

A.3 OCEAN BIOLOGY AND BIOGEOCHEMISTRY

NOTICE: Amended March 23, 2020. This Amendment presents final text for this program element. Notices of intent are requested by April 30, 2020, and proposals are due July 23, 2020.

Proposers to this program element must use Earth Science Division templates for the required summary table of work effort and current and pending support sections of the proposal, see Section 4.3.

1. Scope of Program

NASA's [Ocean Biology and Biogeochemistry](#) (OBB) Program focuses on better understanding the ocean's role in the Earth System, and predicting future causes and impacts of change driven by Earth's climate, the environment, and event-scale phenomena on ocean biology, biogeochemistry, and ecology. NASA utilizes remotely sensed measurements of aquatic properties, including data obtained from space, aircraft, and other suborbital platforms; data from field studies and campaigns; and interdisciplinary data assimilation and modeling efforts to describe, understand, quantify, and predict changes to the biological and biogeochemical regimes of the upper ocean. Ocean Biology and Biogeochemistry research primarily supports NASA's [Carbon Cycle and Ecosystem Focus Area](#), which addresses changes in Earth's carbon cycle and ecosystems to improve understanding of the structure and function of global aquatic ecosystems, their interactions with the atmosphere, terrestrial and cryospheric systems, and the ocean's role in the cycling of the major biogeochemical elements.

A.1, The [Earth Science Research Overview](#), provides an overview of how the OBB 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](#).

The OBB Program supports a number of Presidential mandates and associated Federal research objectives, such as the 2018 [Executive Order Regarding the Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States](#), which calls for the need to provide economic, security, and environmental benefits for present and future generations of Americans. In addition, the NASA OBB Program supports the U.S. Global Change Research Program (USGCRP) and its [strategic plan](#) (last updated in 2017) which, as part of its treatment of the full Earth system, addresses aspects of Carbon Cycle and Ecosystem research from space, with a focus on understanding Earth's aquatic environment and its role within the Earth System. The OBB Program is also responsive to and supports priorities identified in the Subcommittee on Ocean Science and Technology (SOST) 2018 report [Science and Technology for America's Oceans: A Decadal Vision](#). This vision identifies five goals to advance U.S. ocean science and technology and the Nation in the coming decade; OBB Program research will utilize space-based observations and provide new suborbital observations that support the identified goals, furthering our understanding of the ocean's role in the Earth System in support of a blue economy, ecosystem management, and policy for societal benefits. Research developed under the OBB Program is anticipated to support the Global Ocean Observing System (GOOS) Essential Ocean Variables (EOV) defined by the GOOS [Biogeochemistry](#) and [Biology](#)

[and Ecosystems](#) panels, all of which specify remote sensing as a critical tool in Earth system research. The OBB Program also supports the [International Ocean Color Coordinating Group](#) (IOCCG) scientific objectives as appropriate, in support of the [Committee on Earth Observing Satellites](#) (CEOS), as well as the [Surface Ocean - Lower Atmosphere Study \(SOLAS\)](#) research project.

2. Types of Solicited Research

This solicitation calls for research on specific topics of current, strong scientific interest and programmatic relevance. In addition, key research to prepare scientifically for new measurements derived from the observables and scientific priorities recommended by the 2017 Decadal Survey for Earth Science and Applications from Space (ESAS) of the National Academies of Sciences, Engineering and Medicine (NASEM), [Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space](#), is also sought.

The NASA OBB Program requests the following subelements of research investigations in no priority order:

- a. New quantitative analyses of vulnerability and shifts of aquatic biology and/or ecosystems in response to climate change.
- b. Science investigations to advance ocean biology/ecology research through the development and utilization of new and/or multisensor remote sensing approaches or data fusion, utilizing data from historical, existing, and new NASA and non-NASA sensors.
- c. Studies that focus on remote detection, quantification, and analysis of marine debris.
- d. Research in ocean ecology, specifically to prepare scientifically for new ocean measurements from the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission in the program of record or the Surface Biology and Geology (SBG) and the Aerosol and Cloud, Convection and Precipitation (ACCP)-designated observables recommended by the NASEM report, [Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space](#).
- e. Research to advance foundational optical oceanography with an eye on the next decade of ocean biology remote sensing.
- f. Successor studies that clearly demonstrate past performance and offer to significantly advance the results of prior NASA Ocean Biology and Biogeochemistry research toward meaningful answers to important NASA [Earth Science Research questions](#).

These six research subelements are detailed in the following subsections (2.1-2.6); in some cases, there may be more than one "area" within a research subelement.

NASA makes no commitment to funding proposals in each of these areas, and for those areas for which proposals are funded, NASA will base the number of proposals selected for the different areas on a combination of programmatic priorities and quality of the submitted proposals.

2.1 Analyses of Vulnerability and Shifts of Aquatic Ecosystems

The global ocean is being rapidly transformed in response to anthropogenic climate forcings, which alter its physical, biological, and chemical properties. These changes are happening at semi-annual, annual, and decadal time scales, and have a direct impact on aquatic ecosystems, including loss of species habitat and degradation, with economic and other consequences for humans who depend on these resources. Indeed, the Intergovernmental Panel on Climate Change (IPCC) [Special Report on the Ocean and Cryosphere in a Changing Climate](#) notes the risk of severe impacts to ecosystem structure and function under current emissions scenarios, thus making it a priority to understand how aquatic ecosystems have already been altered under climate change, to understand the intensity and frequency of such climate-driven disturbances on these ecosystems, and to improve predictions of aquatic ecosystem response to global ocean change. Deciphering, understanding, and quantifying the impact(s) of climate change on aquatic ecology are paramount to adequately devise strategies for mitigation and/or adaptation. However, identifying the response of aquatic ecosystems to climate change represents a challenge since it requires complementary types of observations to capture the complexity of the ecosystem. Oftentimes, such observations must be collected over long periods of time to avoid aliasing and to capture time of emergence (ToE) of ecosystem response to climate change. While large-scale climate change is important, marine ecological systems respond to local climate and environmental conditions, rather than to basin-scale or global averages. In addition, ecosystem sensitivity and resilience will vary depending on the organisms and the regionally distinctive stressors or forcings that may impact them. Whether marine ecosystems endure or disappear under changing ocean conditions will depend on their suitability to adapt, how the climate is changing, and our ability to manage the Earth and its resources.

This subelement seeks investigations in two main areas:

- Area 1. New quantitative remote sensing analyses of impacts to and vulnerability of aquatic ecosystems to global environmental or climate variability and change. Of particular interest are coastal areas and interactions between the open ocean and coastal areas.
- Area 2. Research focused on understanding changes in aquatic ecological patterns, habitat shifts, and effects of environmental change on biological or ecological community structure that utilize multi-platform remote sensing and other observational data. Of particular interest are ecosystems in high-latitude and tropical regions.

2.1.1 *Area 1: New analyses of impact and vulnerability*

Biological and ecosystem variability and change in response to a changing climate are anticipated to be greater in the coastal ocean (including islands) than in the open ocean. Responses of local biology to climate shifts will have important implications for coastal species and ecosystem services on which humans depend. In addition, the complex coastal conditions (e.g., freshwater interfaces, large sediment and nutrient inputs, high temporal variability, etc.) can mask and complicate the detection of trends and changes. But coastal regions are not isolated; they are impacted by, and exert an influence on, the open ocean. To understand future impacts on and vulnerability of coastal

ecosystems to changing conditions, it is necessary to measure aquatic ecosystem properties across biological, physical, and chemical boundaries and better integrate coastal observations within regional and global frameworks and models.

Research proposed under this area must be integrative, and utilize remote sensing observations to identify significant ocean biology and ecology impacts and vulnerabilities in response to global climate and environmental variability and change, to understand the processes controlling them, and to assess and quantify the likely magnitude of change(s). Proposals must offer compelling rationales as to (1) why the impacts and/or vulnerabilities to be studied are expected to be highly significant, representing major perturbations to the Earth system, and (2) how the remote sensing data and data products to be utilized in the study provide unique and powerful information for addressing the research issues/questions posed. The proposal must also provide a clear definition of the "geographic" boundaries of the ecosystem under study. Ecosystem in this context could be defined on any number of scales but must be clearly defined for the study, and MUST be compellingly defined and justified in the global context.

2.1.2 Area 2: Understanding environmental change utilizing multi-platform data

High-latitude ecosystems, in particular in the Northern Hemisphere, have experienced some of the most dramatic warming during the past century, which has resulted in critical ecosystem shifts and changes. Tropical aquatic ecosystems are highly productive and contain a disproportionate amount of global biodiversity; however, tropical ecosystems are subject to a range of stressors and societal pressures, are critically under-sampled, and are challenging to observe by satellite because of persistent cloudiness and limited on-ground calibration/validation information. NASA seeks proposals in this area that utilize existing in situ/field data - in particular bio-optical data (See Sec. 3.4) - in conjunction with satellite and/or NASA airborne measurements to investigate (1) how marine ecosystems have been altered under climate change, (2) what have been the main causes of change, and (3) how the system is anticipated to continue changing in the future in response to further climate change. As marine ecological systems respond to local climate and environmental conditions, local/regional studies are of interest, but proposals must provide a rationale for investigating a particular ecosystem and region, and explain the importance of such choices within the global context. In addition, research ideas with a tie to applications, such as ecosystem management, economic valuation, sustainability, etc., are sought. Utilization of Earth system model experiments, in conjunction with in situ/field data to better understand the ramifications of climate change on aquatic ecosystems are also encouraged. Collaborations with field research organizations and scientists already working in established time-series or ecological programs are welcome.

2.2 Development of New and/or Multisensor Remote Sensing Approaches

Continuing research is needed to develop, evaluate, and utilize new data analysis methodologies for extracting biological, ecological, and biogeochemical information from space-based observations of the ocean. This research applies to new uses of historical, existing, and new airborne and/or spaceborne satellites or sensors such as, but not limited to, Hyperspectral Imager for the Coastal Ocean (HICO), Global Ecosystem

Dynamics Investigation (GEDI), Orbiting Carbon Observatory (OCO)-2, OCO-3, DLR Earth-Sensing Imaging Spectrometer (DESI), ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS), Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), Airborne Visible/Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG), Portable Remote Imaging Spectrometer (PRISM), High Spectral Resolution Lidar (HSRL), and Second-generation Global Imager (SGLI). This research includes utilization of data from Earth Venture-Suborbital (EVS) efforts such as the North Atlantic Aerosols and Marine Ecosystems Study ([NAAMES](#)) and the Coral Reef Airborne Laboratory ([CORAL](#)). Multisensor research approaches are especially important and relevant given that abundant, complementary types of satellite and airborne observations are now available, as are adequate computational resources and analytical tools.

This sub-element specifically solicits research to apply new combinations of data and/or data products from different sensors, and to demonstrate their suitability for answering key ocean biological, ecological, and biogeochemical science questions. These investigations MUST use NASA airborne or satellite data as one primary research tool. Exploratory studies and projects that demonstrate new scientific applications are relevant. Studies to actively utilize such data and data products in ocean biological and biogeochemical modeling, synthesis activities, and diagnostic analyses are of interest. This opportunity is not appropriate for the production of major, new Earth System Data Records (ESDR).

2.3 Detection, Quantification and Analysis of Marine Debris

Marine debris is a major threat to ocean ecosystems and human health and poses new risks to ocean safety. Plastic debris is ubiquitous in all marine environments, from shorelines to coasts, the open ocean's surface, its water column, and the deep sea. Marine debris is a global problem; it is durable, and is able to survive long travels from the continents where it originates, across the vastness of the ocean. Marine debris is transported by ocean currents, winds, waves, and turbulence. These factors dictate aggregation pathways and areas in the ocean and on the coastline. Unfortunately, the current level of understanding of sources, transport, fate, and impacts of marine debris is low. This knowledge gap not only impedes the identification of effective solutions for marine plastic debris, but it also prevents decision-makers from effectively mitigating emerging threats to human health, such as hazards from microplastics. Because of the global nature of the marine debris problem, satellite remote sensing is particularly poised to provide solutions in terms of tracking, assessing, and quantifying marine debris. However, remote sensing of marine debris is in its infancy. The ocean surface is tremendously complex, and the broad diversity of types of debris (e.g., chemical composition, geometric shape, etc.), coupled with the different factors controlling plastic distribution, make identification and tracking of floating marine debris a challenge.

While imaging spectroscopy offers great potential for the detection and characterization of marine debris, there is still a lot of work to be done in this arena (e.g., better characterizing reflectance properties with the degree of submersion of plastics, impact of weathering degree on reflectance magnitude, impact of biological growth on spectral signal, etc.). This sub-element seeks to advance the area of remote sensing of marine debris by specifically focusing on (1) developing new approaches that use passive or

active satellite and/or airborne radiometric techniques to detect and characterize marine debris, and (2) improvements to atmospheric correction approaches that take into consideration potential contributions of plastics in the open ocean. Of particular interest are investigations that will advance the potential capabilities of future missions described in the NASEM report, [Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space](#), for the detection of marine debris. Also of interest are proposals that, as part of the research, will contribute to the expansion of spectral libraries of marine debris. Proposers are encouraged to use, in addition to NASA and non-NASA Earth observing satellite sensors currently in orbit, data acquired by the Commercial SmallSat Data Acquisition Program ([CSDAP](#); see Section 3.1 below and A.1 the [Earth Science Research Overview](#)).

2.4 Preparing for New Ocean Measurements

Spectral radiometry is a very useful tool to infer many aquatic biogeochemical properties, and hyperspectral radiometry is particularly useful, especially in rapidly changing regions such as coasts and inland waters. Hyperspectral imaging data can delineate signatures of phytoplankton taxonomic diversity and particle size distribution, as well as the characteristics and conditions of shallow submerged systems such as coral reefs and seagrasses. In addition to hyperspectral imaging, active remote sensing such as lidar can provide information on phytoplankton composition and distribution, as well as organic carbon pools, down to three optical depths, complementing and expanding observations from passive radiometry.

The 2017 NASEM report, [Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space](#), recommends Observing System Priorities to be developed over the next decade, beyond what is in the program of record (PoR). [Surface Biology and Geology](#) (SBG) is one of the identified designated observables, and its Science/Applications Objectives include surface biology, functional traits of inland and near-coastal aquatic ecosystems, and gross primary production (GPP). [Aerosol and Cloud, Convection and Precipitation](#) (A-CCP) is also one of the designated observables whose objectives include advancing seasonal and interannual climate variability and prediction (note that NASEM identified separate observables for Aerosols and for Clouds, Convection and Precipitation, but given the overlaps and synergy among the observables, NASA has chosen to combine the ongoing studies into a single integrated observable). In addition to the 2017 targeted observables, the NASEM report supports the implementation of the PoR, which includes the [Plankton, Aerosol, Cloud, ocean Ecosystem](#) (PACE) mission. NASA is currently developing Agency [Designated Observables](#) (DOs) science, applications, and architecture options within the costing profiles identified by the NASEM report, including SBG and A-CCP, in preparation for potential future formulation activities. Research and applications studies and activities will be critical to provide the required information and material to achieve the PoR and DO objectives. This sub-element specifically seeks to advance preparatory work focused on aquatic biology and ecology in anticipation of PACE, SBG, and A-CCP.

2.4.1 *Plankton, Aerosol, Cloud, ocean Ecosystem Mission*

PACE science is expected to significantly advance aquatic ecology and biogeochemistry research both in the open ocean and in coastal and inland regions

(including estuaries, tidal wetlands, and lakes). In 2020, NASA selected the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Science and Applications Team; the team will develop and create data products to address basic and applied research, specifically exploiting the unique capabilities of the PACE observatory. This subelement welcomes research in ocean ecology that will lay the scientific groundwork in observations, modeling, and research for the new ocean measurements from PACE, in particular focusing on the [PACE inherent optical properties – Gaps Matrix](#). Additional supporting PACE science publications are available on the [PACE Website](#). Proposers must utilize data from precursors to the PACE instruments (Ocean Color Instrument [OCI], Hyper-Angular Rainbow Polarimeter [HARP]-2, and Spectro-polarimeter for Planetary Exploration [SPEXone]), such as [HICO](#), [DESI](#), [AVIRIS](#), [PRISM](#), AirHARP, AirSPEX, Multi-angle Imaging SpectroRadiometer (MISR), Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL), and hyperspectral synthetic data sets developed prior to launch.

2.4.2 Surface Biology and Geology

Over the past year, the SBG Study Team has developed a [Science and Applications Traceability Matrix](#) (SATM), using input from a range of science communities and the four working groups within the SBG Study Team (Applications, Algorithms, Modeling and Calibration/Validation). It is anticipated that SBG science will provide critical information on aquatic biochemistry and ecosystems in coastal regions, estuaries, tidal wetlands, and lakes, as well as on functional traits and health of inland and near-coastal aquatic ecosystems such as macroalgae, seagrasses, and corals. This sub-element specifically solicits theoretical and analytical studies for the development of one or more algorithms or approaches - including cross-instrument approaches - for ocean color products that are analog to the anticipated hyperspectral data to be produced by the SBG mission. Example analog datasets include, but are not limited to, [HICO](#), [DESI](#), [AVIRIS](#), [AVIRIS-NG](#), and [PRISM](#).

2.4.3 Aerosol and Cloud, Convection and Precipitation

With input from the relevant scientific communities, the A-CCP team has developed a [Science and Applications Traceability Matrix](#). The A-CCP mission is contemplating a variety of instruments for the mission architecture, including a lidar, which would be fundamental for observations of ice clouds and aerosols. As demonstrated by the Cloud-Aerosol Lidar with Orthogonal Polarization ([CALIOP instrument](#)), these high-resolution measurements can also capture a variety of important aquatic biogeochemical and ecological characteristics, such as ocean carbon biomass and the vertical distribution of ocean primary producers through cloud and aerosol layers globally, year round, and trustworthy down to three optical depths—which is not possible using passive radiometry. Future ocean-optimized satellite lidars will be able to obtain vertically resolved profiles of phytoplankton biomass; potentially discriminate phytoplankton functional types, bloom phenology, and particle size distribution; and further improve retrievals of phytoplankton biomass at high-latitudes during winter, at night, and through clouds and thick aerosols. In addition, such measurements would provide complementary observations and added value to missions such as PACE. This sub-element welcomes research that advances theoretical and analytical studies focused on lidar for ocean biology measurements with an eye towards potential

contributions to the A-CCP mission. Examples of potential studies include furthering the current state of knowledge about the shape and concentration of marine particles, as well as the development of radiative transfer codes to better understand the laser path for diverse oceanic water types through the use of analog data sets such as [HSRL](#) and [CALIOP](#).

2.5 Research to Advance Foundational Optical Oceanography With An Eye On The Next Decade Of Ocean Biology Remote Sensing

Over the past two decades, there have been significant advances in ocean color remote sensing and the foundational optical oceanography techniques that are needed to ensure that the variations of light in response to different constituents within the ocean surface layer are accurately interpreted to derive concentrations of biogeochemical constituents and inherent optical properties. Several methods have been developed to estimate the concentration and type of seawater constituents, size distribution of particles, and chemical composition of particulate and dissolved matter. As technological advances propel us into the next decade of biological and biogeochemical ocean measurements, novel core optical oceanography approaches are needed that will capitalize on the new technologies at our disposal. For example, there are fundamental geophysical properties that can only be retrieved with novel techniques such as polarimetry and lidar. These measurements will complement standard ocean color products and provide a more comprehensive view of our dynamic ocean. Research is solicited to further advance core optical oceanography related to biological and biogeochemical remote sensing, with an eye to new space-based measurements being developed over the next decade on missions such as [PACE](#), and the designated observables currently under planning (e.g., [SBG](#)). Contributions to the recently selected Earth Venture Instrument Geosynchronous Littoral Imaging and Monitoring Radiometer ([GLIMR](#)) are also welcome. Areas of interest include, but are not limited to, studies to develop and evaluate algorithms and analysis strategies that address the utility of ultraviolet observations from space, complementary optical approaches in support of water quality measurements, remote sensing in polar seas, and determination of phytoplankton functional types.

2.6 Successor Studies

This sub-element provides opportunities for integrative research relevant to the goals and objectives of the OBB Program that will significantly advance the results of prior OBB-funded research toward addressing Science Mission Directorate goals and the [Carbon Cycle and Ecosystem Focus Area](#) research questions, and enhance current and future NASA missions. EXPORT Processes in the Ocean from Remote Sensing (EXPORTS) and EXPORTS-related research will not be considered under this sub-element. In 2020, EXPORTS will complete its second and last field campaign in the North Atlantic, and the synthesis phase of the project (Phase 2) is anticipated to be solicited no earlier than 2021. Successor proposals and follow-on research from past NASA OBB research projects submitted to this sub-element must (1) offer demonstrable scientific advances beyond the earlier study, and (2) explain the continuing relevance and priority of the research to be pursued within the framework of the OBB Program. If new studies do not cite the specific prior NASA OBB-funded study, do not document the progress made in that study, and do not provide explicit information on how the

continuation will significantly advance the understanding of the research question (beyond simply incremental science), then the proposed research will be considered nonresponsive to this element.

3. Programmatic Information

3.1 Required Elements for Proposals

All proposals submitted in response to this program element must include (1) a discussion in the Scientific/Technical/Management Section describing how errors and uncertainties will be addressed (see Section 3.2) and (2) a description in the Data Management Plan that addresses the dissemination and sharing of research results and compliance with NASA Earth Science data policy (see Sections 3.3). Unless specified in this section, proposals should follow the format and instructions provided in the [NASA NRA/CAN Guidebook for Proposers](#), which describes the policies and procedures for submitting responses to the Agency's Broad Agency Announcements.

Substantive use of remote sensing data is required in all studies. Proposers are encouraged to use, in addition to NASA and non-NASA Earth observing satellite sensors currently in orbit, data acquired by the Commercial SmallSat Data Acquisition Program ([CSDAP](#); refer also to A.1). Proposers may use the commercial data that have been previously acquired by NASA for scientific purposes at no cost to Principal Investigators (PIs), in adherence to vendor-specific terms and conditions and subject to scientific use licenses. An up-to-date list of available data and associated licenses can be found at <https://earthdata.nasa.gov/csdp>.

3.2 Requirement to Address Errors and Uncertainties

Characterization of uncertainties will be essential in all analyses proposed to be undertaken under this program element. 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. This explanation must include characterization of uncertainties and quantification of errors associated with data, analytical approaches, model results, and scientific interpretations. This discussion must be described in the Scientific/Technical/Management Section of the proposal.

3.3 Requirement for a Data Management Plan (not to exceed two pages)

The data management plan (DMP) must be placed in a special section of the proposal, entitled "Data Management Plan." All proposals must contain this section. The DMP may not exceed two pages in length and must immediately follow the references and citations for the Scientific/Technical/Management Section of the proposal. The two-page DMP section does not count against the 15-page limit of the Scientific/Technical/Management Section. Formatting requirements for DMPs are the same as for the Scientific/Technical/Management Section. The DMP section must include, as 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 in compliance with [NASA Earth Science Data and Information Policy](#). A valid DMP may include only the statement that no detailed plan is needed, as long as a clear justification is provided. The DMP must describe how errors and uncertainties

will be reported, including the data and products to be shared and archived. Additional information about data management is available at the Oak Ridge National Laboratory ([ORNL\) Distributed Active Archive Center \(DAAC\) Web site](#). For any new data sets proposed, the DMP must include plans for quality assessment, timely public release, and long-term archive of the data set(s). Consistent with the DMP, costs needed to support all data management activities, including quality assessment, documentation, data and product sharing, and preparation for long-term archive, must be included in the budget presented in the proposal. In addition, the person(s) within the proposing team responsible for data management must be identified, and the time to be devoted to data management detailed in the table of personnel effort. NASA strongly encourages allocating resources within the proposal budget to adequately address data management needs.

If the data are to be archived in the [SeaWiFS Bio-optical Archive and Storage System](#) (SeaBASS), within the Ocean Biology Distributed Active Archive System (OB.DAAC), proposers are asked to provide, in addition to the types of data generated in the form of a list or table, plans and a timeframe for submission to SeaBASS; an example may be found in Table 1, below. If the dataset is not anticipated to be submitted within a year after collection, proposers must provide a brief explanation justifying the time needed for submission. For each dataset, proposers should identify the method for collection or instruments, briefly describe the data type, and specify the expected data size. Data collection and analysis methods are expected to follow community-vetted protocols, and datasets must be accompanied by complete documentation and calibration information (see "Contribute Data" sections of the [SeaBASS website](#)). Datasets will be reviewed for compliance after submission.

Table 1 Example of data table detailing the type of information that will be submitted to a data repository

Data Parameter	Instrument/ Method	Dataset size	Submission timeline (after collection)	Repository	Explanation/comments
Beam attenuation coefficient	AC-s ¹	<1Gb	4 months	SeaBASS	
Particle size distribution	UVP ²	<1Gb	4 months	SeaBASS	
Particle images	UVP	1 TB	15 months	SeaBASS	Images require intense validation

¹Spectral Absorption and Attenuation Sensor

²Underwater Vision Profiler

3.4 Requirement regarding the use of existing in situ/field data

Sub-element 2a requires the utilization of existing in situ/field data in conjunction with satellite and/or NASA airborne data. This approach includes data collected through past NASA projects, autonomous and ship-based time series, bio-optical and biogeochemical floats (e.g., the Southern Ocean Carbon and Climate Observations and Modeling project, [SOCCOM](#)), etc. NASA encourages the utilization of its repositories as sources of data, in particular [SeaBASS](#), which archives in situ oceanographic and atmospheric data, and is maintained by the NASA Ocean Biology Processing Group (OBPG). Complementary data from other data repositories are also welcome.

4. Other Proposal Requirements

All proposals submitted in response to the OBB Program sub-elements of this program element must explain the significant advance in scientific understanding anticipated and its societal relevance. Substantive use of remote sensing data is required in all studies.

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 a complete suite of acetone-extractable HPLC pigment analysis is \$100 per sample at the [NASA-supported analytical facility](#). Approximately 5% of the pigment samples should be submitted in duplicate for assessment of replicate sample precision. Proposed budgets must also include shipping costs of samples and return of the 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 subset of duplicate samples (~10% of total) to the NASA GSFC facility and budget for these samples accordingly. This allows for lab-to-lab intercomparison of pigment results and assessment of uncertainties.

Proposers must budget to attend one Ocean Color Research Team (OCRT) meeting or equivalent each year in the United States (e.g., PIs should budget a four-day trip to the farthest coast once per year).

Any data collected will be subject to the standard [NASA Earth Science Data and Information Policy](#). Proposals planning to collect field data should contain a table that, to the extent possible, details what data will be collected and specifies the cruise or field visit and date(s) when data will be collected. The table should also provide a detailed plan for data submission to a NASA data center, such as [SeaBASS](#), within one year of collection or as soon as the data completes quality assurance/quality control (QA/QC). This table should be included in the Data Management Plan (See Section 3.3).

4.1 Requirement Regarding Duration of Study

The maximum duration of an award under this program element is three (3) years. Proposers must document and carefully justify the need for the amount of time requested. It is possible that many activities that exploit existing data sources, as well as some follow-on or successor studies, can be completed within a shorter amount of time.

4.2 Requirement for Proposals Requesting Acquisition of New Airborne or Shipborne Data, or Other Platform Needs.

Investigators should make clear any special requirements or platform needs, e.g., airborne data acquisition, ships/ship modifications, additional boats, and/or specific sampling requirements in a separate section of no more than one page immediately following the Data Management Plan. This special platform requirement section does not count against the 15-page limit of the Scientific/Technical/Management section.

To request NASA High-End Computing (HEC) resources for the proposed research, please refer to Section I(d) of the NASA Research Opportunities in Space and Earth Science (ROSES) Summary of Solicitation and the [HEC](#) website.

Proposals requiring data from airborne sensors must detail in the 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 (including costs for 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> (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 platform (e.g., vessel or aircraft) is not a NASA asset, proposers must take responsibility for making all arrangements to secure the availability of the needed platform 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 platform.

4.3 Work Effort Table and Current & Pending Support (no page limit)

Proposers must use the Earth Science Division's standard templates for detailing the level of work effort for project participants and for the current and pending support of project participants. These templates are available at <https://science.nasa.gov/researchers/templates-for-earth-science-division-appendix-a-roses-proposals>. The table of work effort must be placed immediately following the budget narrative.

5. Programmatic Information

5.1 Eligibility

This program element is open to all categories of institutions interested in conducting research that directly addresses the objectives of the [Ocean Biology and Biogeochemistry Program](#). Proposals from non-U.S. organizations will be funded on a no-exchange-of-funds basis (see Appendix A of the [NASA NRA/CAN Guidebook for Proposers](#)). Collaborations between researchers at U.S. and non-U.S. organizations are welcome, but the portion of the work to be conducted by the non-U.S. institution must be funded through other sources in order to comply with NASA's no-exchange-of-funds policy.

5.2 Proposal Evaluation Criteria

Proposals will be evaluated according to the criteria defined in Appendix D of the [NASA NRA/CAN Guidebook for Proposers](#) and as specified in Section VI(a) of the ROSES *Summary of Solicitation*. In addition to the factors given in the NRA/CAN Guidebook for Proposers, the evaluation shall take into account the following considerations:

- The quality and completeness of the Data Management Plan
- The expertise 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

While it is expected that proposals will be selected in each of the sub-elements, the Earth Science Division reserves the right to select proposals in none, some, or all of the sub-elements, depending on the nature and distribution of proposals received and the outcome of the peer review process.

6. Summary of Key Information

Expected annual program budget for new awards	Up to \$3.5 M
Number of new awards pending adequate proposals of merit	~ 10-15
Maximum duration of awards	Up to 3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA.
Due date for Proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	February 2021
Page limit for the central Scientific/Technical section of proposal	15 pp; see also Table 1 of the <i>ROSES Summary of Solicitation</i> and the NASA Guidebook for Proposers
Relevance	This program is relevant to the Earth science strategic goals and subgoals in NASA's Strategic Plan. 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> .
General requirements for content of proposals	See Section IV and Table 1 of the <i>ROSES Summary of Solicitation</i> and Section 3 of the NASA Guidebook for Proposers .
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the NASA Guidebook for Proposers and Section IV(b) of the <i>ROSES Summary of Solicitation</i> .
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.

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	NNH20ZDA001N-OBB
points of contact concerning this program both of whom share this address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Laura Lorenzoni Telephone: (202) 358-1709 Email: laura.lorenzoni@nasa.gov Paula Bontempi Telephone: (202) 358-1508 Email: paula.bontempi@nasa.gov