fill the gap? The UN thinks so. On 24 December, it convened an intergovernmental conference to produce a legally binding treaty on the conservation and sustainable use of biological diversity in the high seas outside national maritime boundaries. It's a crucial first step, and is encouraging because it suggests that political will is building to draft international rules that protect the ocean wilderness.

The vote, after almost a decade of preparatory work, reflects scientists' growing concern about the alarming state of the global oceans. And public awareness about issues such as overfishing, plastic pollution and species extinction is sharply on the rise in many countries.

The planned treaty, due by 2020, is much needed. A global commons, the high seas cover half of Earth's surface and provide eco-services of immeasurable value. Still, any new pact cannot address all the ills of the seven seas. The surge in plastic waste, for example, has to be tackled at its terrestrial source, mainly with the producers. But a well-crafted and properly enforced rulebook can do much to protect ocean ecosystems from man-made harm.

Any future network of high-seas reserves will need to cover a large variety of species in representative ecosystems in all climate zones. To do this, researchers with the UN Convention on Biological Diversity suggest that marine protected areas should cover at least 10% of the global ocean by 2020. At present, the figure is closer to 6% — almost all in coastal waters. The higher target will be impossible to reach without setting aside reserves in high-seas regions that are as yet legally out of reach. Hence the need for a new treaty.

The treaty's range and scope are yet to be defined, and science has the chance to help frame its demands, and to ensure that the goals of protection and conservation are effectively met. Our understanding of marine ecosystems is best for coastal and inshore regions. An evidence-based approach to protecting the wilderness of the high seas will require massive amounts of research. For example, to get a better sense of the scale of the looming ocean crisis, scientists need to map ecosystem structures and deep-seabed habitats, and to track migratory patterns of critical species. They will also want to take a closer look at how biological processes in the deep ocean control key chemical cycles, such as carbon uptake and release, that govern Earth's climate.

Research can benefit from, as well as inform, protection. Recent studies show that marine reserves can help species adapt to ocean acidification and other impacts of climate change (see, for example, C. M. Roberts *et al. Proc. Natl Acad. Sci. USA* **114,** 6167–6175; 2017). Such areas can serve as a control by which to evaluate the impact of fishing and environmental change on marine ecosystems. Researchers can also help to set priorities, by working to identify key ecosystems that need protection from overfishing and other human interference.

"Implementation of any rules will have to rely on effective satellite surveillance."

A meaningful high-seas pact must also encourage effective fisheries management outside protected areas, to support sustainable catch. And implementation of any rules will have to rely on effective satellite surveillance of fisheries activities on the open ocean. The International Maritime Organization (and Interpol) is already using vessel-monitoring technology to track ship movements and suspicious activity.

The next step will be the first session of the intergovernmental conference, on 4–17 September. It is unclear whether key fishing nations — including the United States, Russia and China — will ratify any agreement. Encouragingly, these countries have not blocked the work of the preparatory committee. Other nations, including Norway, Iceland, Japan and South Korea, have signalled full support for a legally binding instrument. The number of signatures required for the treaty to be enforced is yet to be negotiated.

Whatever arrangements emerge, the UN's move should provide ample research opportunities. Funders should take note. A treaty involving an international research mandate — including a regime to regulate controversial geoengineering experiments such as ocean iron fertilization — would be a boon for ocean health and responsible science. ■

In the jeans

An environmentally friendly way to dye denim could usher in a long-overdue new fashion.

In his Latin description of the Gallic Wars, Julius Caesar wrote: "*se Britanni vitro inficiunt*" — widely translated as meaning that the Britons dyed themselves with woad. Hence, many sources will tell you, the Romans named the ancient people of northern Britain the Picts, or 'painted ones'. Among the objections to this claim is that woad is not a very good dye for people — it's caustic and irritates the skin and eyes.

It's not a great dye for textiles, either. The indigo colour squeezed from plants including woad (*Isatis tinctoria*) doesn't dissolve in water and so can't penetrate and bind cloth fibres. Instead, it must be chemically converted into a water-soluble compound called leucoindigo, or white indigo, which then adsorbs to the textile surface. It is most commonly used on denim. Over 4 billion denim garments are produced each year. These days, most are dyed blue with synthetic indigo, but the artificial colour must still be fixed using a potent bleaching agent. This is one reason why indigo dyeing is so polluting, as shown vividly by the numerous rivers in China and elsewhere that have been turned blue by untreated waste from jeans factories. According to environmental groups, textile dyeing is one of the most polluting industries in the world.

Indigo dyeing is so widespread that it is hard to replace with a cleaner process. But scientists are trying. Writing online in *Nature Chemical Biology*, researchers describe a more environmentally friendly method of making and applying indigo dye that relies on genetically engineered bacteria (T. M. Hsu *et al. Nature Chem. Biol.* http://dx.doi.org/10.1038/nchembio.2552; 2018).

The process borrows a chemical switch from nature. Inside plant leaves, the unstable indigo precursor indoxyl is combined with glucose and stored as a colourless molecule called indican. The researchers mimicked this by adding genes to *Escherichia coli* bacteria to make them secrete indican. To dye material with this biosynthetic indican, the scientists dissolved it in water and applied the solution alongside an enzyme that stripped away the glucose to re-form indoxyl. This indoxyl then spontaneously oxidized to leucoindigo. When removed from the liquid, the leucoindigo reacted with the air and turned to indigo.

The clever mechanism goes further than previous attempts to clean the process, because it kills two polluting birds with one stone. First, it does away with the wasteful chemical synthesis of indigo.

Second, unlike previous indigo biosyntheses, this project removes the damaging bleaching stage that converts indigo to leucoindigo.

Industry churns out some 50,000 tonnes of synthetic indigo a year, and the bacterial system will need to be optimized and scaled up to make it commercially viable. The glucose molecules must be separated and removed, for one, and the enzyme used to liberate the indoxyl is expensive.

The scientists are optimistic that these challenges can be overcome. Are they right to be? One reason that biofuel production is cheap enough to be possible commercially is that it uses enzymes farmed from fungi. A useful step to prove the credentials of the greener denim dye would be to develop a similar low-cost way to make the required enzyme.

Still, indigo production has not always welcomed novelty. Until well into the eighteenth century, France protected its wood industry by threatening users of indigo imported from India and other foreign sources with the death penalty. But given that the popularity of blue denim shows no signs of slowing, the process that produces it sorely needs a new trend. ■