platform are not NASA facilities, proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and aircraft and explain these plans in the proposal.

Proposers should include any required supporting paperwork that provides insight into costs or requests in support of the use of the vessel. Proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and vessel and explain these plans in the proposal.

3.6 Other Requirements Regarding General Content

Unless otherwise specified above, proposed investigations must utilize remotely sensed (e.g., ocean color) observations as a primary research tool, but may also seek to improve existing ocean color observations or explore the development of new biological properties from space-based assets beyond traditional ocean color in support of the project objectives.

Coordinated or individual efforts may be linked with other projects or proposals and these linkages must clearly and explicitly be called out by all involved proposals and investigators. Regardless of any clearly identified “linked” status, each individual proposal will be evaluated as a stand-alone effort using the Proposal Evaluation Criteria identified in Section 3.7 of this program element. Each individual proposal must address all required elements of the solicitation.

Investigators should make clear any special requirements or platform needs, i.e., ship modifications, additional boats, specific sampling requirements, or high-end computing requirements (see Section I(d) of the *ROSES Summary of Solicitation*), in a separate section.

All data collected will be subject to the standard NASA Earth Science data policy (<http://nasascience.nasa.gov/earth-science/earth-science-data/data-information-policy/>).

Proposals planning to collect field data should contain a table that, to the extent possible, details what data will be collected, on what cruise or field visit and when, and provide a detailed plan for submission to a NASA data center, such as the SeaWiFS Bio-optical Archive and Storage System (SeaBASS- <http://seabass.gsfc.nasa.gov>), within one year of collection.

Investigators proposing high performance liquid chromatography (HPLC) phytoplankton pigment sample analysis must include the analytical cost for such measurements within their proposal budgets. The current cost for HPLC pigment analysis is \$100 per sample at the NASA-supported analytical facility (currently Goddard Space Flight Center; GSFC) for a complete suite of acetone-extractable pigments (<http://oceancolor.gsfc.nasa.gov/cms/hplc>). Approximately 5% of the pigment samples should be submitted in duplicate for assessment of replicate sample precision. Proposed budgets should also include shipping costs of samples and return of shipping container. Investigators may make separate arrangements with a non-NASA supported analytical facility for HPLC pigment sample analysis. However, investigators that do not use the NASA-supported facility must send a sub-set of duplicate samples (~10% of total) to the GSFC facility and budget for these samples accordingly. This allows for lab-to-lab inter-comparison of pigment results and assessment of uncertainties. Furthermore, PIs should

also complete the table of planned field measurement collection and include the table as an appendix to the proposal.

Investigators selected under this call will be strongly encouraged to participate in any meetings and coordination workshops sponsored or co-sponsored by NASA (e.g., post-cruise data workshops, pre-cruise planning meetings, etc.). PIs will also be encouraged to attend annual NASA co-sponsored science coordination meetings with international research programs, as needed. Investigators selected by the Ocean Biology and Biogeochemistry program are strongly encouraged to attend the annual NASA Ocean Color Research Team meeting or equivalent within the United States (e.g., PIs should budget a three day trip to the farthest coast once per year, unless specified otherwise). [Clarified February 17, 2016.]

3.7 Proposal Evaluation Criteria

Proposals will be evaluated according to the criteria specified in Section VI (a) of the ROSES Summary of Solicitation and Section C.2 of the *Guidebook for Proposers*. In addition to the factors given in the *Guidebook for Proposers*, the determination of a proposal's intrinsic merit shall take into account the following additional considerations as aspects of the offeror's and investigator team's capabilities:

- The experience of the investigators and their institutions in engaging in data sharing and providing timely access to data and research products on related and relevant projects, and
- The quality and completeness of the data management plan.

NASA reserves the right to select or not select proposals in any given program subelement based on the aforementioned specific and existing NASA review and selection criteria, see Section II a of the ROSES Summary of Solicitation.

4.0 Summary of Key Information

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| Expected annual program budget for new awards | Up to \$2.5M; Subelements 2.1-2.3 ~\$1.5M; Subelement 2.4 ~\$1.0M |
| Number of new awards pending adequate proposals of merit | ~ 10-20 |
| Maximum duration of awards | 3 years |
| Due date for Notice of Intent to propose (NOI) | January 7, 2016 |
| Due date for Proposals | March 3, 2016 |
| Planning date for start of investigation | July 1, 2016 |
| Page limit for the central Scientific/Technical section of proposal | 15 pp.; see also Chapter 2 of the <i>NASA NRA/CAN Proposers Guidebook</i> |

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| Relevance to NASA | This program is relevant to the Earth science strategic goals and subgoals in NASA's <i>Strategic Plan</i> ; see Table 1 and the references therein. Proposals that are relevant to this program are, by definition, relevant to NASA. |
| General information and overview of this solicitation | See the <i>ROSES Summary of Solicitation</i> . |
| Detailed instructions for the preparation and submission of proposals | See the <i>NASA NRA/CAN Proposers Guidebook</i> at http://www.hq.nasa.gov/office/procurement/nraguidebook/ . |
| Submission medium | Electronic proposal submission is required; no hard copy is required or permitted. See Section IV of the <i>ROSES Summary of Solicitation</i> and Chapter 3 of the <i>NASA NRA/CAN Proposers Guidebook</i> . |
| Web site for submission of proposal via NSPIRES | http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376) |
| Web site for submission of proposal via Grants.gov | http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726) |
| Funding opportunity number for downloading an application package from Grants.gov | NNH15ZDA001N-OBB |
| NASA point of contact concerning this program | Paula S. Bontempi Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1508 E-mail: paula.bontempi@nasa.gov |