is projected to increase in the coming decades, as sea ice recedes — a thaw that could be exacerbated by particles of black carbon, which hasten melting when they land on snow and ice.

Measuring black-carbon emissions is not a trivial task, Lack says. The most accurate, and expensive, technology fires a laser pulse through exhaust samples in a tube. Black-carbon particles absorb and then release the energy from the pulse, creating a pressure wave whose strength is equivalent to the amount of light that was absorbed. The shipping industry is pushing for a cheaper, but less accurate, method that draws exhaust through a filter; measurements of the reflectivity of that filter before and after use are then used to determine how much pollution a ship emitted.

Both approaches could serve a purpose as the IMO moves forward with regulations, Comer says. But he adds that many of the regulatory actions that the organization could pursue to reduce black-carbon emissions do not require regular measurements from ships. Shifting from 'heavy' fuel oil to cleaner types — similar to those used in trucks — would reduce ships' black-carbon output by 35–80%, depending on the engine. And installing filters on the vessels' exhaust systems would cut emissions by at least 85%.

The shipping industry is under pressure to curb other types of pollution. The United States, Canada and the European Union already require ships to use lower-sulfur fuels in some coastal zones. And in 2016, the IMO agreed to reduce the sulfur content in all shipping fuels from 3.5% to 0.5% by 2020. That is good news for public health, but it could inadvertently exacerbate global warming, says James Corbett, an engineer at the University of Delaware's School of Marine Science and Policy in Newark.

In a study this week (M. Sofiev *et al. Nature Commun.* **9,** 406; 2018), Corbett and his colleagues found that the IMO sulfur standard could reduce global cardiovascular and lung-cancer deaths attributable to fine particulate matter by 2.6%, and the incidence of childhood asthma by 3.6%. But the new standard could accelerate climate change by decreasing the number of bright, sulfur-containing particles in the atmosphere that cool the planet by reflecting sunlight back into space. The researchers estimate that this effect would increase the human contribution to warming by around 3%.

"We're talking some big numbers," says Corbett.

For Comer, that is all the more reason to press forward with black-carbon regulations. "It's frustrating," he says. "We already know how to control [black-carbon] emissions, but we're stuck going through the three-step process." ■

Cuts to Bulgaria's science budget sparked strikes in November, following earlier protests by students.

OLEG POPOV/REUTERS

BUDGETS

Funding cuts hit Bulgarian science

A push to attract investment in innovation has floundered.

BY INGA VESPER

European Union science ministers met on 2 February in their bloc's poorest member state — Bulgaria — to discuss future EU research policy. For the host nation, it was supposed to be a chance to showcase ambitious plans to boost economic growth by attracting international research institutes to the country.

But the timing of the event was awkward, to say the least. In July 2017, Bulgaria had been due to receive €150 million (US$186 million) from the EU to build facilities for research and innovation, under a programme that aims to boost economic growth in poor regions. The programme, which was expected to give Bulgaria €700 million between 2014 and 2020, is designed to help with the costs of research infrastructure.

However, EU authorities withheld the money after Bulgaria failed to identify enough sufficiently qualified scientists to evaluate the proposals. Then, in November 2017, the Bulgarian government cut its 2018 science and higher education budget by around 25%, a move it had planned in anticipation of the windfall.

The decision has frustrated scientists in Bulgaria, because they had wanted to use the new infrastructure to forge links with researchers outside the country. "Now, we cannot prepare proposals because we are not going to have the infrastructure," says Ana Proykova, a physicist at Sofia University and an adviser on European research infrastructure to Bulgaria's government. She says that the government should reinstate the funds it cut from the 2018 budget. "We are still fighting very strongly for the funding procedure to be reopened, even if it is in the middle of this year. Otherwise, our budget is going to be very tiny."

Bulgaria, which took over the six-month rotating presidency of the EU on 1 January, produces little science compared with the bloc's other member states. The country's output is low (see 'Bulgaria's output lags behind'), and more than 30% of PhD-holding Bulgarians are at present pursuing careers abroad. But scientists in Bulgaria hope for improvements. The country intends to bid for a proposed Balkan synchrotron particle accelerator, a light source that many hope will promote international diplomacy in the region.

Its universities still want to tap into EU infrastructure funds. During its presidency, Bulgaria is also in charge of negotiating Framework 9, the EU's latest seven-year plan for science, which is due to be finalized in May. It sees the plan, in part, as an opportunity for Bulgarian companies to enter into

lucrative contracts with international research consortia. "Industry is very important for us," says Karina Angelieva, adviser for education and research at Bulgaria's permanent representation to the EU, in Brussels.

RAISED SCRUTINY

These plans are now at risk, unless Bulgaria can persuade the EU's regional-policy directorate general to release the frozen funds. Meanwhile, the 2018 science and higher education budget stands at 2013 levels: just 415 million leva (US$263 million), plus another 98 million leva for the Bulgarian Academy of Sciences.

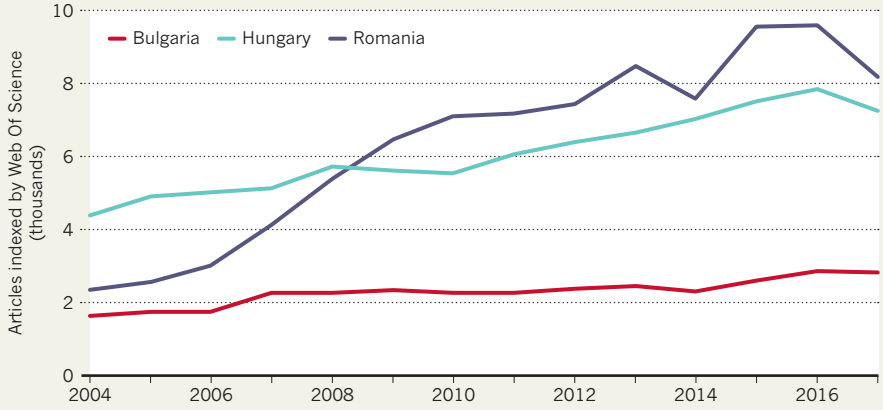
The financial difficulties also threaten Bulgaria's national research-infrastructure road map, which was published in June 2017. Kostadin Kostadinov, an adviser to the country's science and education minister, Krasimir Valchev, says that the road map "will increase research potential in Bulgaria according to the needs of local industry and regional development", and that it is part of a plan ultimately to raise the country's total science spending to 1.5% of gross domestic product (GDP). That figure currently stands at 0.96% of GDP, which is less than half the EU average.

Problems with science funding are exacerbated by corruption, say several scientists. Not only is Bulgaria the poorest country in the EU, it is also the most corrupt, according to Berlin-based lobby group Transparency International. Proykova says that science is rarely directly affected by monetary fraud, but corruption makes itself felt in procurement. "For example, things are never delivered to the lab, even though the money has been transferred," she says. "Or, you get less good equipment for the same money, because the company takes some of the funds."

Some scientists see Bulgaria's turn in the EU presidency as a chance for change. Lidia Borrell-Damián, director for research and innovation at the European University Association in Brussels, says that it provides an opportunity for Bulgaria's universities to connect with others. Daniel Smilov, a political scientist at Sofia University, hopes that the presidency will put the country's problems on the map, forcing change from outside that has been lacking from within. "It is an important moment," he says, "because our visibility will be great." ■

BULGARIA'S OUTPUT LAGS BEHIND

Efforts to boost science in the European Union's poorest country have been undermined by a lack of funds. Bulgaria's production of published research has risen at a slower rate than that of its neighbours.



SOURCE: WEB OF SCIENCE

DNA SEQUENCING

Super-invasive crayfish revealed to be a genetic hybrid

Scientists examine DNA of a marbled crayfish that is spreading ferociously.

EWEN CALLAWAY

Molecular biologists have sequenced the genome of an invasive species of crayfish that can reproduce without mating and is spreading rapidly across Madagascar. The marbled crayfish (*Procambarus virginalis*) was first spotted in aquariums in Germany in the 1990s. Now, DNA sequencing suggests that the species is probably the product of two distantly related members of a different crayfish species, the team reported on 5 February in *Nature Ecology and Evolution*[1].

The marbled crayfish has already been banned in the European Union and some parts of the United States because of the threat it poses to freshwater ecosystems. The species has now spread into the interior of Madagascar and risks crowding out seven native crayfish species. "This is a very aggressive population," says Frank Lyko, a molecular biologist at the German Cancer Research Center in Heidelberg, who co-led the study. "If the marbled crayfish continues to explode at its current pace, it will probably outcompete endemic species."

"If the marbled crayfish continues to explode at its current pace, it will probably outcompete endemic species."

The marbled crayfish carries three copies of each chromosome, instead of the usual two[2]. Lyko and his team sequenced the genome of a single individual from a laboratory strain known as Petshop. Its DNA revealed a surprise: it had two different genotypes at many places in its genome. The best explanation for this pattern, says Lyko, is that two of the chromosomes are nearly identical in sequence, but the third differs substantially.

The two distinct genomes are closely related to those of another freshwater crayfish, *Procambarus fallax*, native to Florida and popular with aquarists. Lyko speculates that marbled crayfish emerged when the genome of a sperm or egg of one *P. fallax* individual became duplicated, which can happen in response to sudden changes in temperature. If this cell was then fertilized by another individual living in the same aquarium, it would have resulted in an embryo with three copies of its genome, says Lyko. This would represent a new species. Lyko says that the first marbled crayfish was probably born in an aquarium in either Germany or the United States, and its offspring widely shared between fish collectors.

The first scientific description of the marbled crayfish appeared in 2003, in a ▶