NASA wants to identify phytoplankton species from space. Here's why

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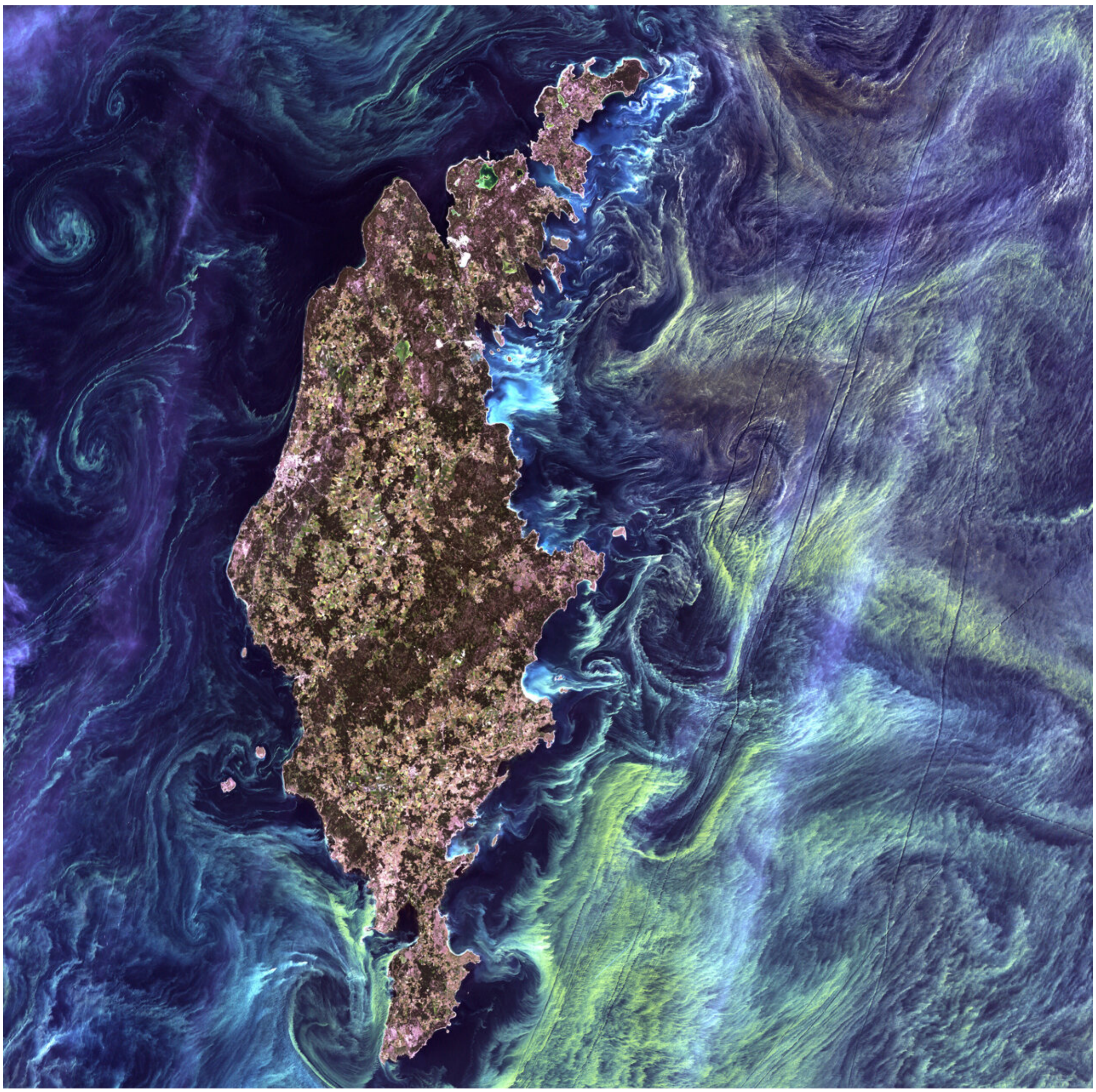

"Without phytoplankton, we may not be able to breathe or eat sushi," said Aimee Neeley, a NASA Goddard oceanographer. Large green blooms of phytoplankton swirl in the dark water around Gotland, a Swedish island in the Baltic Sea. Credit: USGS/NASA/Landsat 7

They're small, but they're mighty. From producing oxygen we breathe to soaking up carbon we emit to feeding fish we eat, tiny phytoplankton are a crucial part of ocean ecosystems and essential to life as we know it on Earth. To give us a new view of these extraordinary aquatic organisms, NASA is launching a satellite in early 2024.

Instruments on the PACE (short for Plankton, Aerosol, Cloud, and ocean Ecosystem) satellite will peer down at the ocean and collect data on the colors of light reflecting off it, telling us where different types of phytoplankton are thriving.

The Ocean Color Instrument on PACE will be able to observe more than 100 different wavelengths, and is the first scientific satellite to do so daily on a global scale. This "hyperspectral" instrument will make it possible to identify phytoplankton by species for the first time from space.

Phytoplankton and photosynthesis

Phytoplankton are tiny organisms that float on the surface of the ocean and other water bodies. Like land-based plants, phytoplankton use photosynthesis to absorb sunlight and carbon dioxide and generate oxygen and carbohydrates, which are carbon-filled sugars. These sugars make phytoplankton the center of the ocean food web: They nourish larger animals—from zooplankton to shellfish to finfish—that are then eaten by even larger fish and marine mammals. The creation of those sugars from sunlight is called primary production.

Even though phytoplankton make up less than 1% of the total biomass on Earth that can photosynthesize, they deliver about 45% of global primary production. Without phytoplankton, most oceanic food webs would collapse, which would be devastating for both marine life and humans who rely on fish for food.

The tiny organisms provide more than just nutrients. Through photosynthesis, phytoplankton create oxygen that is released into the ocean and atmosphere. In fact, since they began photosynthesizing over 3 billion years ago—more than two billion years before land plants and trees—phytoplankton have made about 50% of all the oxygen that has been produced on Earth.

Photosynthesis gives them a key role in the global carbon cycle as well, as they soak up carbon dioxide from the atmosphere. What phytoplankton do with that carbon depends on the species.

"Like plants on land, phytoplankton are highly diverse," said Ivona Cetinić, a biological oceanographer in the Ocean Ecology Lab at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Each of these diverse species has different characteristics that allow them to take on different jobs in Earth's carbon systems, she said.

Phytoplankton like Emiliana huxleyi incorporate carbon into their shell-like outer coating. When they die, the shells sink and sequester the carbon in the ocean depths. Other phytoplankton species fit a certain niche for picky eaters like oysters, which only eat phytoplankton of a certain size. Still other species of phytoplankton may capture carbon through photosynthesis, where it then remains on the ocean surface until the organisms decompose, releasing the carbon back into the atmosphere as carbon dioxide.

"I hope that PACE, once it gives us a view of ocean phytoplankton diversity, can tell us so much more about global carbon flow in oceans, now and in the future," Cetinić said.

Phytoplankton in the cold

Even in colder waters at higher latitudes, phytoplankton are crucial to ocean life. In polar regions, phytoplankton blooms—when the organisms grow and multiply in vast numbers visible from space—can follow the cycle of sea ice melt.

When sea ice cover recedes, sunlight can reach the surface of the ocean and the phytoplankton that float on it, allowing them to photosynthesize and thrive after a long period of being covered. This produces fuel for other species. Polar species from clams and krill all the way up to walruses and whales rely on these timely blooms for their food sources.

"An alteration of the timing of the blooms impacts the entire ecosystem," said Aimee Neeley, a biological oceanographer at NASA Goddard.

As the timing and extent of sea ice retreat changes in a warming climate, PACE will be able to track changes to the timing of blooms, providing insights into the wider impacts to the ecosystem.

Identifying harmful phytoplankton

Not all phytoplankton are beneficial for ecosystems. Some species can produce toxins that are dangerous for humans or other marine species. These harmful algal blooms can disrupt ecosystems as well as daily life for people near coasts, lakes, and rivers. Blooms of cyanobacteria, for example, can spoil drinking water and recreational water use with the toxins they generate.

Scientists have been using some satellite data to track and monitor these blooms and the conditions that cause them. PACE should make it easier to decipher these species and conditions, allowing people to develop ways to mitigate the impacts and prevent future blooms.

"Not all phytoplankton create harmful algal blooms, so if we can use the satellite data to better separate harmful from non-harmful blooms, that would be helpful for water managers and scientists that are trying to understand phytoplankton communities in a region," said Bridget Seegers, an oceanographer at NASA Goddard.

PACE will not be the first satellite to let us see phytoplankton from space. The mission is a successor to missions like Terra, Aqua, Landsat, and SeaWiFS (the Sea-viewing Wide Field-of-view Sensor), which have gathered data on phytoplankton since the 1990s. PACE, which is being assembled at and managed by engineers at NASA Goddard, will significantly expand our ability to distinguish and track phytoplankton every day, all over the planet.

"Hopefully, the hyperspectral nature of the Ocean Color Instrument will allow us to better tease apart the phytoplankton types from each other and from non-phytoplankton particles," Neeley said. "To me, the opportunities for research will be endless."

Provided by NASA

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