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# EXPLORING OCEAN CURRENTS 20,000 FEET UNDER THE SEA

Shipboard measurements of ocean depths emphasize the importance of Deep Argo

CTD rosette descends during a cast from NIWA's R/V Tangaroa. Photo: NIWA

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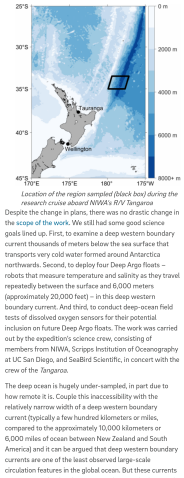
You never know what's going to happen while at sea. We hadn't even left port from Tauranga, New Zealand yet and had already changed plans at least twice due to extreme winds and rain associated with an atmospheric river – the type of weather system that delivered extensive precipitation to the U.S. West Coast this past winter – hitting the North Island of New Zealand.

Instead of boarding the National Institute of Water and Atmospheric Research (NIWA) research vessel *Tangaroa* (named after the Māori god of the sea) early morning on May 2, 2023, to steam east for a few days, our boarding and departure times were pushed back and the call was made to head northeast to the closer Tonga-Kermadec Ridge and Kermadec Trench in the Southwest Pacific Ocean.

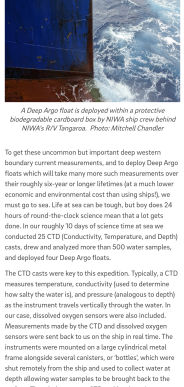



*Location of the system sampled (black box) during the research cruise aboard NIWA's R/V Tangaroa*

Despite the change in plans, there was no drastic change in the scope of the work. We still had some good science goals lined up. First, to examine a deep western boundary current thousands of meters below the sea surface that transports very cold water formed around Antarctica northwards. Second, to deploy four Deep Argo floats – robots that measure temperature and salinity as they travel repeatedly between the surface and 6,000 meters (approximately 20,000 feet) – in this deep western boundary current. And third, to conduct deep-ocean field tests of dissolved oxygen sensors for their potential inclusion on future Deep Argo floats. The work was carried out by the expedition's science crew, consisting of members from NIWA, Scripps Institution of Oceanography at UC San Diego, and SeaBird Scientific, in concert with the crew of the *Tangaroa*.

The deep ocean is hugely under-sampled, in part due to how remote it is. Couple this inaccessibility with the relatively narrow width of a deep western boundary current (typically a few hundred kilometers or miles, compared to the approximately 10,000 kilometers or 6,000 miles of ocean between New Zealand and South America) and it can be argued that deep western boundary currents are one of the least observed large-scale circulation features in the global ocean. But these currents are important for distributing water, heat, and salt around the global ocean and therefore they influence, and are influenced by, Earth's climate. We can think of these currents as part of the arteries and veins of the climate system.

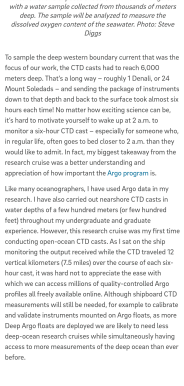
Recent research suggests that waters in deep western boundary currents – such as the one in the Southwest Pacific – are warming at greater rates than in the ocean interior. This deep ocean warming causes increased sea level rise, demonstrating that changes in the deep ocean can directly impact us at the surface.



*A Deep Argo float is deployed within a protective biodegradable cardboard box by NIWA ship crew behind NIWA's R/V Tangaroa. Photo: Mitchell Chandler*

To get these uncommon but important deep western boundary current measurements, and to deploy Deep Argo floats which will take many more such measurements over their roughly six-year or longer lifetimes (at a much lower economic and environmental cost than using ships!), we must go to sea. Life at sea can be tough, but boy does 24 hours of round-the-clock science mean that a lot gets done. In our roughly 10 days of science time at sea we conducted 25 CTD (Conductivity, Temperature, and Depth) casts, drew and analyzed more than 500 water samples, and deployed four Deep Argo floats.

The CTD casts were key to this expedition. Typically, a CTD measures temperature, conductivity (used to determine how salty the water is), and pressure (analogous to depth) as the instrument travels vertically through the water. In our case, dissolved oxygen sensors were also included. Measurements made by the CTD and dissolved oxygen sensors were sent back to us on the ship in real time. The instruments were mounted on a large cylindrical metal frame alongside several canisters, or 'bottles', which were shut remotely from the ship and used to collect water at depth allowing water samples to be brought back to the surface. The whole set-up – CTD and bottles – is commonly referred to as a carousel or rosette. We call the process of lowering the CTD through the ocean then returning it back to the ship a cast.



*Mitchell Chandler poses onboard NIWA's R/V Tangaroa with a water sample collected from thousands of meters deep. The sample will be analyzed to measure the dissolved oxygen content of the seawater. Photo: Steve Diggs*

To sample the deep western boundary current that was the focus of our work, the CTD casts had to reach 6,000 meters deep. That's a long way – roughly 1 Denali, or 24 Mount Soleadas – and sending the package of instruments down to that depth and back to the surface took almost six hours each time! No matter how exciting science can be, it's hard to motivate yourself to wake up at 2 a.m. to monitor a six-hour CTD cast – especially for someone who, in regular life, often goes to bed closer to 2 a.m. than they would like to admit. In fact, my biggest takeaway from the research cruise was a better understanding and appreciation of how important the Argo program is.

Like many oceanographers, I have used Argo data in my research. I have also carried out nearshore CTD casts in the vicinity of a few hundred meters (or few hundred feet) throughout my undergraduate and graduate experience. However, this research cruise was my first time conducting open-ocean CTD casts. As I sat on the ship monitoring the output received while the CTD traveled 12 vertical kilometers (7.5 miles) over the course of each six-hour cast, it was hard not to appreciate the ease with which we can access millions of quality-controlled Argo profiles all freely available online. Although shipboard CTD measurements will still be needed, for example to calibrate and validate instruments mounted on Argo floats, as more Deep Argo floats are deployed we are likely to need less deep-ocean research cruises while simultaneously having access to more measurements of the deep ocean than ever before.

*Mitchell Chandler is a fourth-year physical oceanography PhD student at Scripps Institution of Oceanography studying upper-ocean and deep-ocean western boundary currents. You can find Mitchell on Twitter at @sz_mitch.*