MARINE LIFE

Data on mining the deep sea

Scientists will track damage caused by marine dredging.

BY OLIVE HEFFERNAN

For decades, mining companies have been eager to extract valuable metals and minerals from the deep sea — a practice that scientists have long warned could damage marine life. Now, the first large test of a major mining technique promises to provide robust data on the impacts of the controversial practice.

Next month, Belgian mining firm Global Sea Mineral Resources (GSR) will use a protoype machine to hoover up metals, such as copper and iron, that lie in rock deposits — nodules — on the bed of a remote part of the Pacific Ocean. Alongside GSR, an independent team of European scientists will study the effects of the mining method: in particular, how sediment plumes created by the churning could affect vibrant deep-sea communities. The scientists' findings are expected to inform discussions about an international code of conduct that would allow commercial mining to move forwards while minimizing harm to sea life.

"This will, hopefully, help us to close some of the knowledge gaps that we have on the expected impacts of deep-sea mining," says Matthias Haeckel, a biogeochemist at the GEOMAR Helmholtz Centre for Ocean Researh Kiel in Germany, who is leading the research expedition.

The International Seabed Authority (ISA) — a 168-member body that promotes and regulates seabed mining and is developing the code — has granted 29 licences that give contractors permission to explore minerals in the deep sea. Sixteen are for the Pacific's Clarion Clipperton Zone (CCZ), one of the world's largest untapped collections of high-value metal ores.

Over eight days, GSR will harvest metal-rich nodules from a small area in the CCZ, as scientists on a research vessel deploy deep-sea cameras and sensors to monitor how the dredging disturbs the soft, sedimentary sea floor.

Researchers fear that mining could create plumes of suspended sediment that extend tens or even hundreds of metres above the seafloor, which could bury, smother and toxify sea animals such as rare, squid-like worms, sea cucumbers and urchins. "It is likely that the CCZ communities are extremely sensitive to sediment plumes," says Smith.

The ISA ultimately plans to award contractors 30-year exploration licences. Kristina Gjerde, a high-seas-policy specialist at the International Union for Conservation of Nature, says that, ultimately, the experiment isn't long enough to gauge mining's long-term effects. ■

NOC

OCEANOGRAPHY

Sea walls wired to track flood risk

WireWall device measures waves crashing onto shore.

BY ALEXANDRA WITZE

Jenny Brown is hoping for really bad weather. She is consulting tide tables, watching forecasts and rooting for strong westerly winds that would push the spring tide over the sea wall at Crosby, on Liverpool Bay in the United Kingdom, in the days around 21 March.

Brown, a physical oceanographer at the National Oceanography Centre (NOC) in Liverpool, wants to help local officials understand how much the ocean is breaching the sea wall — and how much they need to strengthen their flood defences.

To do that, she needs the waves to splash onto a device her team will bolt into the concrete sea wall. It's a box-like frame built of pipes, with wires strung between them like strings on a harp. When seawater slops over the top of the barrier, the wires will measure the volume and speed of the spray.

"We don't have a good understanding of the impact of storms," says Brown. "Offshore, we have wave measurements and tide gauges, but what we don't have is measurements of water coming on land."

Such data are important to make sure that people strolling by the sea aren't swept off their feet by big waves, and to help communities prepare for coastal flooding during storms. In the United Kingdom alone, at least £150 billion (US$197 billion) of property and 4 million people are at risk from coastal flooding. "Nobody's going to make the call to shut a four-lane highway unless they're really sure the conditions are likely to be hazardous," says Tim Pullen, a coastal engineer at UK civil-engineering company HR Wallingford.

Brown's team's device, called WireWall, has collected data at Crosby over three particularly high tides since October. Mid-March is their last chance to catch the ocean crashing over the sea wall before they have to start writing up their results. The researchers want to use the information to improve oceanographic models — and perhaps deploy WireWalls in other places, to study topics such as dam safety and the effectiveness of mangrove trees as coastal barriers.

WAVE OF THE FUTURE

There are hardly any field data on how often seawater splashes over coastal defences, says Pullen. In the early 2000s, he helped put large tanks behind the sea wall at a coastal park in Kent, next to the tunnel under the English Channel. The tanks captured water slopping

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The WireWall frame measures waves sloshing over sea walls.

over the wall and, by measuring the depth of water after each slop, the scientists could take some of the only such field measurements captured so far (T. Pullen *et al. Coast. Eng.* **56**, 121–140; 2009).

But tanks are heavy and expensive to deploy, and they don't gather data on how fast water is moving. So Brown got in touch with Margaret Yelland, an oceanographer at the NOC site in Southampton, who has used capacitance wires, which sense contact with salt water, on buoys in the open ocean (R. W. Pascal *et al. J. Atmos. Ocean. Technol.* **28**, 590-605; 2011). Working with Pullen and others, they designed and tested WireWall before taking it to Crosby, where local officials plan to replace the ageing sea wall and are looking for information on how best to do that. (Part of their research involved going through photos from a Facebook group of people who walk on Crosby beach to see how often the car park flooded.)

When tides are high, winds are strong and it looks as if the sea might break over the wall at Crosby, the WireWall team sets up its rig. It's about the height of a person and has 18 wires arrayed in a grid. When seawater hits the wires, it generates an electrical contact that reveals how much of the wire is wet. By measuring how the wires get drenched as the wave passes through them, the researchers can calculate the water's speed and volume.

"We've had a good range of lovely big waves coming over," says Yelland, who has been looking through the data gathered at high tides in October, November and January. One unexpected factor is that when the waves arrive nearly parallel to the sea wall, the water splashes up in a sideways squirt that can be hard for WireWall to detect.

RISING TIDE

Eventually, the researchers aim to use the data to help improve oceanographic models and other tools, such as the European-led industry guide on overtopping known as EurOtop. Brown has already spoken to officials about taking WireWall elsewhere. One option is the Fylde peninsula in Lancashire, UK, where three new sea walls each have a slightly different design on which WireWall could compare sloshing.

"We'd like to be able to go anywhere," says Brown. In Australia, ecologists Rebecca Morris and Beth Strain of the University of Melbourne plan to use WireWall to compare flooding that breaches sea walls with flooding over natural coastal defences such as mangrove forests. In Norway, researchers might use WireWall to study how winds blowing across reservoirs can push water over the tops of dams and destabilize them, says Fjóla Guðrún Sigtryggsdóttir, a civil engineer at the Norwegian University of Science and Technology in Trondheim.

WireWall could become even more relevant as sea levels continue to rise, increasing the risk of waves breaching walls. In the United Kingdom, coastal planners are required to take the effects of sea-level rise into account when building new sea defences. At Crosby, sea level is rising by 1.6 millimetres per year. ■

AWARDS

US mathematician is first woman to win prestigious Abel Prize

Karen Keskulla Uhlenbeck built bridges between analysis, geometry and physics.

BY DAVIDE CASTELVECCHI

US mathematician Karen Keskulla Uhlenbeck has won the 2019 Abel Prize — one of mathematics' most prestigious awards — for her wide-ranging work in analysis, geometry and mathematical physics. Uhlenbeck is the first woman to win the 6-million-kroner (US$700,000) prize, which is given out by the Norwegian Academy of Science and Letters, since it was first awarded in 2003.

Uhlenbeck learnt that she had won on 17 March, after a friend called and told her that the academy was trying to contact her. "I was completely amazed," she told *Nature*. "It was totally out of the blue."

Uhlenbeck is legendary for her skill with partial differential equations, which link variable quantities and their rates of change, and are at the heart of most physical laws. But her long career has stretched across many fields, and she has used the equations to solve problems in geometry and topology.

One of her most influential results — and the one that she says she's most proud of — is the discovery of a phenomenon called bubbling, as part of seminal work she did with mathematician Jonathan Sacks. Sacks and Uhlenbeck were studying 'minimal surfaces', the mathematical theory of how soap films arrange themselves into shapes that minimize their energy. But the theory had been marred by the appearance of points at which energy seemed to become infinitely concentrated. Uhlenbeck 'zoomed in' on those points to show that this was caused by a new bubble splitting off the surface.

She applied similar techniques to do foundational work in the mathematical theory of gauge fields, a generalization of the theory of classical electromagnetic fields that underlies the standard model of particle physics.

DISPARATE FIELDS

Much of Uhlenbeck's work was done in the early 1980s, when research communities that had grown apart were starting to connect again, she recalls. "There was a real flowering of this relationship between mathematics and physics," she says. Mathematicians proved that they had information useful to physicists, who "had great ideas of objects to study that mathematicians couldn't come up with by themselves".

The work of other prizewinning mathematicians has been rooted in techniques introduced by Uhlenbeck, says Mark Haskins, a mathematician at the University of Bath, UK, who was one of her doctoral students. These include Fields Medal winner Simon Donaldson — who ▶

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