A.3. OCEAN BIOLOGY AND BIOGEOCHEMISTRY

NOTICE: Amended March 20, 2017. Text concerning the duration of awards has been corrected to explicitly state that only Science Lead proposers may plan on a fourth year of activities; all other proposers may budget only up to three years. Sections 1, 3.1, 3.2, 5.3 and 6 have been updated to reflect this correction. Moreover, small corrections have been made in Sections 4.1 and 4.2.3. The Step-2 proposal due date has been delayed to April 21, 2017. The new planning start date for awards is August 15, 2017. New text is in bold and old text is struck through.

NOTICE: Amended January 12, 2016. This amendment releases final text for A.3 Ocean Biology and Biogeochemistry program, which had previously been listed as To Be Determined (TBD) in ROSES-2016. This program accepts proposals by a two-step process, in which the Notice of Intent is replaced by a mandatory Step-1 proposal submitted by an Authorized Organizational Representative (AOR). See Section 5.2 for details. Required Step-1 proposals are due by February 13, 2017, and Step-2 proposals are due April 13, 2017.

Proposers to this program will not be asked to submit a data management plan via the NSPIRES cover pages, as it is included in the proposal PDF and evaluated as part of Merit, see Sections 4.2.3 and 5.4.

1. Scope of Program

NASA's Ocean Biology and Biogeochemistry (OBB) program focuses on describing, understanding, and predicting the biological 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. Additionally, NASA Ocean Biology and Biogeochemistry research addresses changes in Earth's carbon cycle and ecosystems using space-based observations in order to improve understanding of the structure and function of global aquatic ecosystems, their interactions with the atmosphere and terrestrial systems, and their role in the cycling of the major biogeochemical elements.

The focus of this program element is the initial research to begin the EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) field campaign – a large-scale field campaign that will provide critical information for quantifying the export and fate of upper ocean net primary production (NPP) from satellite observations. The overarching goal of EXPORTS is to develop a predictive understanding of the export and fate of global ocean primary production and its implications for the Earth's carbon cycle in present and future climates.

Research that will be carried out as part of EXPORTS will link field-based, process-level studies with geospatial data products derived from satellite sensors, building a foundation for improving the analysis and modeling capabilities needed to understand the export and fate of ocean net primary production and predict how such changes will impact the global carbon cycle. It is envisioned that a successful EXPORTS program will (1) create a predictive understanding of both the export of organic carbon from the well-lit, upper ocean (or euphotic zone) and its fate in the underlying twilight zone (depths of 500 m or more), where a variable fraction of that

exported organic carbon is respired back to CO_2; (2) generate a new, detailed understanding of ocean carbon transport processes and pathways linking phytoplankton primary production within the euphotic zone to the export and fate of produced organic matter in the underlying twilight zone using a combination of field campaigns, remote sensing, and numerical modeling; and (3) establish mechanistic relationships between remotely sensed signals and carbon cycle processes, thereby ensuring the ability of the NASA oceanographic community to successfully achieve the scientific goals associated with its future satellite missions.

The scientific rationales and overall societal importance for EXPORTS, as well as specific science questions to be addressed and the study's top-level requirements, are documented in the *EXport Processes in the Ocean from RemoTe Sensing (EXPORTS): A Science Plan for a NASA Field Campaign* document, which may be found at http://cce.nasa.gov/cce/pdfs/EXPORTS_Science_Plan_May18_2015_final.pdf.

EXPORTS will contribute to the priorities of the U.S. Global Change Research Program (USGCRP) and National Ocean Council (NOC) by providing critical information that will expand our current understanding of the export and fate of organic matter from the surface ocean to the deep ocean, and the impact of the vertical transport of carbon in the ocean on the current and future global carbon cycle. The USGCRP Carbon Cycle Interagency Working Group has goals that include conducting research that responds to the vulnerability of carbon fluxes and stocks and predicting the effects of different CO_2 and climate change scenarios on ecosystems (http://www.globalchange.gov/about/iwgs). Additionally, the Executive Order establishing the National Ocean Council (https://www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes) calls for increased scientific understanding of ocean ecosystems as part of the Earth system, including their relationships to humans and their activities, and improved understanding of changing environmental conditions, trends, and their causes in oceans.

The region of study for EXPORTS, hereafter referred to as the EXPORTS Study Domain, is shown in Figure 1. The study design for EXPORTS calls for a phased implementation (Phase I

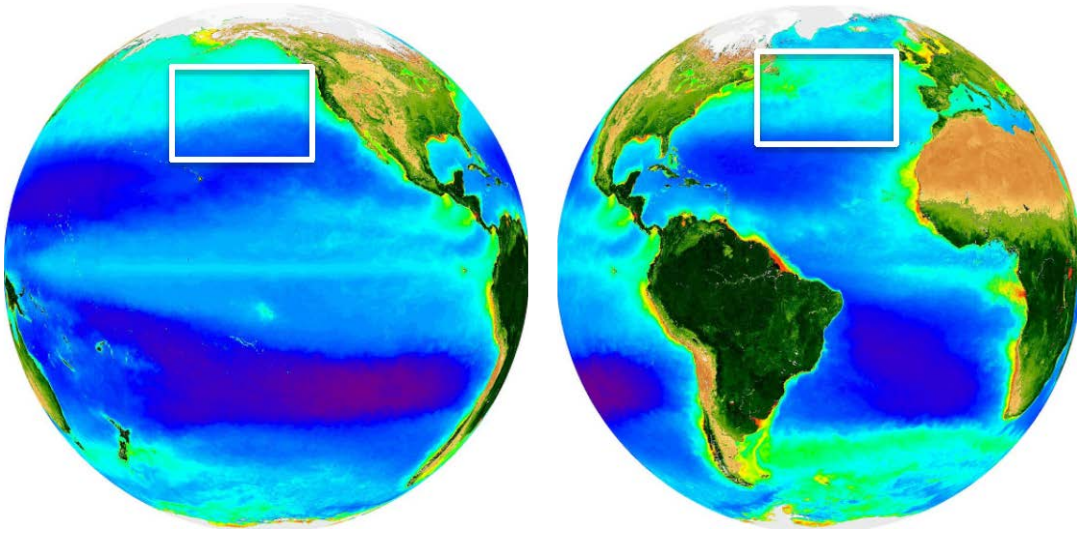

Figure 1. The EXPORTS Study Domain is depicted on this global biosphere image of (left) Northeast Pacific and (right) North Atlantic. The areas outlined by boxes are the proposed core study regions, which may shift based on the results of ongoing data mining and OSSEs.

and Phase II) over a total of eight years of research (Figure 2), with the first investigations starting in late Fiscal Year (FY) 2017 (late summer 2017). Coordinated EXPORTS activities will be conducted in two phases: a first three to five-year period (Phase I), emphasized on field work and modeling efforts to sample the range of ecosystem states needed to address the carbon/organic matter transport pathways, followed by a second two to three-year period focused on field data synthesis research, and integration of research findings for the global carbon cycle and carbon-ecosystem modeling. The way this timeline is organized will enable advanced biogeochemical and carbon-focused satellite algorithms to be developed and tested during the lifetime of EXPORTS and using EXPORTS observations, which will later be applied by NASA's upcoming advanced ocean measurement mission, the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission. PACE will be aimed at quantifying carbon cycle processes far beyond today's ocean color retrievals of phytoplankton biomass proxies (e.g., chlorophyll *a*), focusing on carbon cycle and ecosystem properties of Earth's ocean.

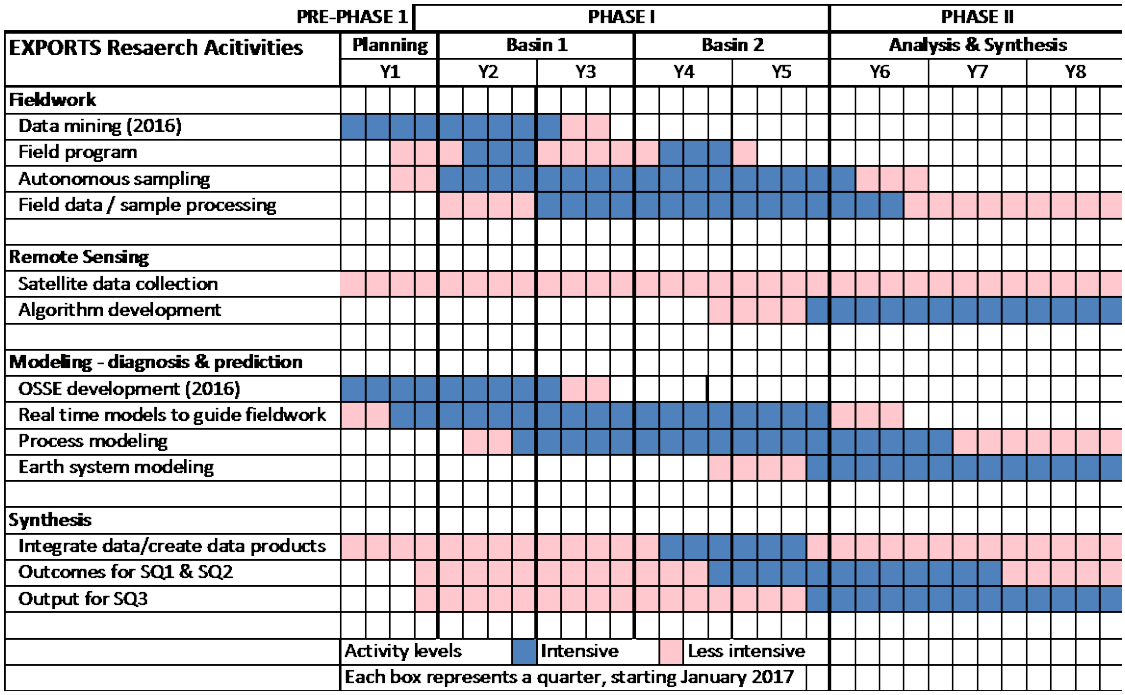

Figure 2 – A **generic** timeline for conducting research activities in support of the EXPORTS field campaign. **Contingency time to account for delays in awards/cruises is also depicted.** Research solicited in this program element pertains exclusively to Phase I **(three years) [Amended March 20, 2017].**

This program element invites proposals for research investigations to participate in the EXPORTS field campaign (Phase I activities), to address the EXPORTS Science Plan goals and objectives, and refine the *EXPORTS Implementation* Plan, as needed. The selected EXPORTS

Science Team will further refine the EXPORTS study design as presented in the Implementation Plan. The EXPORTS Implementation Plan details ideas concerning how specific activities might be carried out (what, when, where, how, for how long, etc.) and can be modified based upon the investigator studies that are selected for participation by NASA and its partner organizations for EXPORTS. It will be used by EXPORTS managers to organize and better direct their support to EXPORTS researchers, and by EXPORTS researchers as a resource for communication and coordination. The Implementation Plan is cited throughout this document to provide further information and Principal Investigators (PI's) are encouraged to refer to it as needed.

Research proposed must address one or more of the following science questions (SQs), but need not address all four lettered subquestions (See Section 3 for specific details):

SQ1 How do upper ocean ecosystem characteristics determine the vertical transfer of organic matter from the well-lit surface ocean?

- 1a How does plankton community structure regulate the export of organic matter from the surface ocean?
- 1b How do the five pathways that drive export (cf., sinking of intact phytoplankton, aggregates or zooplankton byproducts, vertical submesoscale advection and active vertical migration) vary with plankton community structure?
- 1c What controls particle aggregation/disaggregation of exported organic matter and how are these controls influenced by plankton community composition?
- 1d How do physical and ecological processes act together to export organic matter from the surface ocean?

SQ2 What controls the efficiency of vertical transfer of organic matter below the well-lit surface ocean?

- 2a How does transfer efficiency of organic matter through the mesopelagic vary among the five primary pathways for export?
- 2b How is the transfer efficiency of organic matter to depth related to plankton community structure in the well-lit surface ocean?
- 2c How do the abundance and composition of carrier materials in the surface ocean (cf., opal, dust, particulate inorganic carbon) influence the transfer efficiency of organic matter to depth?
- 2d How does variability in environmental and/or ecosystem features define the relative importance of processes that regulate the transfer efficiency of organic matter to depth (i.e., zooplankton grazing, microbial degradation, organic C solubilization, vertical migration active transport, fragmentation and aggregation, convection and subduction)?

SQ3 How can the knowledge gained from EXPORTS be used to reduce uncertainties in contemporary and future estimates of the export and fate of upper ocean net primary production?

- 3a What key plankton ecosystem characteristics (cf., food-web structure and environmental variations) are required to accurately model the export and fate of upper ocean net primary production?
- 3b How do key planktonic ecosystem characteristics vary and can they be assessed knowing surface ocean processes alone?

- 3c Can the export and fate of upper ocean net primary production be accurately modeled from satellite-retrievable properties alone or will coincident *in situ* measurements be required?
- 3d How can the mechanistic understanding of contemporary planktonic food web processes developed here be used to improve predictions of the export and fate of upper ocean net primary production under future climate scenarios?

As discussed in more detail in Section 3, it is expected that the EXPORTS-relevant activities associated with the suite of selected proposals from this program element will include:

- Development and analysis of remote sensing data products;
- Collection and analysis of field-based (surface, *in situ*) data;
- Modeling investigations; and
- Synthesis investigations.

This program element also invites proposals for an EXPORTS Science Lead (SL; Section 3.2) to provide scientific leadership and direction for EXPORTS and foster efficient communications within the ST and with a wide variety of external audiences.

The scope and complexity of the EXPORTS program require that this program element provide more background information than is usual in typical ROSES calls; similarly, proposers must provide specific, detailed information on their planned contributions and commitments to the broad range of EXPORTS activities. The text of this program element includes Organization and Management (Section 2), including the Project Office (Section 2.1), Data and Publication Policies (Section 2.2); Data Archive (Section 2.3); and potential EXPORTS Partner Organizations, Programs, and Projects (Section 2.4). Section 3 focuses on the type of research being solicited and presents the detailed scientific substance of the program element, including, but not limited to, some background on the EXPORTS objectives, the EXPORTS science questions to be addressed in proposals, and types of investigations requested. Section 4 describes unique required proposal elements, including the Project Management Plan (Section 4.2.1), Resource Needs and Utilization Plan (Section 4.2.2), and Data Management Plan (Section 4.2.3). Section 5 outlines programmatic information, including eligibility, available funds/budget profiles/periods of performance, and proposal evaluation criteria.

Due to the specific required (NOT OPTIONAL) proposal sections, proposers are strongly encouraged to read this program element in its entirety. Failure to include a required section of the proposal will result in a proposal being returned to the proposing institution as nonresponsive.

2. Background on EXPORTS Organization and Management

Some aspects of NASA's organizational structure and management support for EXPORTS will be planned and/or established separately with the support of the Earth Science Project Office (ESPO - https://espo.nasa.gov/). ESPO will facilitate shipments to/from deployment sites, including instrument and laboratory support equipment, as well as supplies required for the fieldwork. In addition, NASA will work directly with University-National Oceanographic Laboratory System (UNOLS) for ship time arrangements.

2.1. EXPORTS Project Office, Earth Science Project Office (ESPO) and Field Operations and Support

NASA will establish a virtual EXPORTS Project Office to support the field activities and operations to be conducted as part of the EXPORTS project. The purpose of the Project Office will be to (1) provide cruise planning and logistical support for cruises and deployments; (2) enhance communication among PI's and domestic and international partners, if needed; (3) help direct different platform operations during cruises; (4) oversee data submission by PIs to central data archives; (5) construct and disseminate synthesized data products; (6) oversee and coordinate archived and sample materials; and (7) organize public, community, and agency outreach activities, including maintaining an EXPORTS' online presence. The Project Office will coordinate data submission timelines and requirements with the PIs (see also Sections 3.2 and 3.3). Investigators should plan to work closely with the Project Office and rely upon guidance from it for field activities and coordination and communications of all EXPORTS-related activities.

The EXPORTS Project Office will be established shortly after the selection of proposals submitted in response to this program element. NASA anticipates that the majority of the EXPORTS Project Office business will be conducted virtually; however, NASA's Earth Science Project Office (ESPO) at the Ames Research Center (ARC) will coordinate and support the EXPORTS Project Office, as needed. NASA has already established an EXPORTS Project Office point of contact within ESPO at the ARC to manage EXPORTS field program implementation and support the EXPORTS Project Office. Field activities and operations to be conducted within the EXPORTS Study Domain will be organized, coordinated, and supported through the efforts of the ESPO. Important aspects include coordination and support for field operations and logistics, safety and risk management, and interactions with partners, as well as web site support in partnership with the SL. Depending on the needs of the selected EXPORTS science team, the ESPO may also arrange for the collection of core variable data. The ESPO will be responsible for managing any airborne science, as needed or proposed. Investigators should plan to work closely with the ESPO and rely upon guidance from its staff for field activities, Science Team Meeting logistics, and communications with partners. The NASA ARC-ESPO point of contact (POC) will be a member to the EXPORTS Project Office. Proposers desiring specific information about the ESPO are encouraged to contact its lead:

Ms. Marilyn Vasques
Earth Science Project Office Director
NASA Ames Research Center
marilyn.vasques@nasa.gov
650-604-6120

The EXPORTS Project Office personnel will work in close coordination with the team of selected PIs, the SL, ESPO, and the agency Program Officer(s). EXPORTS virtual Project Office members will include the SL, the EXPORTS logistics lead designated by the ESPO at NASA-ARC, the EXPORTS program SeaBASS lead designated by NASA Goddard Space Flight Center (GSFC), and the NASA Program Officer(s). Additional members may be added pending NASA Program Officer approval and may include any partner organization's Program Officers and/or partner organization designated Science Leads.

The Project Office will also be responsible for organizing and conducting annual PI meetings. Face to face meetings are essential to ensure that the synthetic activities required to answer the science questions are conducted. To this end, proposers should budget for two three-day EXPORTS team meetings in their first year, and one three-day meeting per year thereafter. Proposers should assume a mix of meeting locations (East Coast and West Coast) within the United States, but should budget meeting travel costs to the farthest coast. PI's are also strongly encouraged to attend the annual NASA Ocean Color Research Team (OCRT) meeting or equivalent within the United States (for the NASA OCRT, PIs should budget a four-day trip to the farthest coast once per year, unless otherwise specified).

2.2 Data and Publication Policies

The EXPORTS PIs will be expected to comply with data and publication policies that respect and recognize the needs of partnering organizations and graduate researchers, while being consistent with NASA data policies as described below. The EXPORTS Project Office and Science Lead (SL), in consultation with NASA Headquarters program managers and EXPORTS partner organizations, will develop and coordinate the implementation of the EXPORTS data and publication policies.

All data collected and all science data products (including important model products) produced under NASA sponsorship will be managed in accordance with the NASA Earth Science Data and Information Policy specified at https://science.nasa.gov/earth-science/earth-science-data/data-information-policy/

Public release of all data shall conform to the NASA Earth Science Data and Information Policy, and there can be no period of exclusive access to the data or data products by either an individual scientist or a science team. A short period of time for processing, calibration, correction, and quality assessment prior to public release is permissible. Some exceptions regarding full public access may need to be established for data obtained from sources that bind users to more restrictive data policies or that are inherently sensitive in nature (e.g., commercial satellite data or confidential human-subjects data).

EXPORTS PI's will be expected to publish and share their data making use of the EXPORTS web interface, NASA's existing cyber infrastructure and partnering data system capabilities (see Section 2.3). A tailored Data Rights section will be applied to the resultant award document, where specific timelines of data release and publication will be stipulated.

2.3 Data Archive

NASA's SeaWiFS Bio-optical Archive and Storage System at GSFC (SeaBASS; http://seabass.gsfc.nasa.gov) will provide the cyber infrastructure for data analysis, management, and archive. SeaBASS is part of NASA's Ocean Biology Distributed Active Archive Center (OB.DAAC). Proposers desiring specific information about the SeaBASS database are encouraged to contact its lead:

Mr. Chris Proctor
Science and Exploration Directorate - Code 616.2
NASA Goddard Space Flight Center

christopher.w.proctor@nasa.gov
301.286.4759

NASA anticipates the possibility that some types of EXPORTS data might be more appropriately archived at another NASA DAAC or other equivalent long-term archive, including those of EXPORTS partner organizations. In these limited cases, NASA Program Officer(s), the SeaBASS team, and the Project Office will assist each investigator in identifying the appropriate archive for their data and products. It is recommended that PI's that anticipate the need for a different data archive identify this possibility in their data management section (refer to Section 4.2.4 of this solicitation). The Project web site will provide updated links to all the data repositories where data have been submitted.

It is anticipated that EXPORTS will also generate synthesized data products in addition to the direct field measurement data. Synthesized data products are created through the integration of direct field measurements and include properties such as export flux, productivity, plankton community structure, organic matter partitioning, etc. These synthesized products are of central importance to answering the EXPORTS science questions and their construction and dissemination will be the responsibility of the Project Office. To this end, the Project Office will work with all PIs to coordinate field reporting and metadata standards within the time allocated for data publication (See Section 2.2). The synthesized data products will be submitted to the appropriate data center and/or published in the EXPORTS website.

PIs who are interested in responding to the modeling synthesis analysis subelement (Section 3.1.2.3) should identify a plan for dissemination and archival of model results as per the data management plan (Section 4.2.4).

The following apply to data and products to be archived:

- The science data product formats from awarded projects shall conform to Earth Science Division (ESD) approved data system standards for data and metadata published at https://earthdata.nasa.gov/data/standards-and-references.
- Prior to the end of the project, awarded projects will be required to deliver all data products, along with any scientific algorithm software, coefficients, and ancillary data used to generate these products, to the DAAC (in most cases, SeaBASS) in keeping with the need to ensure long-term stewardship of the data. [The requirement to archive supporting algorithm software, coefficients, and ancillary data is applied primarily to satellite and airborne data products, but while it may be a best practice to be encouraged, it is not usually applied to other types of data to be archived, such as the wide diversity of field, synthesis and model data that will be produced during EXPORTS].
- All terms and conditions of the transfer of data products and associated information to the archive will need to be documented in the awarded *Data Management Plan* (see Section 4.2.4).

2.4 EXPORTS Partner Organizations, Programs, and Projects

Considering the multidisciplinary nature of EXPORTS, NASA welcomes collaborations with other field research groups and programs working within the EXPORTS Study Domain, with the aim of building strong, mutually beneficial partnerships. EXPORTS addresses ambitious science

questions and there have been and currently are other ongoing research projects with similar interests in better understanding the export and fate of global ocean primary production and its implications for the carbon cycle.

NASA anticipates that collaborative activities during EXPORTS will vary in nature and level of commitment depending on the objectives and capabilities of each partner, but could involve, for example, collecting or exchanging complementary data within the Study Domain, developing Synthesis Data Products, sharing access to research infrastructure, providing logistical support, supporting additional research investigations, participating in joint or parallel solicitations for research investigations, and collecting analogous data to EXPORTS in another region of the world's oceans. Discussions continue with several organizations that have expressed interest in collaborating with NASA during EXPORTS, including some already carrying out significant research in the EXPORTS Study Domain.

A description of potential partnerships is also provided in the EXPORTS Implementation Plan (http://cce.nasa.gov/ocean_biology_biogeochemistry/exports/documents/Implementation_Plan.pdf; refer to Sections 4.7 and 7.6). This informal, nonexhaustive list reflects those organizations or programs that have presently overlapping interests with EXPORTS and are comfortable in being identified as potential partners. NASA expects its partnerships in EXPORTS to grow and evolve over the course of the study.

3. Types of Proposals Solicited

The study design for EXPORTS calls for an overall six- to nine-year program of research composed of an initial one to two year ramp up of funding and research activities (begun in 2016), a three- to four-year period of peak funding and intensive studies (2017-2020) with the first field activities starting approximately mid-2018 (refer to Section 5 and 6, and Figure 2), and a concluding two- to three-year ramp down of synthesis research focused on continued data analysis and integration of research findings. Annual funding for science investigations should vary based on field years, but is expected to be up to $4M per year beginning in 2017. Any key gaps in scientific studies that are critical to answer key science questions may be the subject of subsequent solicitations. This program element is for a set of research activities to begin the field program and to evolve the *EXPORTS Implementation Plan*, as the study design needs further refining based on selections. Specifically, this program element requests proposals for:

1) EXPORTS ST members to conduct a set of research investigations focused on addressing the three Science Questions for EXPORTS and EXPORTS sub-Science Questions (see the aforementioned Science Questions, including the subquestions in Section 1), and

2) The EXPORTS Science Lead to guide the overall scientific implementation of EXPORTS and serve as Science Team Leader.

All Principal Investigators (PI) on selected projects will become members of – and must demonstrate in their proposals how they will contribute in a sustained way to – the EXPORTS Science Team (ST). The Principal Investigator for each selected proposal will be responsible for his/her investigation's participation in ST activities. The ST will be responsible for setting and advancing the EXPORTS scientific content, direction, and priorities throughout all phases of EXPORTS.

All proposals submitted in response to this program element must explain the significant advance in scientific understanding anticipated and how their study addresses the predictive understanding of the export and fate of global ocean primary production and its implications for the Earth's carbon cycle in present and future climates.

While not all proposals submitted in response to this program element are required to make significant use of remotely sensed data, all proposals must explain any utilization of satellite or airborne observations and the relevance of their investigation in the context of a remote sensing-oriented regional field campaign.

3.1. EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) Research Field Investigations

The EXPORTS research program is a measurement, modelling, and synthesis field program designed to deliver science results of societal relevance (e.g., carbon management, climate adaptation) and understanding the impacts of climate variability and change on the Earth's carbon cycle. Ocean ecosystems play a critical role in the Earth's carbon cycle through net primary production (NPP) processes that fix dissolved CO_2 into organic matter in the well-lit, surface ocean, as well as via the combination of ocean food web and oceanographic processes that lead to the vertical transport of this fixed organic carbon to the ocean's interior, where it is sequestered from the atmosphere on time scales of months to millennia. The spatial and temporal variations in upper ocean food web structure and circulation alter the efficiency of ocean carbon sequestration. Only a fraction of the organic matter formed in the upper ocean is exported from the surface ocean to deeper waters, where its sequestration depends on both the magnitude of the export flux and where that exported organic carbon is respired in the water column. Carbon can flow through different pathways in ocean food webs, with different efficiencies that lead to variations in carbon export and vertical transport.

Our present ability to quantify the export and fate of ocean NPP from satellite observations or to predict future fates using Earth system models is limited. In fact, current estimates of global carbon export flux from the well-lit surface ocean range from 5 to >12 Pg C yr^{-1}, an uncertainty that is as large as the annual perturbations in the global carbon cycle due to human activities. Yet seemingly small changes in the export and fate of NPP carbon can have profound effects on the global carbon cycle. Further, these differences also influence other ecosystem services that the ocean supports (fisheries, biodiversity, etc.). Figure 3 shows a conceptual diagram linking program resources and elements to societal benefits.

The EXPORTS program is built on three Science Questions (SQs; Section 1) whose answers provide a path for the remote monitoring of the export and fates of net primary production (NPP) in the modern ocean. EXPORTS will also improve how we predict these changes under future climates (For more information refer to the EXPORTS Science Plan). To answer these questions, EXPORTS will examine the role of each of the five pathways of organic material transport from the surface ocean into the interior by measuring a suite of observables that are grouped into five key Program Elements (Figure 3). Principal Investigator (PI)-driven projects will address domain-specific science objectives in these key Program Element areas.

Of the three key interrelated questions concerning the fate of ocean NPP (Section 1), Science Questions 1 and 2 focus on how processes in the surface and the subsurface oceans control the export (SQ1) and attenuation (SQ2) of organic matter into the ocean interior. These in turn are

broken down into four subquestions that identify the most significant current uncertainties in our understanding of those ecosystem characteristics that promote export of organic matter and controls on the efficiency of its vertical transfer into the ocean's interior. Science Question 3 asks how the answers to SQ1 and SQ2 improve current and future estimates of ecosystem/carbon cycling processes and their implications on larger time and space scales.

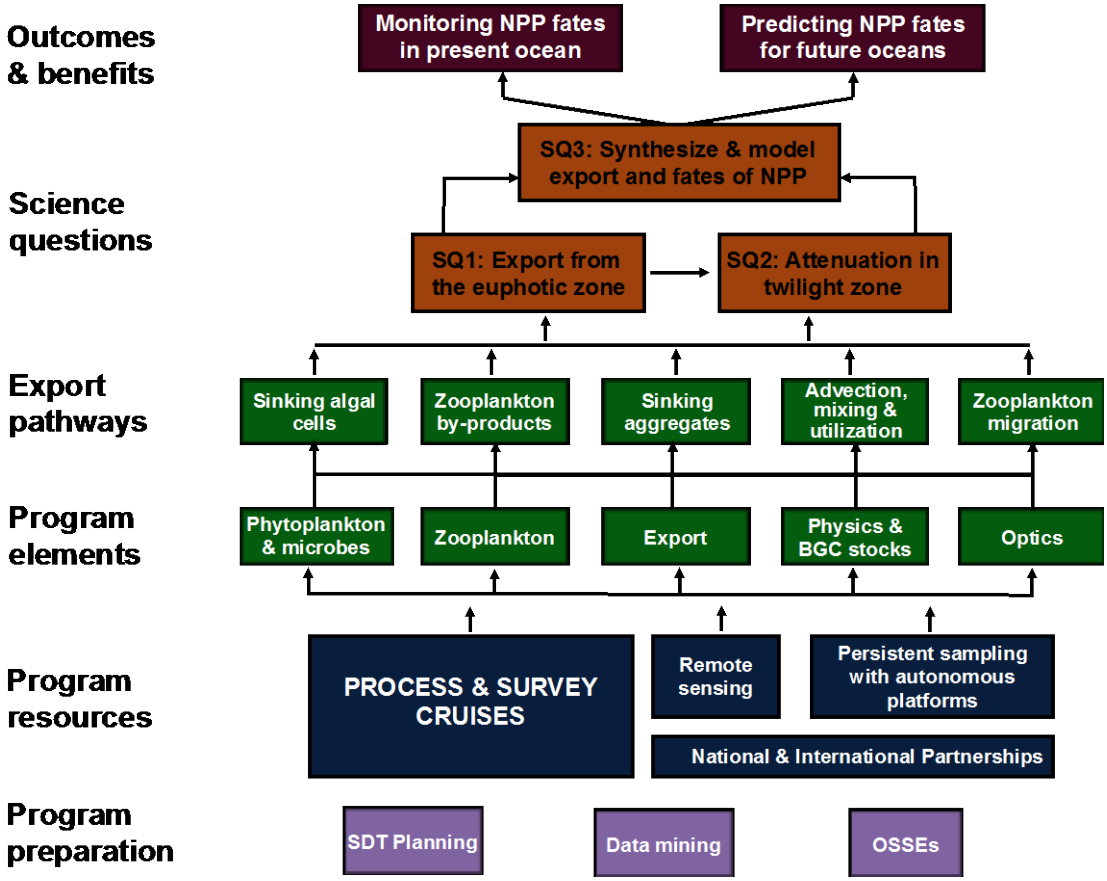

Figure 3 – The EXPORTS conceptual diagram linking program preparation, resources, and elements via export pathways to science questions and societally relevant outcomes.

For this program element, the highest priority will be accorded to research investigations that address how processes in the surface and the subsurface oceans control the export (EXPORTS SQ1) and attenuation (EXPORTS SQ2) of organic matter into the ocean interior (Section 1). However, it is imperative that this research set the stage for addressing the EXPORTS program overarching goal of developing a predictive understanding of the export and fate of global ocean primary production and its implications for the Earth's carbon cycle in present and future climates. Thus, all investigations must address how their research will contribute to a body of knowledge that will enable EXPORTS synthesis and integration phase (Phase II) researchers to address Science Question 3 - how the answers to SQ1 and SQ2 improve current and future estimates of ecosystem/carbon cycling processes and their implications on larger time and space scales (Section 1).

The timeline for EXPORTS (see Figure 2) calls for an emphasis in the first three ~~to four~~ years **[Amended March 20, 2017]** (Phase I) on the Field Work, Remote Sensing Research, and initial Modeling Research to address EXPORTS Science Questions (SQ) 1: What controls the carbon flux exiting the euphotic zone? and SQ2: What is the fate of that export flux in the twilight zone?, to be followed in the second two- to three-years by an emphasis on Data Synthesis, Integration and further Modeling Research to address EXPORTS SQ3: How can the knowledge gained reduce uncertainties in contemporary and future assessments of the ocean carbon cycle? While this program element focuses on and solicits proposals for Phase I and is aimed at answering Science Questions 1 and 2 (refer also to Section 1), it is recognized that modeling in support of Science Questions 1 and 2, which may ultimately be needed to address SQ3, may also take place during Phase I.

Preliminary research in support of Phase I, termed "pre-Phase I" and competed under ROSES-2015, addresses data mining and observational system simulation experiment (OSSE) research, which will contribute to the planning and design of the final EXPORTS field program. In August 2016, NASA announced the funding of six Data Mining and OSSE numerical modeling proposals in support of the EXPORTS field program planning and science (https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=536603/solicitationId=%7BEAB4311C-7130-7F75-BDC2-AB50BCC8A900%7D/viewSolicitationDocument=1/OBB15_Web%20Posting.pdf).

3.1.1. Research Topics

For this EXPORTS program element, highest priority will be accorded to initiating interdisciplinary studies that address the Science Questions 1 and 2:

- How do upper ocean ecosystem characteristics determine the vertical transfer of organic matter from the well-lit surface ocean?
- What is the fate of that export flux in the twilight zone?

as well as their subquestions.

Research conducted as part of EXPORTS will address carbon export (from the well-lit surface layer to the twilight zone), biogeochemical-ecosystem interactions, resulting carbon sequestration, and the prediction of carbon fluxes for present and future oceans and climates. The EXPORTS program's observational focus is on quantifying the mechanisms controlling the export and fate of upper ocean net primary production. The underlying hypothesis of EXPORTS is that changes in food web structure in the surface ocean that are observable using remote sensing (e.g., phytoplankton functional types, particle size spectra and carbon stocks) can be used to quantify the export and fate of upper ocean NPP.

The EXPORTS program will address questions that are associated with processes that are critical to understanding the environmental impacts of climate change on ocean carbon cycle and ecosystems, as well as biogeochemical responses that in turn affect trajectories of future change and/or feedback to the global climate system. The EXPORTS program will begin its fieldwork with research in the Northeast Pacific basin (Figure 1), with the first campaign circa mid-2018, tentatively supporting one global class and one ocean class vessel. This field plan for the two vessels assumes that enough proposed research will be successful to meet the field sampling requirements for the process and the survey ships, as identified in the EXPORTS Science Plan. Following a scientific assessment of the first field effort's data collected (an analysis that may

take up to one year), the EXPORTS Science Team, Science Team lead(s), Project Office, and NASA Headquarters managers will determine whether an investment in a second field effort is merited. The basin for the second set of cruises will be determined after evaluating whether the sampling of the range of ecosystem states needed to address SQ 1 and SQ 2 has been met by the first field effort in the Northeast Pacific. If so, then the second field effort will take place in the North Atlantic basin; if not, then a revisit of the Northeast Pacific Basin will take place. Following the two field sampling efforts, the fieldwork portion of Phase I for the EXPORTS program will be complete.

In order to answer each of the EXPORTS science questions and subquestions, the EXPORTS Science Definition Team (SDT) developed different implementation scenarios for the Science Plan, including detailed study designs and field sampling strategies for the EXPORTS field campaign. These strategies are summarized in the Implementation Plan (http://cce.nasa.gov/ocean_biology_biogeochemistry/exports/documents/Implementation_Plan.pdf). While proposers are encouraged to refer to the Implementation Plan, research proposed under this program element does not necessarily need to fall within the program elements or measurements identified within the Plan, as long as the proposed research clearly addresses the EXPORTS scientific objectives. Proposers are encouraged to contact the NASA program officers with any relevant questions.

Finally, it is imperative that EXPORTS research set the stage for addressing the EXPORTS program overarching goal of developing a predictive understanding of the export and fate of global ocean primary production and its implications for the Earth's carbon cycle in present and future climates. Thus, all investigations should address how their research will contribute to a body of knowledge that will enable EXPORTS synthesis, integration, and modeling phase (Phase II) researchers to address the Science Question 3.

3.1.2 Types of Research Activities

This program element contains four main components: Development and Analysis of Remote Sensing Data Products (Section 3.1.2.1), Collection and Analysis of Field-based (*in situ*) Data, (Section 3.1.2.2), Development, Incorporation and Analysis of Data Assimilation Experiments and Models (Section 3.1.2.3), and EXPORTS Science Lead (Section 3.2). A Step-1 proposal will be mandatory for all proposals submitted in response to this (A.3 OBB) program element. The Step-1 proposal must include (1) the EXPORTS program element the proposal targets (refer to Table 1 for examples) and (2) a list of PIs and Co-Investigators (Co-Is). EXPORTS activities will take place roughly over an eight-year time frame (see Figure 2), with the first investigations starting in mid to late 2017.

NASA requests the following types of research activities to address the EXPORTS Science Questions 1 and 2 (Section 1), and to be focused on the EXPORTS Study Domain.

3.1.2.1 Development and Analysis of Remote Sensing Data Products

An additional overarching objective for the EXPORTS program is to ensure the success of future satellite mission goals by establishing mechanistic relationships between remotely sensed signals and carbon cycle and ecosystem processes. Global monitoring of the export and fate of surface ocean NPP is best accomplished using satellite-based synoptic imaging. Fulfilling this objective will require use of existing and new data products derived from satellite remote sensing systems.

Research relating satellite data products is encouraged to be coordinated with the *in situ* effort so as to maximize analysis and interpretation of EXPORTS field data and associated remote sensing data.

Addressing many of the overarching Science Questions and their subquestions can be done using existing and new data products derived from satellite remote sensing systems. Research to produce and analyze these data products should emphasize the unique capabilities provided by remote sensing for studying important surface characteristics. Ensuring that the remote sensing data are compiled and co-registered will be a key priority; thus, one of the most important research opportunities for EXPORTS is to develop a set of readily accessible, validated data products derived from multiple sensors that can be integrated to form the basis for addressing SQ 3 globally, as well as over the entire EXPORTS Study Domain.

Since measurements may be used from international satellite sensors whose data are openly available, the compatibility of existing national data products (e.g., primary productivity) may require investigation and efforts to either harmonize or create new, mutually acceptable, seamless data products for the EXPORTS study domain. Satellite data products will be critical to enable scaling of the local field observations to regional and global scales. In addition, both *in situ* and remote sensing data products will be used for initializing, driving, calibrating, and validating models. This specific component of the program element emphasizes the production and utilization of data products from satellite sensors, but analysis of existing airborne remote sensing data is also of interest. Priority will be accorded to investigations that address the high importance remote sensing data products identified in the EXPORTS Science Plan.

NASA strongly encourages proposals that provide risk reduction for future satellite ocean color (e.g., PACE) mission retrievals, including novel data products that are physiologically-driven models of net primary production, phytoplankton carbon concentration, particle size distributions and phytoplankton community composition; all of these are components for quantifying the export and fate of global ocean NPP.

3.1.2.2 Collection and Analysis of Field-based (*in situ*) Data

EXPORTS will focus on carbon flow via three classes of processes that constitute the biological pump. These are (1) export associated with gravitational settling of particles, (2) the vertical advection and mixing of organic carbon to depth, and (3) the vertical migration of zooplankton and their predators.

The strength and efficiency of the biological pump can be related to a simple food web with five fundamental processes:

1) Gravitational settling of phytoplankton as single cells or fragments of cells;
2) Sinking of aggregates comprising bacteria, phytoplankton, zooplankton, and their byproducts;
3) Sinking of zooplankton byproducts and their carcasses;
4) Vertical advection and mixing of organic carbon to depth by physical oceanographic processes; and
5) Vertical transport of organic carbon due to the diurnal and/or life cycle migration of zooplankton and their predators.

The combination of these five fundamental vertical pathways quantifies the functioning of the biological pump. These five fundamental processes roughly correspond to the Program Elements

identified in the Implementation Plan (Figure 3; http://cce.nasa.gov/ocean_biology_biogeochemistry/exports/documents/EXPORTS_Imp_Plan_Oct17_2016_FINAL.pdf). An example of measurements and data products associated with the Program Elements and EXPORT processes is shown in Table 1.

Table 1: Program Elements and examples of associated measurements and data products (modified from the EXPORTS Implementation Plan). C = Carbon.

Elements	Data Products	Types of Measurements
Phytoplankton & microbes	biomass/comm structure	Flow cytometry, including sorting; omics; maximum quantum yield (Fv/Fm), virus
	rates - intrinsic & C transforming	Net community production, net primary production, gross primary production, bacterial production, dilution experiments, nutrient experiments; dissolved organic matter bioavailability; viral lysis
Zooplankton	biomass/comm structure	nets, including day/night tows; bioaccoustics (including fish)
	rates - intrinsic & C transforming	day/night; feeding/pellet experiments; dilution experiments/metabolic rates
Export & aggregates	Flux and attenuation particle abundance & size	Sediment traps (direct and optical), radionucludes, in situ pumps, cameras for particle size distribution (CTD, autonomous operated vehicles)
	C transformation rates & processes	aggregation/dissaggregation experiments; in-situ incubations/drifters; sink rates
Optics	Links to remote sensing	Optical measurements to build optical models to link to satellites
	C proxy building	Optical measurements to lead to poxies of particle properties; LIDAR?
Bulk biogeochemical stocks & physics	Hydrography- CTD	CTD/Rosette, oxygen Fluorescence, nitrate, particulate and dissolved organic matter
	Hydrography- towed	CTD, oxygen, fluorescence, nitrate, optics
	Site planning	pre/during/post cruises; remote sensing, all vehicles/hydrography, physical oceanography models, acoustic doppler current profilers, etc
	AUV team	Pre/post deployments and Lagrangian float; all sensors & optics
Innovation	Novel methods, sensors, measurements, models	Novel approaches using materials/data collected on cruise

Proposers should consider field work spanning two years (notionally 2018 and 2020, as per the aforementioned timeline, Figure 2) and including one initial cruise (tentatively two vessels per cruise) in the first field year. Exact timing of the cruises is TBD (pending vessel scheduling, availability, and results from the OSSE and data mining activities), but proposers should plan for the first field effort to begin in summer of 2018. NASA anticipates that the scheduling and timing of the ocean basins sampled may change based on preliminary findings from the first field sampling by the process and survey ships during the postcruise analysis. It is fundamental that all proposed research be hypothesis-based and seeks to address the objectives of the EXPORTS Science Plan. Submissions proposing to carry out measurements without a strong EXPORTS Science Plan-based scientific driver will be deemed nonresponsive.

A range of methods and measurements will be required to answer the EXPORTS Science Questions. It is important to note that each measurement may include a number of different approaches; field-based research should focus first and foremost on measurements necessary to address the EXPORTS Science Questions in full. Proposals should detail the specific

measurements to be made as part of the investigation, and specifically note what SQ or subquestion a given proposal is will address.

While partnerships and collaborations amongst PIs and PI teams are encouraged to holistically address science questions and subquestions, multi-PI proposals are not required. If a team wishes to propose individually, but be considered as part of a measurement team for a given subquestion or science question, they should identify which proposal(s) or team(s) the given proposal is linked to. Proposers should keep in mind that each proposal will be evaluated individually and should stand on its own in its evaluation.

Ship-based sampling will be the backbone of the EXPORTS field campaign, as ships are the only platform where all of the export and fate pathways can be sampled and later analyzed in a laboratory setting. However, ship-based observations can be augmented if complemented by autonomous platforms; autonomous platforms extend the vertical reach of satellites and expand both the spatial and temporal reach of ship measurements. Autonomous sampling relevant to EXPORTS may include, but is not limited to, Bio-Argo floats, Particle Flux floats, and gliders that will guide, complement and extend the ship-based sampling.

Proposals are encouraged to outline how their proposed work benefits from, and interfaces with, the already funded data mining and observational system simulation experiments (OSSE) numerical modeling proposals selected under the ROSES-2015 competition.

3.1.2.3 Development, Incorporation and Analysis of Data Assimilation Experiments and Models

Modeling provides an integrating framework for translating data from the field and remote sensing studies into diagnostic and predictive information products for scientific analysis and possibly decision support. Our present ability to quantify the export and fate of ocean NPP from satellite observations or to predict future fates using Earth system models is limited. Recent analysis demonstrates that satellite observations of NPP and upper ocean carbon stocks can be combined with food web diagnostic models to obtain global scale patterns of carbon export and the efficiency that NPP is converted to export flux leaving the upper ocean. Although field determinations of carbon export were used to successfully validate the satellite estimates, the validity of the temporally and spatially fixed food web model used could not be examined because comprehensive oceanographic observations of key mechanisms and fluxes remain unavailable. Planktonic food webs are known to vary both regionally and with environmental conditions, making the application of a prognostic model to future oceans under different climates highly uncertain. Models run in prognostic mode will provide information on possible outcomes for carbon management under different climate scenarios that could be used as a basis for decision support. Modeling will be an essential activity in all phases of EXPORTS.

For this program subelement, targeted modeling studies needed in support of addressing SQ 1 and 2 and that begin to address Science Question 3 are encouraged during Phase I. NASA may support a limited number of justified, focused, multiscale data assimilation experiments and model/forecast validation studies in the study area(s) that include ocean, atmosphere, biogeochemical, carbon cycle, and ecological components if relevant to the EXPORTS Science questions. Significant advances can be made in regional and global ecological and biogeochemical modeling, but models need to effectively assimilate the existing and developing remote and *in situ* observational databases to enable realization of their practical forecasting

potential. As basic research unfolds, new understandings of ocean ecosystem structure and biogeochemistry, as well as the interdependence of ocean and atmosphere are achieved; simultaneously, advances in computing enable more sophisticated, coupled Earth System models to be developed. Parallel advances must be made in assimilating new observations and insights into models that advance the state of the art in ecological and biogeochemical simulations, and that can be directly applicable to the work being performed and the science questions pursued by EXPORTS**.**

3.2 EXPORTS Science Lead

NASA requests submissions for a Principal Investigator for the EXPORTS Science Lead (SL) position. The SL will be responsible for providing scientific leadership and direction for EXPORTS, providing scientific inputs regarding EXPORTS priorities and activities to NASA management, working with the Project Office on the EXPORTS web site and support, and communicating about EXPORTS to a wide variety of scientific, governmental, and public audiences. The SL, in close coordination with the selected PIs, the EXPORTS Program Officer(s), ESPO, and EXPORTS partner organizations, will be responsible for coordinating roles and responsibilities for PIs involved in the different EXPORTS activities during its execution. The SL will be responsible for leading the update of the EXPORTS Implementation Plan, as needed. He/she, together with the Project Office (see Section 2.1), will be responsible for calling and organizing EXPORTS annual PI meetings and related activities in coordination with NASA Program Officer(s) and ESPO staff. In addition, the SL will organize, plan, and chair any additional team meeting, help coordinate all PI teams and any measurement groups, integrate the input of the various team members within the individual groups, and work to achieve consensus on the overall science objectives of the integrated team in support of the EXPORTS Science Plan. The SL will be responsible for working with the EXPORTS Project Office and the SeaBASS team to ensure any procedures and formatting for data Quality Assurance/Quality Control (QA/QC), metadata, standards, etc. are met and all data collected or produced by each EXPORTS project submitted within one year of collection. He/she should expect to meet with NASA HQ and Project Office/ESPO management on a quarterly basis to review progress, resolve problems, and discuss next steps for implementation.

NASA will select one SL from among the proposing investigators to oversee and coordinate activities for the full EXPORTS team. A desire to serve as the EXPORTS SL should be clearly identified in a separate section of the proposal. Proposers for the SL will be allotted an additional two pages to the standard 15 page NASA proposal, capping the SOW at 17 pages. Proposers for the SL role should indicate their clear interest in serving as SL in the extra two pages of their proposal, and title that section accordingly as "Letter of Application"; this section should follow their Statement of Work, and in it SL proposers should detail their ability and willingness to serve in this role for the entire duration of Phase I of EXPORTS. The SL role will be recompeted at the start of Phase II. Proposers should also recognize that their performance in this role will be reviewed periodically by NASA Program Officers and could be subject to change either through mutual agreement or as a result of inadequate performance. NASA estimates the time commitment necessary for service as SL to be approximately half time (approximately six months per year), but recognizes that it could vary from one-third to two-thirds time depending on the stage at which EXPORTS is (refer to Figure 1 for an estimate of activity intensity throughout the duration of the project). PIs interested in being the EXPORTS Science Lead

should budget accordingly and include a separate budget and budget narrative/justification for the work associated with the SL duties for the duration of the term. **Science Lead PIs should plan for a four-year proposal, with that additional time dedicated to Science Lead activities, not research. NASA anticipates some coordination activities will be required on behalf of the SL prior to the start of the science investigations, as well as 6-9 months after the end of the period of performance of the science investigations which will be devoted to wrapping up and closing Phase I of EXPORTS [Amended March 20, 2017].** NASA will track the budget request for the leadership role separately, thus this budget should remain separate from any proposed research activities. Please use row 8 or 9 in the Other Direct Costs section of the NSPIRES-based budget to report all costs (including any additional salary) associated with this role. The Science Lead costs should also be discussed as a separate section within the budget justification and/or Total Budget file, as appropriate to the type of costs (ODCs or salary) being discussed.

Any PI interested in serving in the SL role is strongly encouraged to talk with the NASA Headquarters Points of Contact for this program element prior to submitting their proposal. The applicant for SL should provide evidence of expertise and knowledge in areas highly relevant to the EXPORTS primary scientific goals and related research activities. The types of expertise and knowledge desired are described in the EXPORTS Science Plan (http://cce.nasa.gov/cce/pdfs/EXPORTS_Science_Plan_May18_2015_final.pdf).

NASA reserves the option to select a SL through an alternative process should proposals of adequate merit and suitability not be received for the SL role. NASA also reserves the right to appoint a Deputy Science Lead to assist the EXPORTS SL to ensure the breadth of scientific expertise is well represented. Selection of a PI as the SL does not guarantee selection of that PIs research as proposed.

4 Required Elements for Step-2 Proposals only

Step-2 proposals have specific requirements, which are outlined below. Step-1 proposals do not have to meet such requirements. Unless otherwise specified in the ROSES *Summary of Solicitation* or this program element, proposals should follow the format and instructions provided in the *NRA/CAN Proposers Guidebook* (https://www.hq.nasa.gov/office/procurement/nraguidebook/), which describes the policies and procedures for submitting responses to the Agency's Broad Agency Announcements. Where this program element differs from the guidebook, instructions within this program element take precedence over the guidebook.

4.1 Requirement to Address Errors and Uncertainties

The research supported under this solicitation will be expected to characterize uncertainties and quantify errors associated with data, analytical approaches, model results, and scientific interpretations. Therefore, Step-2 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 and 2) a description in the Data Management Plan (see Section ~~5.2.3~~ **4.2.3** below) of how they will be reported with the data and products to be shared and archived. **[reference corrected March 17, 2017]**

4.2 Required Plans and Statements

All proposals for participation in EXPORTS must include the plans detailed below in Sections 4.2.1 through 4.2.3, and these plans must be presented as separate sections of the proposal to follow the References and Citations section. Proposals lacking these required plans will not be considered for selection and will be returned without review. All of these plans are in addition to the Scientific/Technical/Management Section and are not included in its 15-page limit.

4.2.1 Project Management Plan (PMP)

Proposals must include a separate Project Management Plan (PMP) that presents a management structure describing how the proposed research activities will be organized, who will be doing what work, and how such activities will be coordinated with the broader EXPORTS team, including the Project Office. The Project Management Plan section should be inserted after the References and Citations section in the proposal and does not have a page limit (in most cases, two to three pages are likely to be adequate for the Project Management Plan).

4.2.1.1 PMP: Roles and Responsibilities of all Investigators

The Project Management Plan must present a management structure describing roles and responsibilities for the Principal Investigator and all Co-Investigators and Collaborators and how the research activities will be coordinated and integrated. If students and postdoctoral scientists are involved, their roles should be described in this plan. Consistent with this section, the separately uploaded "total" budget and NSPIRES cover page budget must include full cost information for all Co-Investigators (Co-Is) to receive funding. The summary table of work effort must list the time (in person months) for all Co-Is whether or not they are to receive funding.

4.2.1.2 PMP: Summary of Institutional Collaboration(s)

In order to facilitate proposal analysis by the NASA Program Office, proposers must briefly summarize the number and nature of all institutional collaborations integrated within their proposed research investigation. The relationship(s) with the collaborating institution(s) and terms and conditions of their participation should be clearly described. This section should include a summary of any resources provided by these collaborating institutions (i.e. cost-sharing, in-kind resources, such as access to research infrastructure or equipment, personnel time, data or data products, and/or matching funding). In support of this summary information, letters of commitment from each collaborating institution documenting their role and specific contribution to the investigation should be included in an appendix to the proposal. The generic statement of commitment provided in Section 2.3.9 of the *NRA/CAN Proposers Guidebook* (http://www.hq.nasa.gov/office/procurement/nraguidebook/proposer2016.pdf) does not provide an acceptable level of detail for this program element’s needs and should not be utilized.

The summary of institutional collaboration(s) element of the Project Management Plan is required but, while collaborations of all types are encouraged and will be viewed favorably, collaborations are not required. An acceptable summary of institutional collaboration(s) may simply state, "No institutional collaborations are proposed."

Individual activities or projects, including those with multiple PIs, may be linked with other separately submitted projects; these linkages must clearly and explicitly be called out by all

involved proposals and investigators in the summary of institutional collaboration(s) element of the Project Management Plan, and include a short description of how such linkage will benefit EXPORTS. 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 5 of this program element. Each individual proposal must address all required elements of the program element.

4.2.2 Resource Needs and Utilization Plan

As outlined in Section 2.1, the Project Office, together with ESPO, will provide logistical and field operations support to the EXPORTS field campaign and will work to efficiently arrange for field infrastructure and seek economies of scale that will minimize costs and maximize utilization. Special support for individual investigations will be provided when it is most efficient and cost effective to do so. Selected scientists should expect a dialog with the Project Office, the SL, ESPO, and NASA Headquarters managers to ensure that their infrastructural and logistical needs are met adequately and in a cost-effective manner – either through the efforts of the Project Office or through their own funding award.

Proposals must include a separate Resource Needs and Utilization Plan that details the research infrastructure and logistical support needed for the investigation. Requirements for *in situ* observations, logistical support, NASA computer use, etc., must be detailed. Special support required that is likely to be unique to an individual investigation must be described. Proposers are urged to delineate such needs specifically in their budget or budget justification, item by item, if at all possible. Proposers should clearly state what support exists and they are leveraging, what they propose to do within their funded investigation, and what they expect the Project Office or other investigators to provide.

Consistent with the Resource Needs and Utilization Plan, costs for all logistical and infrastructural support items must be included in the budget presented in the proposal. However, proposers are advised that some or all of these costs may be pulled out postselection and funded directly through the Project Office and in coordination with ESPO. If difficulties arise in estimating costs for requested logistical and infrastructural support, proposers should describe their needs in sufficient detail that ESPO and Project Office staff can evaluate the requirement. Questions regarding planned Project Office and ESPO support may be directed to the NASA point of contact for this program element (see Section 6).

The Resource Needs and Utilization Plan section should be inserted after the Project Management Plan section of the proposal and does not have a page limit (in most cases, two to three pages are likely to be adequate for the Resource Needs and Utilization Plan).

4.2.3 Data Management Plan

Proposals must include a separate Data Management Plan that addresses the dissemination and sharing of research results and compliance with the NASA Earth Science data policy (http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/) and SeaBASS metadata formats and standards (http://seabass.gsfc.nasa.gov). When relevant to the type of study being proposed, the Data Management Plan should include the existing data and data products or other materials to be utilized in the course of the project, the 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 archiving the data and other research

products consistent with EXPORTS data policies and management practices (see also Sections 3.2 and 3.3 of this program element). Any use of proprietary or sensitive information requiring special protection or constraints on redistribution should be identified, and plans/processes for sharing research findings or derived products and for others to secure access to the data should be described. The data-sharing plan called for in Section ~~4.3~~ **2.3.6** of the *NRA/CAN Proposers Guidebook* must be included in the Data Management Plan. **[reference corrected March 17, 2017]**

The Data Management Plan must describe how errors and uncertainties will be reported for each data product.

NASA intends for the Data Management Plan to become a living document; successful proposers will be requested to update their Data Management Plan to reflect any changes in data set production, sharing and archiving, should these occur during the execution of EXPORTS. If as part of changes to the Data Management Plan NASA imposes additional requirements on the PIs, then NASA will adjust funding appropriately; similarly, if data planned to be collected during the field program are not collected, thereby affecting the management plan, then NASA will adjust funding appropriately. Consistent with the Data Management Plan, costs for 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.

The Data Management Plan section should be inserted after the Resource Needs and Utilization Plan section of the proposal and does not have a page limit (in most cases, two to three pages are likely to be adequate for the Data Management Plan).

4.3 Requirement Regarding Remote Sensing

While for NASA Ocean Biology and Biogeochemistry proposals the use of remote sensing data is strongly encouraged, for this specific program element focusing on Phase I of the EXPORTS field campaign the use of remote sensing data will not be required. However, proposals must explain how the data to be collected addresses the EXPORTS objectives, how it will meet a NASA Ocean Biology and Biogeochemistry priority need, and be used in future research to complement satellite remote sensing data analysis.

4.4 Other Requirements Regarding General Content

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 the shipping container.

Investigators may make separate arrangements with a non-NASA supported analytical facility for HPLC pigment sample analysis but, should they choose to do so, will need to provide a justification as to why such facility is preferred. However, investigators that do not use the NASA-supported facility must send a subset of duplicate samples (~10% of total) to the GSFC

facility and budget for these samples accordingly. This allows for laboratory-to-laboratory intercomparison of pigment results and assessment of uncertainties.

In order to facilitate proposal analysis by the NASA Program Office, PIs are encouraged to include a table of planned field measurement collection and include the table as an appendix to the proposal.

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 EXPORTS field program (http://cce.nasa.gov/ocean_biology_biogeochemistry/exports/index.html). Proposals from non-U.S. organizations should propose to participate on a no-exchange-of-funds basis (see Section 1.6 of the *NASA Research Announcement (NRA)/Cooperative Agreement Notice (CAN) Proposers Guidebook*). 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.

No-cost, low-cost, or cost-shared proposals from researchers supported by partner organizations are encouraged, though not required nor part of the evaluation criteria. The selection official may consider cost sharing in NASA's selection process.

NASA anticipates establishing more informal relationships with individual research investigators or organizations interested in exchanging information about related research activities with EXPORTS and/or collaborating on certain aspects of EXPORTS.

5.2 The Two-Step Proposal Submission Process

To facilitate the early recruitment of conflict-free reviewers, this program element will use a two-step proposal submission process (see Section IV(b)(vii) of the ROSES *Summary of Solicitation*) in which the Notice of Intent (NOI) is replaced by a mandatory Step-1 proposal which must be submitted by the proposing organization.

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal is essentially a required Notice of Intent (NOI) that must be submitted electronically by the Authorized Organizational Representative (AOR), as opposed to an NOI which may submitted by the PI alone. The body of the Step-1 proposal is a summary briefly describing the proposed work. The proposal summary is entered directly into a mandatory 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. No PDF attachment is possible for a Step-1 proposal submission. No budget is requested for the Step-1 proposal. The Step-1 proposal must identify the PI and all funded Co-Is on the proposal. These team members are added to the Step-1 proposal through NSPIRES, just like any other ROSES proposal. Team members will be carried through to the Step-2 proposal by default, but some changes to the team are permitted.

Step-1 proposals will not be subjected to a review. The purpose of the Step-1 proposal is simply to avoid conflicts in the assembly of the review panel, and no response will be provided to proposers regarding the content of the Step-1 proposal. However, a generic communication will

go out to all who submitted a Step-1 proposal to indicate that Step-2 proposals can be submitted when the Step-2 response structure is opened on the NSPIRES web page. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 proposal. Submission of the Step-1 proposal does not obligate the proposer to submit a Step-2 (full) proposal later.

Proposers should refer to the PDF document entitled "How to submit a Step-2 proposal" under "Other Documents" on the NSPIRES page for this program. The process for preparation and submission of the Step-2 (full) proposal is essentially identical to that associated with any other ROSES proposal, with the following exceptions:

Team members who were listed on the Step-1 proposal may be omitted from the Step-2 proposal. Collaborators who not were listed on the Step-1 proposal may be may be added to the Step-2 proposal. The addition of Co-Is or any kind of funded investigator to the Step-2 proposal is only permitted if proposers notify the NASA points of contact listed in Section 6 via E-mail (with a cc to sara@nasa.gov) at least four weeks in advance of the Step-2 proposal due date.

5.3 Available Funds, Budget Profiles, and Periods of Performance

The availability of funds is expected to be in the range of $4M per year exclusively for science research activities for the duration of Phase I (anticipated three ~~to four~~ years). NASA anticipates that up to six months of preparation will be needed prior to the first field campaign (Refer to Figure 2), to allow time for purchasing of equipment and supplies, logistical arrangements, field work coordination, etc. Therefore, NASA expects that most proposals offering field studies will require higher level of funding during the first years and reduced resources in the years following field research activities. **[Amended March 20, 2017]**

~~All types of~~ Investigations considered under this program element ~~may only request up to four years of funding~~ **are capped at three years, except for candidates seeking the Science Lead position**. **Only the Science Lead can propose four years of funding, with the fourth year strictly devoted to Science Lead activities**. However, studies of shorter duration are welcome and specifically encouraged if earlier delivery of their findings or data products is feasible and would benefit the EXPORTS project, help address its science questions, and/or contribute to future directions. **[Amended March 20, 2017]**

NASA anticipates issuing another solicitation in or near ROSES-2020 for Phase II of the EXPORTS project with a focus on data synthesis, addressing Science Question 3 (Section 1).

5.4 Proposal Evaluation Criteria

Proposals will be evaluated according to the criteria specified in Section C.2 of the *NRA/CAN Proposers Guidebook*. In addition to the factors given in the *NRA/CAN Proposers Guidebook*, the determination of a proposal's intrinsic merit shall take into account the following considerations:

- The quality and completeness of the following required plans: Project Management Plan, Resource Needs and Utilization Plan, Data Management Plan, and
- The proposer’s ability to serve as a constructive, productive team member, as demonstrated in the proposal and related and relevant projects.

In addition to the proposal's responsiveness to the goals, objectives, and requirements described in this program element, the determination of a proposal's relevance shall take into account the following consideration:

- The degree to which the investigation addresses the EXPORTS Science Questions, as outlined in Section 1, and takes into consideration the EXPORTS Science and Implementation Plans.

For candidates seeking the SL position, the following factors will be considered in evaluating their potential as EXPORTS Science Lead:

- The proposer's scientific qualifications, leadership skills, management experience, and communications skills for the leadership position,
- The proposer's time commitment and management plan describing his/her approach to EXPORTS leadership, and
- The proposer's understanding of the EXPORTS Science Plan and ability to work creatively, flexibly, and constructively with scientists, NASA and partner organization managers, and a wide variety of stakeholders.

6 Summary of Key Information

Expected annual program budget for new awards	Up to $4 M
Number of new awards pending adequate proposals of merit	10-25
Maximum duration of awards	3 years **(if proposing science investigations**) 4 years (if proposing for EXPORTS Science Lead, see Section 3.2) **[Amended March 20, 2017]**
Due date for Notice of Intent to propose (NOI)	See also Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for Proposals	See also Tables 2 and 3 in the *ROSES Summary of Solicitation*
Planning date for start of investigation	~~July~~ **August** 15, 2017 **[Amended March 20, 2017]**
Page limit for the central Scientific/Technical section of proposal	15 pp.; 17pp. for those proposing to be EXPORTS Science Lead; see also Chapter 2 of the *NASA NRA/CAN Proposers Guidebook*
Relevance to NASA	This program is relevant to the questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the ROSES *Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the NASA NRA/CAN Proposers Guidebook 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

	ROSES *Summary of Solicitation and Chapter 3 of the NASA NRA/CAN Proposers Guidebook.*
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	NNH16ZDA001N-OBB
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