Autonomous Bio-Optical Instruments

Russ E. Davis
Scripps Institution of Oceanography
La Jolla CA 92093-0230
phone: (858) 534-4415 fax: (858) 534-9820 email: rdavis@ucsd.edu

Jeffrey T. Sherman
Scripps Institution of Oceanography
La Jolla CA 92093-0230
phone: (858) 534-9863 fax: (858) 534-9820 email: jtsherman@ucsd.edu

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James K.B. Bishop
EO Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS90-1116
Berkeley, CA 94720-0001

Casey Moore
Western Environmental Technology
Laboratories (WETLabs), Inc.,
PO Box 518, Philomath, OR 97370-0518

LONG-TERM GOALS

Our long-term goal is to understand the biogeochemical dynamics of the ocean's upper kilometer. Such an understanding is fundamental to prediction of the processes partitioning carbon between atmosphere and ocean and to the redistribution of carbon and associated elements within the water column. Key to predictability is understanding day-to-day variability of processes governing abundances of carbon species (dissolved and particulate, inorganic and organic) in the water column.

OBJECTIVES

Our objective is to demonstrate the concept of low-cost autonomous profiling vehicles outfitted with a suite of low-power optical, physical and chemical sensors. When widely deployed, these will permit high-frequency four-dimensional observations of the variability of ocean biological processes, carbon biomass, upper ocean physics, and parameters of the carbon system in the upper 1000 m. It is envisioned that once proven, such vehicles can be widely deployed to explore carbon variability on global scales. An immediate objective is to demonstrate that we can explore Particulate Organic Carbon and Particulate Inorganic Carbon biomass variability in the water column on daily to seasonal time-scales in remote and extreme environments.

APPROACH

Platform. The autonomous platform to be used is the Sounding Oceanographic Lagrangian Observer (SOLO; Davis et al., 2000), a low-cost autonomous profiling float. This well-proven ocean physics platform, augmented with new optical sensors for biogeochemistry, will permit the rapid and precise determination of two important products of photosynthesis, particulate organic carbon (POC) and

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particulate inorganic carbon (PIC), as well as physical data (T, S and derived density stratification) relevant to understanding the variability of these products. SOLO will be modified to accommodate POC and PIC sensors and with ORBCOMM transceivers for bi-directional telemetry of data at much higher data rates than the previously used System Argos.

Implementation of the faster telemetry permits transmission of data from the expanded sensor suite while significantly reducing the time (and hence susceptibility to biofouling) of the float in the surface layer. SIO leads the modification of SOLO. Coordination and testing of the integrated float/sensor package is a joint effort led by LBNL and SIO. LBNL is responsible for calibration and data reduction.

POC sensor. Bishop (1999) and Bishop et al. (1999) demonstrated that beam attenuation at 660 nm is strongly correlated to POC in open ocean waters. Accurate and precise long-term high-frequency measurement of POC in the upper 1000 m requires the following: (1) a stable and precise transmissometer (beam attenuation stable to better than 0.001 m^{-1}), and (2) effective antifouling protection for transmissometer optics. Work on these issues is led by WETLabs.

PIC sensor. Particulate inorganic carbon occurs mostly as the mineral calcite and in most locations calcite is the dominant mineral in suspension. For this reason, we investigated optical properties (e.g. refractive index, birefringence...) specific to calcite that might be used to quantify PIC suspensions. LBNL is developing and proving the PIC sensor concept and WETLabs is implementing the PIC sensor concept in hardware and addressing biofouling issues.

WORK COMPLETED

New SOLO electronics have been built and tested to handle temperature, conductivity, pressure and up to four optical channels as well as controlling ORBCOMM satellite communication and GPS navigation. This includes a more powerful CPU to handle the data reduction, satellite interfacing, and a more sophisticated mission structure, including options for real-time adaptive control of mission parameters. Mounting, and interfacing to, a WETLabs transmissometer is underway and software development is on track for a November 2000 field test. This test will include a complex schedule of vertical cycling to various depths synchronized with local noon. In November we will test the complete float system including conductivity, temperature and depth measurements and a transmissometer to measure POC meter. This will serve as the dry run for a February 2001 long-term deployment of two floats at the Ocean Station Papa site.

RESULTS

We are still in the instrument development stage and do not yet have any scientific results.

IMPACT/APPLICATIONS

The sensors and methodology employed in this project can easily migrate to other autonomous platforms; furthermore, the work of this partnership will lay the foundation for expanded sensor suites and their integration onto recoverable autonomous self-navigating platforms designed to quantify both the reactants and products of photosynthesis, and the rates of carbon-system processes.

TRANSITIONS

None as yet.

RELATED PROJECTS

As discussed above, Jim Bishop (LBNL) and Casey Moore (WETLabs) are supported separately by ONR under this National Ocean Partnership Program project.

Greg Mitchell (SIO) and Jeff Sherman are supported through the ocean optics program to instrument SOLO with radiance sensors. This instrument has recently successfully completed a 76-cycle time series in the Japan Sea with good results. It will be desirable to eventually integrate these sensors with the POC and PIC sensor suite to make more comprehensive observations of the upper ocean carbon system.

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