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The Global Ocean Biogeochemistry (GO-BGC) Array of Profiling Floats to Observe Changing Ocean Chemistry and Biology

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ABSTRACT

The Global Ocean Biogeochemistry (GO-BGC) Array is a project funded by the US National Science Foundation to build a global network of chemical and biological sensors on Argo profiling floats. The network will monitor biogeochemical cycles and ocean health. The floats will collect from a depth of 2,000 meters to the surface, augmenting the existing Argo array that monitors ocean temperature and salinity. Data will be made freely available within a day of being collected via the Argo data system. These data will allow scientists to pursue fundamental questions concerning ocean ecosystems, monitor ocean health and productivity, and observe the elemental cycles of carbon, oxygen, and nitrogen through all seasons of the year. Such essential data are needed to improve computer models of ocean fisheries and climate, to monitor and forecast the effects of ocean warming and ocean acidification on sea life, and to address key questions identified in "Sea Change: 2015–2025 Decadal Survey of Ocean Sciences" such as: What is the ocean's role in regulating the carbon cycle? What are the natural and anthropogenic drivers of open ocean deoxygenation? What are the consequences of ocean acidification? How do physical changes in mixing and circulation affect nutrient availability and ocean productivity?

Vision and Potential Transformative Impact

Vision: To implement an innovative and sustained robotic network of profiling floats carrying chemical and biological sensors. The unprecedented data stream will drive a transformative shift in scientific and public understanding of chemical and biological (biogeochemical) cycling in the ocean and its dynamics at the global scale. The GO-BGC array is enabling research across the entire span of open ocean environments. The broad suite of sensors and improved technology on the floats will extend the types of analyses that are possible. For example, float 5906449 is part of an array deployed in the Oxygen Deficient Zone (ODZ) of the Eastern Tropical North Pacific (Figure 1, Panel A). The float has now executed 10 profiles over 90 days and should operate for years. Oxygen sensors show concentrations < 2 µmol/kg from 100 to 500 m depth (Figure 1, Panel B). A well-defined decrease in nitrate concentration occurs in this zone (Figure 1, Panel C) due to microbial denitrification and anammox reactions. Continuous refinements of the nitrate sensor optics and calibration are now allowing GO-BGC analysts to explore the detection of nitrite (Figure 1, Panel D), where each observation is colored by the oxygen concentration at levels < 10 µmol/kg. Robust determination of nitrite would greatly expand the capability of the science community to understand the processes that regulate nitrate loss in ODZs, which is a global control on ocean productivity.

How Is the Project Realizable, With Connections to Existing Scientific Infrastructure, Technology Development, and Public–Private Partnerships

Funding for the GO-BGC Array is provided through the NSF's Mid-Scale Research Infrastructure-2 Program (MSRI-2; NSF Award 1946578). It extends biological and chemical observing from robotic profiling floats globally, and builds on two highly successful ongoing efforts (the Argo Array and the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) program). GO-BGC is one of five endorsed NSF Decade Actions for the UN Ocean Decade (2021–2030), which hopes to bring the global community together to recognize the ocean as essential for the health and well-being of our planet. "The Ocean Decade calls on the international community to unlock innovative ocean science solutions to foster an equitable and sustainable world" (https://www.oceandecade.org/).

Scientific/Technological Sectors Engaged Outside of Traditional Ocean Sciences

MBARI will coordinate the project, refine the sensors, take the lead in processing data from the floats, and perform outreach for the program. The University of Washington, the Scripps Institution of Oceanography, and the Woods Hole Oceanographic Institute will build and deploy floats in collaboration with commercial partners. Researchers at Princeton University will contribute to the array design and project management, and ensure that the data are linked to global computer models of the Earth's ocean and climate.

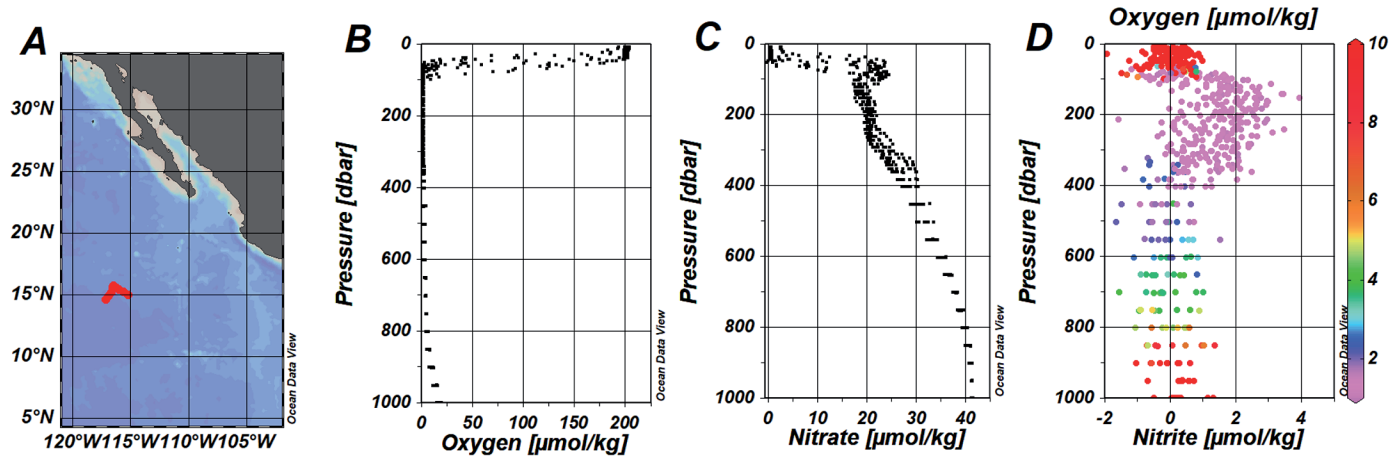

FIGURE 1. Float 5906449 is part of an array deployed in the Oxygen Deficient Zone (ODZ) of the Eastern Tropical North Pacific (Panel A). The float has been adopted by Twin Oaks High School in San Marcos, California and is named *Flabellina iodinea*. The float has now executed 10 profiles over 90 days and should operate for several more years. Oxygen sensors show concentrations < 2 µmol/kg from 100 to 500 m depth (Panel B). There is a well-defined decrease in nitrate concentration in this zone (Panel C) due to microbial denitrification and anammox reactions. Continuous refinements of the nitrate sensor optics and calibration are now allowing GO-BGC analysts to explore the detection of nitrite (Panel D), where each observation is colored by the oxygen concentration at levels < 10 µmol/kg.

This program will also have a significant impact on the ocean technology industry, including a number of commercial suppliers of ocean sensors and profiling floats. We are actively working with industry partners for float components as well as sensors. Float deployments involve coordination with international and NOAA Argo efforts and rely on colleagues around the world to provide ship time for float deployment and (when possible) water quality measurements.

Opportunities for International Participation and Collaboration

The researchers hope that GO-BGC will inspire other countries to contribute similarly instrumented floats, as part of the new global biogeochemical ARGO effort. Ideally, this expanded network would grow to a sustained array of 1,000 biogeochemical floats uniformly distributed around the world ocean, and spaced about 1,000 kilometers apart.

To inform and engage a broader oceanographic user community, the Ocean Carbon & Biogeochemistry (OCB) and the U.S. Climate Variability and Predictability (CLIVAR) Programs, along with GO-BGC leadership, held a virtual GO-BGC Scientific Workshop from June 28–30, 2021 (the first of three researcher outreach workshops). The objectives and presentations are online.

Develops Global Capacity and Encourages the Development of the Next Generation of Ocean Scientists, Engineers, and Technologists

A broad public-outreach program, including workshops, web-based curricula, and hands-on activities, will help scientists, teachers, students, and others use these data. In an expansion of the existing SOCCOM Adopt-A-Float program, both GO-BGC floats and SOCCOM floats are now available for adoption by elementary to college-level classes. Student activities will be developed through a partnership with the national Marine Advanced Technology Education program and through an educator professional development workshop in 2022 and 2024. In addition, courses based on GO-BGC technology will be offered through *The Sandbox*, a makerspace at the Scripps Institution of Oceanography.

FIGURE 2. GO-BGC profiling float *Weddell* adopted by the Beaulieu Convent School, St Helier, UK. Artwork by Elena Perez and photo by Andreas Thurnherr.