

Tyler Prize Honors Two Leaders in Marine and Climate Science

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Biological oceanographers Paul Falkowski and James McCarthy helped revolutionize the world's understanding of Earth's changing climate, both past and present.

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By [JoAnna Wendel](#), 7 February 2018



NASA's Moderate Resolution Imaging Spectroradiometer instrument snapped this image of a phytoplankton bloom off the coast of Iceland in 2010. Scientists didn't always think of organisms like these as being connected to a whole Earth system. Research conducted by the two Tyler Prize recipients focuses on Earth as an intricately connected network, rather than as separate, isolated realms. Credit: [NASA Goddard Space Flight Center](#)

The 2018 Tyler Prize—known as the “Nobel Prize for the environment”—has been awarded to Paul Falkowski of Rutgers University in New Brunswick, N.J., and James McCarthy of Harvard University in Cambridge, Mass. The prize recognizes them for pioneering research and leadership in scientific understanding of the oceans and climate change and for communicating the impacts of a warming world.

“Climate change poses a great challenge to global communities. We are recognizing these two great scientists for their enormous contributions to fighting climate change through increasing our scientific understanding of how Earth’s climate works, as well as bringing together that knowledge for the purpose of policy change,” said Julia Marton-Lefèvre, chair of the Tyler Prize Committee.

Falkowski is a professor of geological and marine science. His influential research on the critical role of Earth’s smallest organisms in its evolving climate helped bring together fields such as biophysics, evolutionary biology, marine ecology, and paleontology, among others. With this interdisciplinary work, Falkowski improved scientists’ understanding of climate change by building a picture of Earth’s changing climate across enormous timescales.

James McCarthy is a professor of biological oceanography and was the first editor of the American Geophysical Union’s (AGU) journal [Global Biogeochemical Cycles](#). His research on marine nutrient cycles added significantly to our understanding of human influence on Earth’s climate. McCarthy engaged with the world’s environmental research and policy leaders, developing the [International Geosphere-Biosphere Programme](#) in 1987 (the program ended in 2015). McCarthy was also a cochair of the Nobel Peace Prize–winning Intergovernmental Panel on Climate Change in 2001.

The [Tyler Prize](#) was established in 1973 by the late John and Alice Tyler and is one of the first international premier awards for environmental science, environmental health, and energy. Falkowski and McCarthy will receive Tyler Prize medallions and share the accompanying \$200,000 monetary award.

Eos spoke with both Tyler Prize winners to hear their thoughts about the past, present, and future of their respective fields. Their responses have been edited for length and clarity.

Eos: What do you think is the biggest difference between your field when you first began doing your research and your field now?

JM: Conceptually, the scope of everything we do has changed. Enormous advances have been made in understanding linkages between biological, chemical, and physical processes in the sea and the linkages between oceanic and atmospheric processes. Subfields once pursued with little sense of importance by scientists in other subfields are now recognized as highly relevant. I sometimes tell students that when I first began my research in ocean science, only those of us who were studying plankton thought that plankton were important for anything other than feeding fish. The role of [plankton](#) in the carbon cycle, notably in the workings of the biological pump, which transforms dissolved carbon dioxide into organic material and facilitates its flux into the deep sea for long-term storage in water and even longer in sediments, was not appreciated. Not to mention how these processes contribute over millions of years to the abundance of oxygen in the atmosphere and the accumulation of organic-rich sediments that are today tapped for oil and gas extraction.



James McCarthy Tyler Prize
James McCarthy. Credit: Katie Voss

In the early 1980s Chuck Drake, while president of AGU, asked me if I would agree to help launch and serve as founding editor of a new journal. The Union thought it timely to draw attention to understanding that was emerging from increasing involvement of biologists in studies of geochemistry. He and I had some long conversations about this, and it seemed that an appropriate title for the journal would be *Global Biogeochemical Cycles*. But there were some strong objections. Some critics thought the first word was too ambitious, while others thought the last word was too restrictive. But Chuck was highly supportive of the aspirations implied by both of these words, and the journal was launched. At this same time I was a member of NASA's Earth System Science Committee, chaired by Francis Bretherton, and I was working with Roger Revelle and others to bring more biological perspective into international ocean science programs. The reports of this NASA committee contained some of the first detailed templates for linkages that we now take for granted between oceans biology, the atmosphere, the geosphere, and Earth's climate. Viewing ocean biological processes through this broader lens has transformed our branch of science.

PF: When I started working in biological oceanography over 40 years ago, many scientists had divided the world into the atmosphere, the biosphere, and the oceans. The "biosphere" was basically a term used to include terrestrial ecosystems but not the oceans, and the term "oceans" was meant to include the chemical and physical circulation but not biology. By the end of the 20th century, largely because of several years of satellite observations of both marine and terrestrial ecosystems, we came to understand that the oceans, although containing less than 1% of the photosynthetic biomass on the planet, are responsible for approximately 45% of global carbon fixation. That realization has led to a greater appreciation that the Earth functions as a system. The result is that many institutions, including my own, have developed programs in Earth system science, where faculty from traditional oceanographic, atmospheric, geological, and terrestrial departments are much more interactive in terms of what they teach and how they collaborate across disciplines. This is a far cry from when I was a student, when evolution of ecosystems was almost never discussed, and geological scientists learned very little, if

anything, about mechanisms of biological processes. We still have a long way to go, but we are definitely moving, as a field, in the right direction.

Eos: How have emerging technologies changed the way we study Earth?

JM: It is easy to take our modern electronic sensing capabilities for granted. But having witnessed the introduction of electronic sensors to determine temperature, salinity, oxygen, light, plankton fluorescence, etc., from ships and buoys, it is difficult to describe just how dramatically this equipment enhanced the capabilities of ocean science. Continuous measurements—whether they be for a profile of the water column, an underway transect, or a buoy time series—added substantial sophistication to the interpretation of biological processes. Filling in the gaps between discrete samples yielded better understanding of underlying processes responsible for the distributions of these properties. With advances in computing capability, it became possible to apply the results from many of these measurements in real time to enable more efficient use of sampling resources.

The next wave of innovation—satellite sensors for ocean properties—was introduced in the 1980s and made operational in the 1990s. Those sensors provided the opportunity to construct global representations of ocean properties and processes. In concert with these developments, biological oceanographers planned and executed a series of major field campaigns. Those addressed fundamental questions related to biological production and the fate of this organic material in open ocean gyres over an annual cycle. They also explored the interannual variability of biological production, the flux of organic material from the surface ocean to the ocean interior in seasonally productive regions, and relationships that define the food webs of marine ecosystems.

PF: There are many technologies that have changed the way we've studied Earth. I probably will leave out some, and if so, it is unintentional. From the top, satellite-based observations of the oceans, land, and the atmosphere have been, in my opinion, totally revolutionary in terms of how we think about coupling processes on global scales. Clearly, the satellites have given us an understanding of interannual variations and are beginning to give us an appreciation for decadal trends in, for example, changes in glacial ice mass, how ocean circulation and stratification potentially influence primary production, how changes in precipitation and temperature influence terrestrial ecosystems, and how atmospheric aerosols are influenced by human activities.

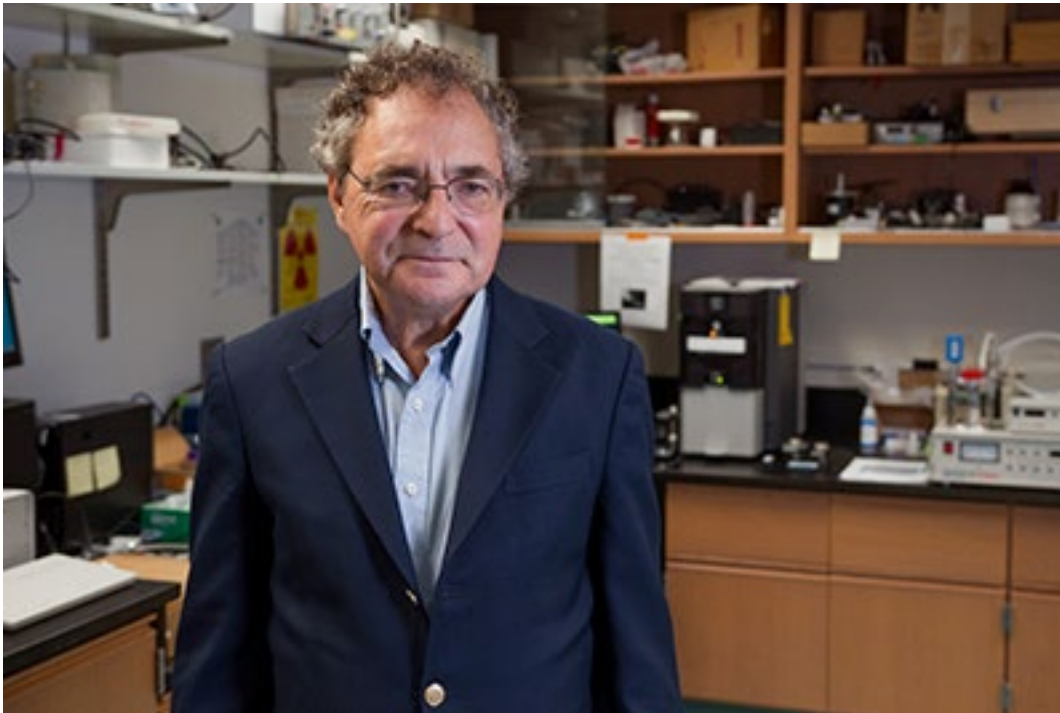
Simultaneously, the ability to rapidly and inexpensively sequence DNA in the oceans and soils was accompanied by huge leaps in computational capabilities that enabled the flood of genomic data to be converted into information. We are discovering the incredible diversity of microbial communities in virtually all ecosystems. In turn, the ability of organisms to live under extreme environments of heat, cold, pressure, and so on has informed us about the potential for life on planetary bodies such as Europa or Enceladus within our solar system as well as on extrasolar planets. It is an extremely exciting time to be an Earth system scientist!

Eos: Which discoveries do you think have been the most significant in your field?

JM: In terms of the natural workings of the ocean, perhaps the abundance of the very small picoplankton, and notably *Prochlorococcus*, might be the most significant discovery. With the deployment of deep sediment traps, many of us were very surprised to see that seasonal plankton blooms in the open ocean provide pulses of organic material to the deep sea. The degree to which the spring bloom in the North Atlantic could draw down inorganic carbon in the upper ocean is another.

Discoveries regarding the effects of human activity have led to questions about how the ocean will function in the future. In the late 1980s, it became clear that much of the surface ocean had warmed over the past century. We now know that more than 90% of the heat retained by anthropogenic greenhouse gases is in the ocean.

Although it could have been anticipated, the realization that anthropogenic emissions of carbon dioxide absorbed by the ocean have reduced ocean pH with negative implications for many calcifying species is another unwelcome discovery. Increasing eutrophication in the coastal ocean contributing to harmful algal blooms and “dead zones” is another.



Dr. Paul Falkowski Tyler Prize
Dr. Paul Falkowski. Credit: Katie Voss

PF: In my specific areas of research, I think the application of biophysical techniques to understanding how microbes work has been extremely profound. We still do not really understand how cells work nor how nanoscale processes that comprise the “engines of life” within each cell connect to global phenomena. While not exactly a “discovery,” this is a new way of thinking about how Earth functions. It is analogous to looking at a [Seurat](#) painting with a magnifying glass to understand the relationship of each point of paint to the next and then stepping back and seeing the image the painter was creating. A fundamental problem in mine, and many other fields, is that scientists are often taught (although usually not formally) to examine a problem from a reductionist perspective. That leads you to seeing the individual points of paint rather than the entire image. In the end, the purely reductionist approach doesn’t help when we are thinking about a “system,” but a descriptive approach to understanding systems is also lacking.

Eos: What are the key questions that still need to be answered?

JM: Climate change is a juggernaut that will increasingly demand the attention of ocean scientists. How will global and regional productivity be affected by changes in upper ocean density? How will

the distribution of marine species and the configuration of food webs change in response to continued warming? How will the Arctic ocean food web contained within, on, and under sea ice be transformed as the season for sea ice continues to shrink? Many people, from the Arctic to the tropics, derive a significant portion of their dietary protein from the ocean. Can this be sustained as the world continues to warm?

PF: Biological oceanography is a bit moribund; we have to get out of our “boxes” and look at how to develop testable hypotheses at relevant scales. What “limits” nitrogen fixation in the ocean? How can (or did) the ocean become anoxic? How efficiently is energy transferred across trophic levels, and what controls that efficiency? Many of these types of questions have been explored by limnologists, but whether the answers apply to large-scale ecosystems, such as an ocean basin, I do not know. I think we need to think differently about the oceans and their evolutionary ecology than we traditionally have.

Eos: What challenges do you think lie ahead for your field?

JM: For decades the pursuit of ocean science has been restricted by access to funding. Ships, satellite sensors, laboratory equipment, computing facilities, etc., are expensive. Moreover, some branches of government that were prominent funders of ocean science early in my career have phased out many of these programs. Additional anthropogenic climate change is inevitable, and even if we are successful in slowing the rate of change substantially during the current century, progress in ocean science will be essential in order to understand how humans can thrive in harmony with ocean life. This won't happen without a higher level of funding for ocean science.

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