How one man's shoes help NASA communicate water clarity issues

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Bernie Fowler walks into Maryland's Patuxent River every June to see how deep he can go and still see the tops of his shoes. As a young man he could see his feet on the river bottom as he stood chest-deep to net blue crabs. Now in his nineties, he ventures into the river to assess the water clarity. Fowler has been collecting this data point for the past 29 years and counting, calling it 'sneaker depth.' Credit: Jefferson Patterson Park and Museum

Wearing white sneakers, a cowboy hat and overalls, Bernie Fowler walks into Maryland's Patuxent River every June to see how deep he can go and still see the tops of his shoes. As a young man he could see his feet on the river bottom as he stood chest-deep to net blue crabs. Now in his nineties, he ventures into the river to assess the water clarity. Fowler has been collecting this data point for the past 29 years and counting, calling it "sneaker depth."

Scientists make precise measurements of water clarity from satellite data, but the calculations can be complex and hard to explain to people outside the discipline of oceanography. Now NASA is adopting Fowler's sneaker idea to communicate satellite measurements of water clarity, enabling the observations to be shared easily with interested the general public, local governments or anyone who is interested. NASA scientists calling this algorithm "Fowler's Sneaker Depth"—the depth of water, in meters, at which a person can no longer see their white shoes. The study was published in the April 2017 edition of The Optical Society journal *Optics Express*.

Retired Maryland state senator Fowler has been using "sneaker depth" as a way to communicate local changes in water clarity to his neighbors and community. Water clarity is vital because sunlight must be able to reach deep beyond the surface to help underwater plants grow and maintain a healthy ecosystem. Throughout the world, coastal waters can become murky due to excess of suspended mineral particles (e.g. eroded soil) or abnormally high abundances of phytoplankton (microscopic algae). While these effects occur naturally, they can be exacerbated by human activity in a watershed, such as land clearing, urban development, and the release of under-treated sewage. Poor water clarity can drastically affect human health, the food chain, and the fishing industry.

"When you talk to people about the chemistry of the river with scientific words like eutrophication, it goes in one ear and out the other," said Fowler. "If you put on white sneakers and wade out in the river until you can't see your feet, that gives you pretty good understanding of what's going on." On June 11, 2017, Fowler, his family, friends and community will wade into the Patuxent River at Jefferson Patterson Park and make sneaker depth measurements for the 30th consecutive year.

Scientists sitting in an ocean ecology lab focus on accuracy, said Lachlan McKinna, an oceanographer at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and one of the study's authors. "But we sometimes need better ways to communicate with the general public."

Ben Crooke, a 17-year-old NASA summer intern, helped derive Fowler's Sneaker Depth as the first author of the paper. Crooke spent part of his summer analyzing Fowler's data and satellite imagery to understand local trends in water clarity.

Crooke and the team looked at data from the Aqua satellite's onboard instrument,the Moderate Resolution Imaging Spectroradiometer, or MODIS. The instrument measures different colors of light, or wavelengths, that are reflected from matter suspended in the water. They specifically looked at the amount of red light reflected of off floating particulates and sediments that make the water appear murky.

The team then developed a mathematical model to relate the amount of red light reflected, as measured by MODIS, with the sneaker depth, as physically measured by Fowler in the Patuxent River, for the years 2002 to 2016.

The resulting algorithm provides an easy way to visualize and communicate water clarity to the public. It also provides satellite-observed sneaker depth measurements for any day of the year not obstructed by a lot of clouds and for the entire Patuxent River estuary.

"We looked at how much variability there was in the sneaker depth on that one day of the year compared to every other day of the year," said Crooke, who graduated from Sandy Spring Friends School in Ashton-

Sandy Spring, Maryland, and plans to study environmental science this fall at Skidmore College in New York.

Crooke and the team observed how the Patuxent's water quality varies with the season. The winter months had the largest Fowler's Sneaker Depth (i.e. best visibility) because river flow is minimal, meaning less incoming sediments, and environmental conditions are less favorable for phytoplankton growth. The late spring and early summer months tended to have the lowest sneaker depth (i.e. lowest visibility) because more phytoplankton and sediments are present.

The study also showed potential sources that influence the Patuxent River's water clarity. In recent years, improved watershed management has reduced the impacts from land use activities that can pollute the river, such as land clearing, sewage treatment, agriculture, and urban development. Yet summer phytoplankton blooms still continue in the lower Patuxent River estuary, suggesting that the nutrients that promote blooms are coming into the river from the Chesapeake Bay - an idea that previous studies have suggested.

Although the sneaker depth was primarily designed as a communication outreach tool for the public, the NASA team doesn't discount its use for science. The sneaker depth concept is actually similar to the Secchi disk depth measurement made monthly by the Chesapeake Bay Program. In oceanography, scientists lower a plain, white disk one foot in diameter - called a Secchi disk—into the water on a rope and record the depth at which it disappears from sight. These measurements are useful for marine scientists who want to know what depth the light is reaching to understand how the phytoplankton and other underwater vegetation are growing.

"Fowler's Sneaker Depth will come in as a metric to look at long term water clarity trends for scientifically meaningful results and communicate those to the general public," said Ivona Cetinic, an oceanographer with the Universities Space Research Association at NASA Goddard and one of the study's authors. Cetinic and the team still need to make a few refinements though. For one, they might set the maximum limit of the sneaker depth as Fowler's height—a way to retain the context of the number and honor Fowler's dedication and work on the Chesapeake Bay. Second, the team would welcome more data points from the community to help refine the algorithm.

"If you have a pair of old white sneakers and put them on your feet or a string and take some measurements, that could help us build a data set and fine tune the algorithm," said McKinna.

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