Emerging technologies in marine ecosystem observation networks

How new technology can help biological oceanography in advancing knowledge of the ocean ecosystems.

This is the situation: The Tropical and Southern Atlantic Ocean is much less observed than the North Atlantic. There is lack of observation and knowledge of the vast South Atlantic, impeding efficient conservation and sustainable furnishing of ecosystems services.

TRIATLAS is a research project focusing on this problem. For the first time and with new technology, there is now a starting point for further studying the ecosystems in this region. During the project period from 2019 – 2023, a series of advanced technologies was further developed and shared among the cooperating partners in the tropical and southern Atlantic.

The program was designed not only to improve measurements of physical and chemical properties, but for the first time also for biological properties at the same spatial scales. Such methodologies allow us to study both the habitat and the living communities of the pelagic ecosystem.

To investigate the vast ocean and everything that lives in it, from the smallest plankton to large fish, we need observations. If we are to understand anything about current changes and potential future changes, we must establish a starting point, a baseline, to assess the variations. To know more about possible changes due to climate change, it is important to also know the natural variations of the ecosystem.

What is oceanography?

- In physical oceanography, researchers investigate the movement of water masses, like ocean currents. They measure temperatures, salinity, currents directions and speed.
- In chemical oceanography, researchers investigate the chemistry of the ocean, like pH, oxygen and carbon in the water masses, and at what depth.
- In biological oceanography, researchers investigate what the living organisms community looks like at different depths, including bacteria, larger plankton up to the fish, from the surface to the ocean floor.

How were ocean ecosystems observed?

During the TRIATLAS project and the sister project PIRATA, several cruises in the Tropical and Southern Atlantic gathered a huge number of biological and environmental datasets.

Underwater acoustics, commonly known as echosounders, and imaging sensors such as in situ camera provide valuable data of the marine ecosystems.

Using sound has several advantages

Echosounders are common features on modern research and fishing vessels, used for navigation, mapping and detection of underwater structures and fish. An echosounder can be used as an underway device, without the need for a stop. It can sample the entire water column down to thousands of meters at the blink of an eye. This puts hydroacoustics at the forefront of deep-sea research. Finally, acoustics is a non-invasive method for biological sampling making it possible to measure fish abundances in marine protected areas and reserves.

The major disadvantage lies in the abstract nature of the data being only "echoes" instead of images or actual animals. Using inverse modeling, progress was made during TRIATLAS to categorize the different types of echoes from crustaceans and fish.

Using imaging techniques has several advantages

Images of all plankton and particles in the water column can be obtained after net collections and microscopic analysis or directly in situ with camera mounted on CTD/rosette platforms tethered to the research vessel or mounted on autonomous floats such as ARGO.

The advantage of in situ imaging is the possibility to rapidly detect and recognize fragile organisms or particles that are destroyed during collection. Their disadvantage is the small volume of observation and lower resolution. They can be used to estimate counts and biomass of broad plankton groups but rarely for biodiversity estimates.

ARGO floats are a kind of robots that float in the ocean at different depths collecting data.

A natural phenomenon affecting the ecosystems

In the Tropical and Southern Atlantic, there is a natural phenomenon affecting the ocean's cycle. It is called the Atlantic Meridional Mode, and it dominates the variations of sea surface temperatures and surface winds – somewhat like its better known cousin in the Pacific, the El Niño.

The high-quality time series of the TRIATLAS program contributed to a better understanding of the processes that drive the ocean's cycles in the eastern tropical Atlantic.

In TRIATLAS, sensors called UVP6LP were mounted on ARGO floats and deployed into the ocean.

For 1.5 years, the instruments were monitoring at the Equator, in the Angola and Benguela system, before the ARGO float was recovered. They acquired basic oceanographic data (CTD, O2, fluorescence) and images of particles and plankton from the surface to 2000 meters' depth. These new observations have been combined with existing optical and image data sets.

All data and images from the ARGO floats were analyzed in the laboratory. The bottleneck lies in the classification of the massive number of images which still require human validation. This is where AI can play a crucial role, with new algorithms to recognize plankton types and traits are expected.

The successful deployments during TRIATLAS will also help to develop better AI algorithms to sort not only plankton but also particles which have an infinity of shapes in the ocean.

The TRIATLAS Legacy: Networking activity and capacity building

One of the main achievements of TRIATLAS was the creation of a working group on “Size Spectra from Small Cells to Big Fish”, with researchers from numerous institutions from Brazil, Africa, and Europe.

This working group has been active in gathering, standardizing, and collecting data on size distributions of different components of pelagic ecosystems in the Tropical, Subtropical, and South Atlantic.

We collected data on tiny plankton in the size of picoplankton, nanoplankton, microplankton, net-caught macrozooplankton (> 500 micron), to the larger sizes of mesopelagic fish communities, pelagic macroinvertebrates, and plankton and particles detected by the sensors.

We used these data to construct their normalized biovolume size spectra (NBSS) in numerous distinct marine ecosystems across the Atlantic Ocean. Our analyses indicate that warmer and less productive ecosystems sustain lower numbers of large-sized organisms, with relevant consequences for ecosystem predictions in the context of climate change.

During TRIATLAS, networking activity was undertaken through the activity in the I/ITAPINA network and through capacity building. TRIATLAS also gave the opportunity to increase the networking activity of scientists to propose for the West African community an infrastructure for plankton monitoring within the Plankt’Eco project.

The TRIATLAS partner Institut Senegalais de Recherches Agricoles – ISRA-CRODT was selected as the host institution for the equipment (UVP6, zooscan and planktoscope). Technical staff of this institute and others will benefit from training and assistance in pelagic imaging within the context of the Plankt’Eco project.

Long term activity of this infrastructure will depend on future projects where this West African imaging infrastructure will be involved.

We foresee the need for coastal monitoring of natural and harvested resources in the coastal environment and also in the upwelling. Combining these imaging instruments with acoustic sensors will be the next step.

The networking activity has enabled TRIATLAS scientists to propose a project to fund imaging observation capacities in West Africa.

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