Researchers view microorganisms from space

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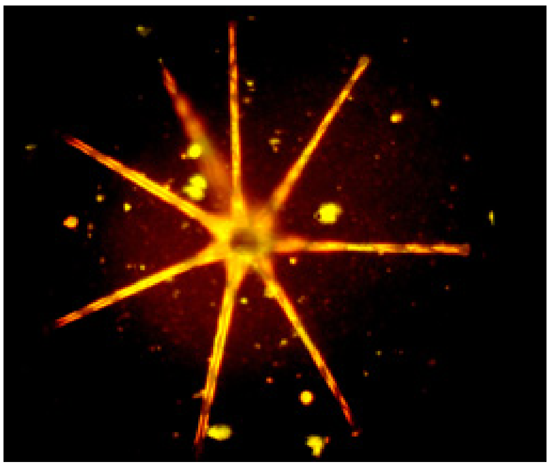

Epifluoresence microscopy image of a diatom from the genus Asterionella. Credit: ASU

What is the smallest thing you can see from space? From a standard shuttle orbit of 217 kilometers above the Earth's surface, it is suggested that you can see the Great Wall of China. With the aid of binoculars, you can also see clearly the pyramids of Giza, large ships and even major roads.

However, these are very large structures, on the order of tens or hundreds of meters in size. But what if you could spy on something only a few millionths of a meter (microns) across from space? Seem far-fetched?

Scientists studying phytoplankton in the oceans have discovered that they can in fact see objects this small using satellites. Of course they can't see just a single individual, but when enough of these tiny unicellular organisms come together in the ocean, they become visible from space.

The reason phytoplankton are easier to see than the Great Wall of China is because they photosynthesize. By absorbing some wavelengths of light and reflecting others, the photosynthetic pigments in these micro-organisms produce distinctive colors. Large numbers of phytoplankton (a thimble of water can contain tens or even hundreds of thousands of individuals) floating together in the ocean change the color of the light that reflects back into space. It is this change in color that is visible to specially designed satellite sensors passing high above the Earth.

Susanne Neuer's lab in the School of Life Sciences uses satellite imagery to support research projects aimed at increasing understanding of phytoplankton ecology and how it affects primary production and carbon flux in the ocean. Primary production, as the ultimate source of organic carbon for marine organisms, is an essential component of all marine ecosystems.

Carbon fixation, which occurs during photosynthesis, is also a significant part of the carbon pump, the means by which chemical and biological processes remove anthropogenic carbon dioxide from the Earth's atmosphere. Increasing knowledge of how primary production and carbon flux occur may well be critical to developing a strategy for sustainable use of the oceans and aid in understanding of global warming. Given the geographic scale of the problem, one can begin to appreciate why images of thousands of square kilometers of ocean showing billions of microscopic phytoplankton become useful.

One of the key satellites used for measuring ocean primary production from space is SeaWifs (Sea-viewing Wide Field-of-view Sensor), which was launched in September 1997. Images from SeaWifs, along with images captured by the more recent MODIS (Moderate-resolution Imaging Spectroradiometer) sensors, are processed by scientists all over the world. In the Neuer lab, researchers combine information gleaned from these satellite images with field data taken directly from the ocean to develop an integrated view of phytoplankton ecology. These researchers are now adapting this process to include micro-organisms in smaller bodies of water, such as the Salt River reservoirs in Arizona.

Given that Roosevelt Lake is only three and a half kilometers across and the other Salt River reservoirs are considerably smaller, adapting MODIS imagery typically used to view ocean basins from space presents a significant challenge. The best spatial resolution of a MODIS image is 250 meters, which means that one pixel of the digital image is equivalent to 250 meters on the Earth's surface. This means that the surface of each of these lakes represents a limited number of image pixels; because some of these "lake" pixels are also contaminated by land, there are only very few from which useful data can be extracted. If these resolution limitations were not enough of a problem, the two 250 meter sensors in the MODIS instrument only see in the red and near infrared wavelengths, which are not the wavelengths normally used for ocean color analysis. However, despite these logistical challenges, these space-borne images can still be used to get a feel for what is happening in the lakes. These data become even more useful when combined with an analysis of field samples viewed under a microscope.

Neuer lab researchers are using epifluorescence microscopy, light microscopy and genetic analysis techniques to obtain a detailed view of our local freshwater algae. Field sampling of Lake Roosevelt and Saguaro Lake shows the lakes harbor diverse communities of algae that vary both within and between the lakes. Some of these phytoplankton groups, such as the diatoms Astrionella and Fragilaria, live and grow as individuals.

Other species, including the filamentous cyanobacterium Anabaena and the colonial green alga Scenesdmus, thrive when individuals come together to create communal organisms. Regardless of their life histories and diverse geometric forms, collectively these primary producers represent an integral part of the food web in the Salt River reservoir system, providing a food source for invertebrates and fish larvae.

Populations of these algae are always present in the water, but when light, temperature and nutrient levels are optimal for growth, their population numbers can explode or "bloom" exponentially. Unfortunately, when these algal blooms occur they can produce toxins and cause unpleasant odors in drinking water. These potential adverse effects on water quality are one reason Neuer's group wants to understand them in more detail. The National Science Foundation funded Water Quality Center at ASU, which is a working group of researchers, city authorities and other agencies, is supporting this project in order to discover if it is possible to predict the conditions that cause these water quality issues. If a way to predict these algal blooms (in their early stages) can be identified, it may be possible to take proactive measures to protect our water quality.

The growing population of the Phoenix metropolitan area will increase the demand for water in central Arizona. Resource management authorities recognize that the limited water supply stored in our reservoirs is a precious resource. Neuer hopes that by combining views from space with views through the microscope, SOLS can contribute to ongoing efforts to improve water quality in all the reservoirs across Arizona. More significantly, if these experimental monitoring techniques prove to be successful, they have the potential to provide similar benefits to understanding of watersheds across the planet.

Source: Arizona State University