Editorial

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Diving in

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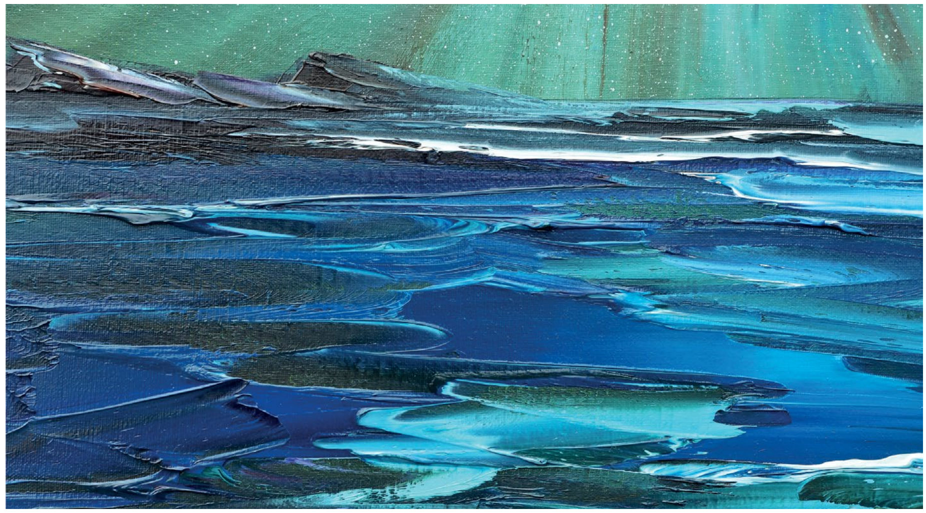
Nearly two years into the United Nations Decade of Ocean Science, research, including some featured in this month's issue, shows that there is still a wealth of scientific secrets to uncover in the ocean depths.



In many ways, considering the ocean as a single unit is overly broad. The global ocean covers 71% of the planet's surface, reaches down to depths of over 10 kilometres, includes about 1.35 billion cubic kilometres of water and houses an approximated 2.2 million eukaryotic species. There are distinct regions, with distinct physical properties, and, in turn, there are distinct species. Yet, the world's oceans do have a level of physical and thematic connectivity.

Physically, a large part of the connection is related to the presence of large rotating ocean currents that transfer heat across latitudes and contribute to ocean mixing (thermohaline circulation). Some of these currents are warming at alarming rates — up to three times faster than the rest of the ocean, leading to questions about the underlying mechanisms of the warming and expectations for change.

Focusing on western boundary currents (WBCs) in the Southern Hemisphere, in an Article in this issue of *Nature Climate Change*, Li and colleagues answer a long-debated question on the mechanisms of change, showing that temperature-gradient-related instabilities, rather than flow-speed-related instabilities are behind the shifts. In another Article, focusing on the global future changes of eddies (including eddy-rich WBCs), Beech and colleagues report the development of a flexible method that maximizes local model resolution while minimizing computational costs, to reveal the long-term geographical specificities and nonlinear temperature increases expected to 2100 (see also the News and Views article by Yang on these papers).

A recent paper[1] has demonstrated the important role of large ocean currents in defining plankton biogeography and dynamics, and WBC warming has previously been linked to impacts such as fishery collapses. The tight link between physical processes and biological responses is an underscoring theme of climate change ecology, but is perhaps more apparent in the open ocean, where physical processes can be easily (if imperfectly) linked to primary productivity using remotely sensed phytoplankton pigment absorption, and where life is generally less impacted by geographical, political or disturbance-based boundaries compared with land and freshwater systems. These aspects may facilitate modelling of current and future communities, while also allowing broader assumptions to be made about biological movement and connectivity.

Despite these benefits, understanding ocean change comes with its own difficulties. Biological sampling, while easy enough in the surface waters, becomes increasingly difficult at depth. Although future habitats for various organisms have been projected on the basis of their thermal limits in the ocean, these predictions often still rely on temperatures at the surface of the sea. Addressing this, Santana-Falcón and colleagues report in an Article the global mapping of ocean temperature changes to depths of 1,000 metres, and reveal the complex depth-dependent changes in thermal upper and lower bounds that marine organisms will soon be subjected to. In another Article, Ariza and colleagues neatly address the issue of directly monitoring deep-ocean change by compiling a large database of sound-based observations, and subsequently classifying the ocean's 'echobiomes', defined as sound-scattering communities with comparable structural and functional properties (see also the accompanying News and Views article by Hazen). Sound-based methods are also increasingly being used on land[2], and represent an exciting tool for monitoring change, particularly in hard-to-reach places such as deep forests, high mountaintops or underground. While the sound reflection method used in the study by Ariza and colleagues has limits in its ability to identify organisms at the individual or species levels, it does provide a community-level focus on change, which remains much needed in the field of global change ecology.

At the other end of the spatial spectrum, research by Lee and colleagues reported in an Article also in this issue dives deep into the DNA of a keystone ocean organism (a copepod), to understand the mechanisms that may allow longer-term adaptation to warming and pH stress. The work reveals remarkable adaptation over just a few short generations, which is linked to epigenetic changes. As climate change impacts continue to escalate, the ability of organisms to invoke both shorter- and longer-term adaptations has become an increasingly relevant area of research. Epigenetics has previously been reported as a quick-response method to cope with environmental stress, and may be particularly relevant in defining the adaptation of short-lived animals such as insects and the resilience of the communities they uphold.

The five research pieces linked to the oceans in this issue reveal just some of the diversity of topics, methods and scales relevant to understanding global change. Also increasingly relevant are works on ocean conservation[3] and on the social and economic impacts of ocean change[4,5]. Like climate change science, the topic of ocean change is less of a field, and more of a cross-disciplinary theme.

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References

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