Researchers plunge into ocean 'twilight zone' to explore ecosystem carbon flow

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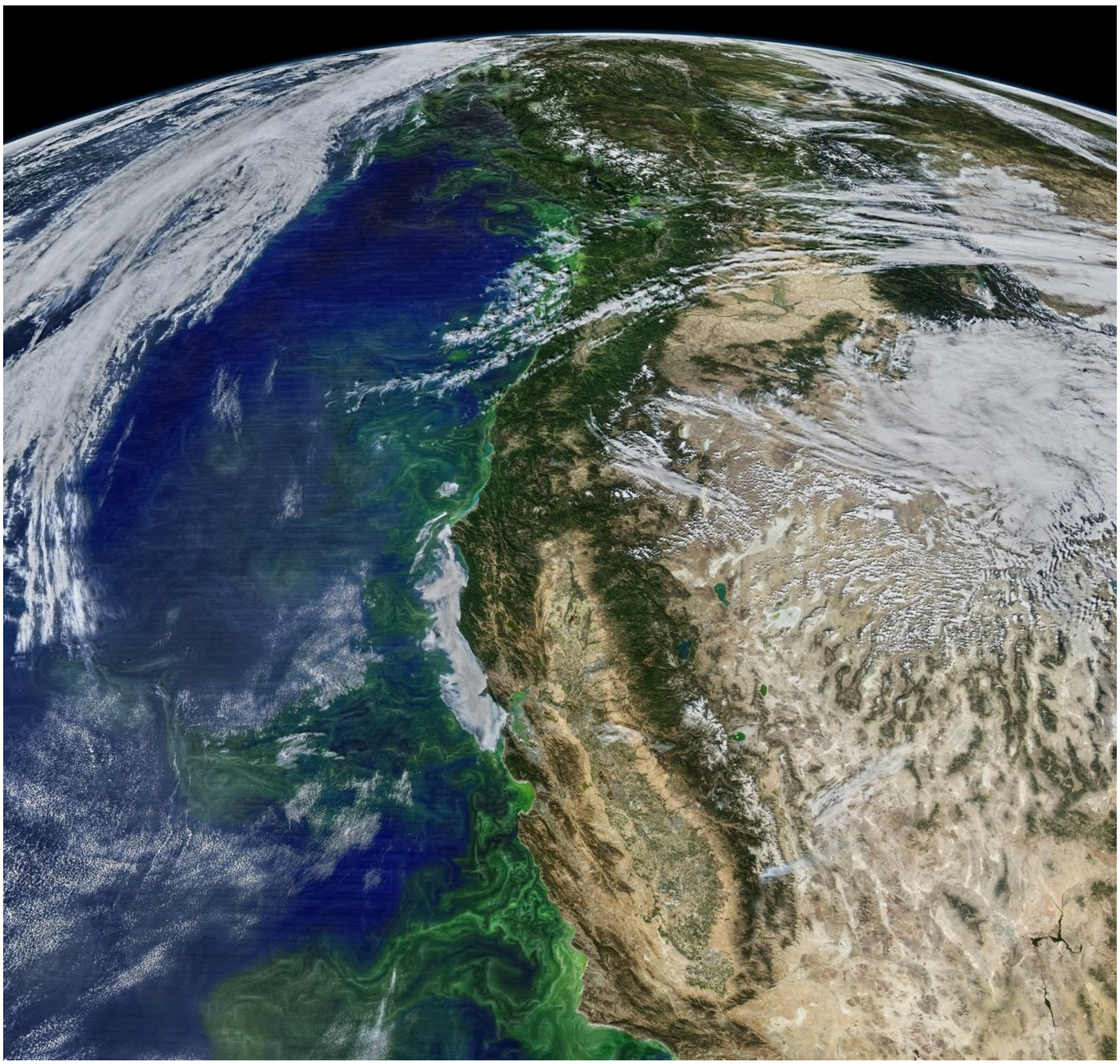


The Pacific Ocean teems with phytoplankton along the West Coast of the United

States, as captured by the MODIS instrument on NASA's Aqua satellite. Satellites can track phytoplankton blooms, which occur when these plant-like organisms receive optimal amounts of sunlight and nutrients. Phytoplankton play an important role in removing atmospheric carbon dioxide. Credits: NASA

A large multidisciplinary team of scientists, equipped with advanced underwater robotics and an array of analytical instrumentation, will set sail for the northeastern Pacific Ocean this August. The team's mission for NASA and the National Science Foundation (NSF) is to study the life and death of the small organisms that play a critical role in removing carbon dioxide from the atmosphere and in the ocean's carbon cycle.

More than 100 scientists and crew from more than 20 research institutions will embark from Seattle for NASA's Export Processes in the Ocean from Remote Sensing (EXPORTS) oceanographic campaign. EXPORTS is the first coordinated multidisciplinary science campaign of its kind to study the fates and carbon cycle impacts of microscopic plankton using two research vessels and several underwater robotic platforms.

The research vessels, the R/V Revelle and R/V Sally Ride, operated by the Scripps Institution of Oceanography, University of California San Diego, will sail west 200 miles into the open ocean. From these seaborne laboratories, researchers will explore the plankton, as well as the chemical and physical properties of the ocean from the surface to half a mile below into the twilight zone, a region with little or no sunlight where the carbon from the plankton can be sequestered, or kept out of the atmosphere, for periods ranging from decades to thousands of years.

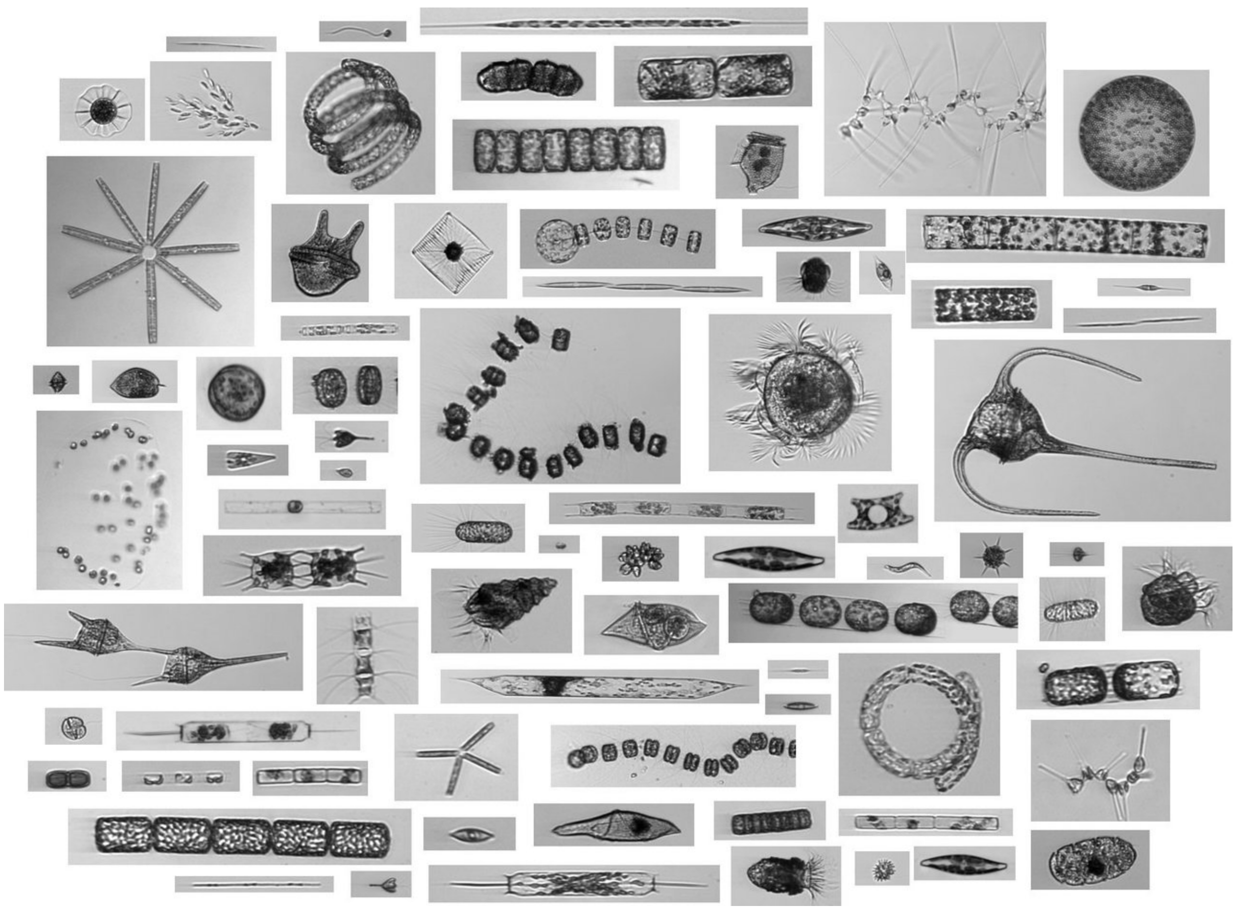
"By employing two ships we'll be able to observe complex oceanographic processes that vary both in space and time that we wouldn't be able to capture with a single ship," said Paula Bontempi, program manager for Ocean Biology and Biogeochemistry at NASA Headquarters.

Phytoplankton are tiny, plant-like organisms that live in the sunlit upper ocean. They use sunlight and dissolved carbon dioxide that enters the upper ocean from the atmosphere to grow through photosynthesis, which is one way that ocean organisms cycle carbon. As primary producers, phytoplankton play an important role in removing atmospheric carbon dioxide and producing oxygen. When phytoplankton are consumed by plankton or die, their remains sink and some fraction of their carbon is exported to depth.

While the major export pathways of how carbon moves through the ocean are known, the magnitude of the carbon flows in the different oceanic pathways and their dependence on ecosystem characteristics are poorly known. Scientists on the EXPORTS team are investigating how much carbon moves through the ocean within the upper sunlit layer and into the twilight zone and how ocean ecological processes affect carbon fate and sequestration. This information is needed to predict how much carbon will cycle back into the atmosphere over what time scales, or how much carbon is exported to ocean depths.

"The carbon humans are putting into the atmosphere is warming Earth," says Mike Sieracki, program director in the National Science Foundation's Division of Ocean Sciences. "Much of that carbon eventually finds its way into the ocean and is transported to the deep ocean, where it is sequestered and will not return to the atmosphere for a long time. This project will help us understand the biological and chemical processes that remove the carbon, and establish a foundation for monitoring these processes as the climate changes."

Seven years in the making, the 2018 campaign has been a huge undertaking, said David Siegel, EXPORTS science lead from the University of California, Santa Barbara.



During the EXPORTS campaign, the Imaging Flow Cytobot will give scientists a continuous view of plankton diversity in the northeast Pacific. This collage represents just a small number of the different plankton types that inhabit Earth's ocean. Credits: WHOI/Heidi Sosik

"The impact the EXPORTS data will have for understanding how our planet is changing will be significant," Siegel said. "NASA's ocean color satellite record shows us these ecosystems are highly sensitive to climate variability. Changes in phytoplankton populations affect the marine food web since phytoplankton are eaten by many animal species big and small. The stakes are high."

The long-term removal of organic carbon from the atmosphere to the ocean depths is known as the biological pump, which operates through three main processes. First, carbon-laden particles from the ocean's surface sink through gravity, as happens with dead phytoplankton or feces produced by small animals called zooplankton. Second, zooplankton migrate daily close to the ocean's surface to feed on phytoplankton and return to the twilight zone during nighttime. Third, physical processes in the ocean, such as the large global overturning circulation of the oceans and smaller-scale turbulent eddies, transport suspended and dissolved carbon to great depths.

NASA's satellites provide a variety of measurements of the ocean's uppermost layer, such as temperature, salinity and the concentration of a pigment found in all plants called chlorophyll. EXPORTS will provide data on the role of phytoplankton and plankton in the biological pump and the export of carbon, information important to planning observations and technologies needed for future Earth-observing satellite missions.

"We've designed EXPORTS to observe simultaneously the three basic mechanisms by which carbon is exported from the upper ocean to depth," Siegel said. "We're trying to better understand the biology and ecology of phytoplankton in the surface water, how those characteristics drive the transport of carbon to the twilight zone, and then what happens to the carbon in the deeper water."

Among the many technologies being used is an autonomous platform called a "Wirewalker" that uses wave energy to move instruments along a taut wire from the surface to 1,600 feet (500 meters) in depth while measuring temperature, salinity, oxygen, carbon, and chlorophyll concentration.

A 6.5 foot-long (2 meter-long) remote-controlled underwater vehicle called the Seaglider will gather similar measurements, but at depths as much as 3,200 feet (1,000 meters.)

On board the ship, samples will be collected for genomic sequencers to assess the composition of the phytoplankton, zooplankton, bacterial and archaeal communities.

New microscopic imaging tools also will be used by EXPORTS scientists, including a high throughput microscope called the Imaging FlowCytobot that will provide real-time, high-resolution images of billions of individual phytoplankton. The Underwater Vision Profiler will measure the sizes of sinking aggregate particles and collect images of zooplankton organisms.

Mounted on the ship's superstructure will be optical instruments that will measure the ocean's color at very high spectral resolution, from the ultraviolet wavelengths to the shortwave infrared bands of the electromagnetic spectrum. Phytoplankton have distinct spectral "signatures"—colors of light they absorb and scatter. By identifying those signatures scientists will be able to develop algorithms for future satellite ocean color missions such as NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission. From space, PACE will use similar optical instruments to distinguish the type and amount of phytoplankton present in the ocean.

"What we will learn from EXPORTS will give us a deeper understanding of how plankton species and other microorganisms such as bacteria interact with their environment," said Bontempi. "Not only will we be able to use this information to develop new approaches to identifying and quantifying plankton species from space, we'll be able to predict how much carbon will cycle back into the atmosphere and how much will be transported to the ocean depths for the long term."

More information: oceanexports.org/

Provided by NASA's Goddard Space Flight Center