

The rise of ocean robots

As the COVID-19 pandemic halts many research cruise activities, exploration of the oceans by autonomous vehicles continues, highlighting the strengths of robotic research, but also the limitations.

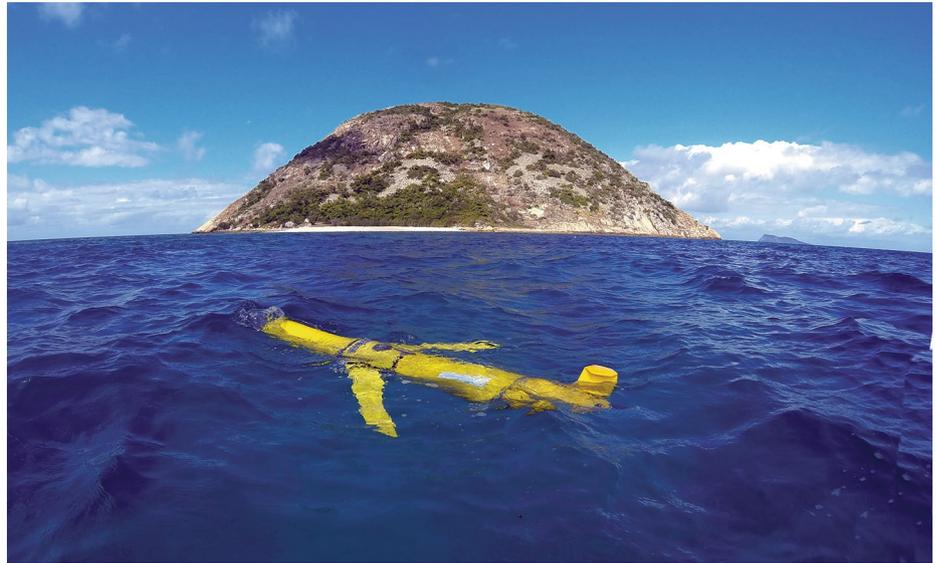
Autonomous systems are growing in number in oceanography. Over the past two decades, the seminal Argo float network, comprising some 4,000 passively drifting floats equipped with sensors, has delivered over two million temperature and salinity profiles throughout the world's oceans. With many research cruises suspended or delayed due to the COVID-19 pandemic, oceanographers will now rely more than ever on these robotic eyes in our oceans. Talking with researchers in the United Kingdom, we learned how autonomous technology enables remote working with a range of benefits, but that ultimately there is still a firm human hand at the controls.

The autonomous revolution now includes sensors tagged onto seals in the *Marine Mammals Exploring the Oceans Pole to Pole* project, in situ moorings, and remotely operated ocean gliders. Collected data are transmitted back to land via satellite communications, meaning researchers only need an Internet connection to receive data in real time. Data stored in centres such as *The Global Ocean Observing System* can then be shared and accessed by a wide range of users, irrespective of their ability to take to the high seas.

With access to the field and laboratory currently restricted, such data could prove an even more valuable resource than usual. Professor Karen Heywood, of the University of East Anglia and president of the European Geosciences Union (EGU) Ocean Sciences Division, is encouraging students and early career researchers to make use of these resources to continue their research and collaborate with fellow scientists on the ever-growing plethora of available data.

Even after the turbulent seas of the current pandemic calm, autonomy has the potential to open up oceanography to anyone. Autonomous systems and data resources allow scientists from a diverse range of backgrounds to be included in research, irrespective of their ability or desire to take to the ocean. For example, Dr Charlotte Williams, of the National Oceanography Centre, began a family during her first postdoc, and found that using gliders and remote data acquisition for her research made it easier for her to balance work and parenting responsibilities.

Autonomous systems can be expensive to deploy and operate, often still requiring a



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component of ship-time in order to launch and recover them. However, even this is changing, as Heywood explained during the *EGU General Assembly*. Introducing *AutoNaut*, a wave-powered, robotic surface vehicle that can transport and release an ocean glider, she explained that it's essentially "a robot that can deploy a robot", with the whole system deployable from the shore by as few as two people. Looking forward, the hope is that the reduced operational costs and workforce requirements mean that such observational systems will increasingly be accessible in developing nations.

Despite the benefits of robotic ocean exploration, some aspects of oceanography do not lend themselves as easily to automation. As in many areas of geoscience, sample collection and laboratory analysis are necessary components of ocean science. Dr Kate Hendry of the University of Bristol works in one such area, using stable isotopes to study marine biogeochemical cycles. Due to the nature and complexity of sample preparation and processing, these are some analyses that robots have yet to master, and she is concerned that the ongoing suspensions of field campaigns may negatively impact the work and future prospects of researchers on short-term contracts. Hendry notes that there are many irreplaceable human aspects of

fieldwork that they will miss: collaborations, community involvement and building trust are at the heart of multidisciplinary research.

However, even autonomous networks require human involvement in their infrastructure, and the current pandemic has exposed this human dependency. While instruments can send their data to shore, autonomous vehicles currently in the water may not be recovered before their batteries run out, and new, ship-based deployments may continue to be restricted. As such, there is some fear that these monitoring networks, which are relied upon by many oceanographers and climate scientists, may be weakened by the current fieldwork restrictions¹.

In these times when oceanographers must stay at home instead of going to sea, autonomous networks provide invaluable opportunities to continue learning, training and conducting research. Oceanographers still need research ships, but robotic exploration is helping to cultivate a more open, inclusive and accessible research field. □

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References

1. Viglione, G. *Nature* **580**, 440–441 (2020).