IN THE EYE OF AN EDDY

My short journey in the ocean has taught me two key lessons: eddies must be crossed directly and with a generous supply of patience.

By Samuele Stante

When I was first invited to join an offshore expedition in Brazil aboard the *RV Pelagia*, one of the most charming and cutting-edge ships of the Dutch NIOZ Marine Service, my response without a second thought was an enthusiastic "Yes!". The mission? Chasing an oceanic eddy. To me, that sounded as exciting as storm chasing.

The expedition was part of a university grant offered to “bold and risk-taking” Master's students in oceanography-related programs, willing to spend at least 15 days at sea. We would set sail from the Port of Bridgetown, in Barbados, in a weirdly warm December, with an 11-person team of well-established scientists plus a young and inexperienced student - yes, that’s me.

My initial excitement, however, was soon tempered by the logistics. As my team and I worked through tight deadlines and filled out an equipment inventory, reality hit: I was nowhere near prepared for what lay ahead. I found myself flooded with questions and had little time to answer them all before departure.

And now, here I am: aboard the *RV Pelagia*, on the way back to the Port of Bridgetown, carrying the answers I could only find after undertaking this staggering voyage.

Figure 1. The photo we took on the 9th December 2022, the day before our departure, at the Port of Bridgetown. Some fellow researchers in the photo contributed to work ashore.

So the first question that struck me was: *what* even is an eddy? A distinctive definition has recently appeared in scientific literature**[1]**: an eddy is basically a ”blob of vorticity”. I know, it is not the catchy name that you could brag about, when telling your friends about your research project. However, it is actually the definition that works best, since trying to identify an eddy because of its velocity, temperature or salinity anomalies it’s simply hard, if not impossible.

Whirlpools and swirls are omnipresent in the ocean (have a look at this animation from NASA). The eddy we are going to study is one of the special mesoscale eddies belonging to the family of the NBC rings**[2]**, namely eddies detaching from the Northern Brazilian Current. As its name suggests, this current flows along the northern coast of South America and, in normal conditions, it would continue into the Gulf of Mexico as a Western Boundary Current. However, as nature loves complexity, seasonal changes in ocean circulation cause the NBC to retroflect into the Northern Equatorial Counter Current.

And here comes the fun part: when retroflection occurs, the uppermost part of the NBC creates a quite sharp loop that sometimes may pinch off and create a massive ring that starts drifting Northwestward toward the Caribbeans.

Imagine an eddy over 100 km in radius, carrying an enormous volume of water at high speed. If these oceanic whirlpools had the same destructive potential as hurricanes, emergency systems in Barbados and Martinica would be sounding alarms nonstop from September to March. Fortunately, that’s not the case.

Indeed, what stroke me most about being in an eddy is that you don’t see it at all. Everything happens below the surface level and no clear signal outside the water may help you identify the ’eye’ of the swirl. Only satellites, with their super precise infrared sensors can spot the difference in the sea surface height between the surrounding area, and help you identify upfront the extension of the eddy**[3]**. But even there, satellites cannot go any farther: water is virtually impenetrable to EM radiation and what’s

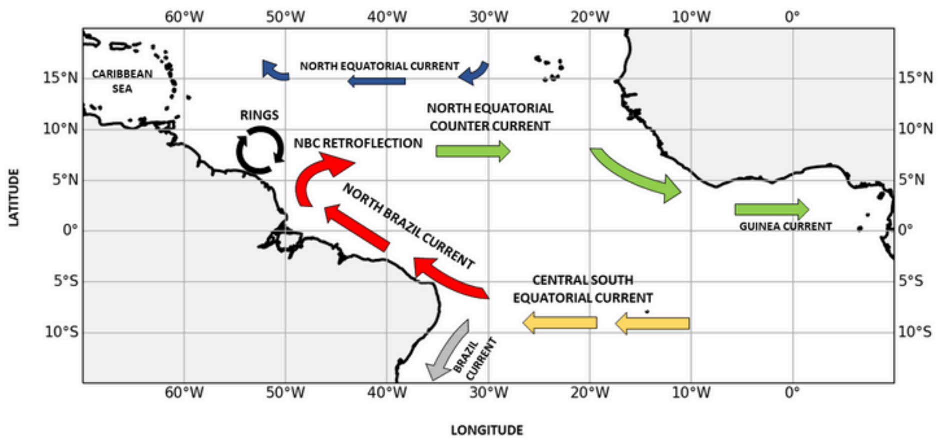

Figure 2. The picture shows the mechanism that lead to the formation of NBC rings offshore the coast of Brazil. Source: Wikipedia

below the surface has yet to be uncovered.

The research we are conducting can be viewed as an Eulerian analysis of an eddy's vertical profile. If you are familiar with fluid dynamics, you might know that water flow can be studied according to two perspectives. An *Eulerian* approach examines it through snapshots of its evolution, while a *Lagrangian* perspective follows the flow, capturing the temporal dynamics of its processes. As for mesoscale eddies, although a substantial amount of recent literature focuses on Lagrangian analyses, Eulerian studies are still needed to gain a comprehensive understanding of how much mass, heat, salt, nutrients, these water structures transport from the Southern to the Northern Atlantic Ocean**[1]**.

To achieve this for our NBC ring, we are using two main types of instruments. The Acoustic Doppler Current Profile (ADCP) uses the Doppler effect to measure how fast the water is moving and reconstruct the eddy's vertical profile of velocity. This instrument is already installed under the vessel, collecting underway data along the transects of interest. On the other hand, the Conductivity-Temperature-Depth profiler (CTD) is deployed overboard to measure temperature and salinity through conductivity proxies. The CTD, which somewhat resembles a TNT bomb (except that its cylindrical "sticks" are actually water-sampling tanks) collects samples for onboard analysis in the ship's *wet lab*.

Figure 3. The CTD on the *RV Pelagia* we deployed to track the temperature and salinity profiles of the NBC ring.

While ADCP measurements are remote-controlled and honestly a bit dull, CTD casts are way more thrilling. You have to secure the instrument to the cables, check that the flasks are properly fastened, lift the CTD, and finally, launch it into the ocean using a winch. The downside? Every cast involves an unbearable amount of waiting: for the ship to anchor, for the CTD to descend, and then waiting for it to slowly go up again. And when your CTD cast is scheduled for 3 a.m., patience isn't enough - I would call it resilience.

Nonetheless, a reward sometimes comes with a signal of the eddy's presence. I say *sometimes* as ocean research is everything but straightforward. CTD casts may fail, bad weather can delay entire schedules, all adding up to the inherent unpredictability of dynamical objects like eddies. But I would leave out a huge part of the story if didn't mention the laughters shared with the crew, the breathtaking dawns from the ship's deck, the intercultural meals we cooked in the cramped onboard kitchen to celebrate even the smallest daily achievements. For the first time, I felt at home in a place as unfamiliar and vast as the open ocean.

But the adventure isn't over yet. I am looking forward to analyzing the data we gathered and to see what secrets might still be hiding behind the interesting profile of an ocean eddy, something I had not even heard of before I set out. And maybe, one day, you'll find yourself in my place, faced with a take-it-or-leave-it chance to set sail on a journey into the unknown. And I suggest you take it.

References

- **[1]** Abernathey, R., & Haller, G. (2018). Transport by Lagrangian Vortices in the Eastern Pacific. Journal of Physical Oceanography, 48(3), 667-685. doi: 10.1175/JPO-D-17-0102.1
- **[2]** Wilson, W. D., Johns W. E. & Garzoli S. L. (2002). Velocity structure of North Brazil Current rings. *Geophysical Research Letters*, 29(8). doi: 10.1029/2001GL013869.
- **[3]** Subirade, C., L'Hégaret, P., Speich, S., Laxenaire, R., Karstensen, J., & Carton, X. (2023). Combining an Eddy Detection Algorithm with In-Situ Measurements to Study North Brazil Current Rings. *Remote Sensing*, 15(7), 1897. doi: 10.3390/rs15071897.
- The images were shown as mine but they are not. The sources are: Figure 1, Figure 2, Figure 3