FS Meteor

Expedition M203 “BOWTIE”

10. August 2024 — 24. September 2024 | Mindelo — Bridgetown

6. Weekly report (09.09.2024 — 15.09.2024)

This week we finished measuring in the central tropical Atlantic around 38°W, collected all deployed oceanographic instruments, and moved our working area to the western tropical Atlantic around 47°W. Here, in our last working area before ending our expedition in Barbados, we again deployed ocean gliders and drifters, at 10°N and 47°W, and will again transect the ITCZ before recovering them. After discussing our atmospheric and physical oceanography measurements in the previous weekly reports, this report focuses on our biogeochemical measurements, which are tightly coupled to the ocean and atmospheric conditions. Since the beginning of the expedition, we have collected three types of biogeochemical measurements: (1) marine particles and plankton using cameras and bottle nets at stations approximately every 60 nm travelled; (2) marine particles and plankton using cameras on the continuously sampling Wire-Walker deployed on a drift buoy in the eastern, central, and western tropical Atlantic; and (3) water samples from stations for methane, nutrients, isotope, DNA and RNA analysis.

Over the course of all the stations conducted since the beginning of the expedition, we have dropped 70 CTDs into the Atlantic Ocean, which also means we have collected 70 particle profiles using the UVP, which has provided lots of pictures of marine particles and plankton to add to the plankton and particle collection! But what particles are we talking about? What is a UVP? Why do we need to take pictures of everything that is falling in the water column? Let’s break it down. The biological carbon pump (BCP) is like the ocean's carbon superhighway. It moves carbon from the surface to the deep ocean, where it can stay for centuries. Phytoplankton at the surface turn CO2 into Particular Organic Carbon. The particles aggregates, known as "marine snow," mainly consist of dead phytoplankton, zooplankton remains, and fecal pellets. These particles then sink deeper into the ocean. This is where the "Go-Pro of the Ocean" comes in — the UVP (Underwater Vision Profiler). The UVP is an underwater camera that takes high-resolution pictures of plankton and marine particles as they sink. This imaging tool is especially great because it lets us study fragile creatures that would not survive being caught in nets, and can also detect, measure, and quantify the distribution of marine particles. The goal is to determine how much carbon is being produced, what types of particles are sinking, and which zooplankton are in the water column and how much they contribute to the carbon cycle.

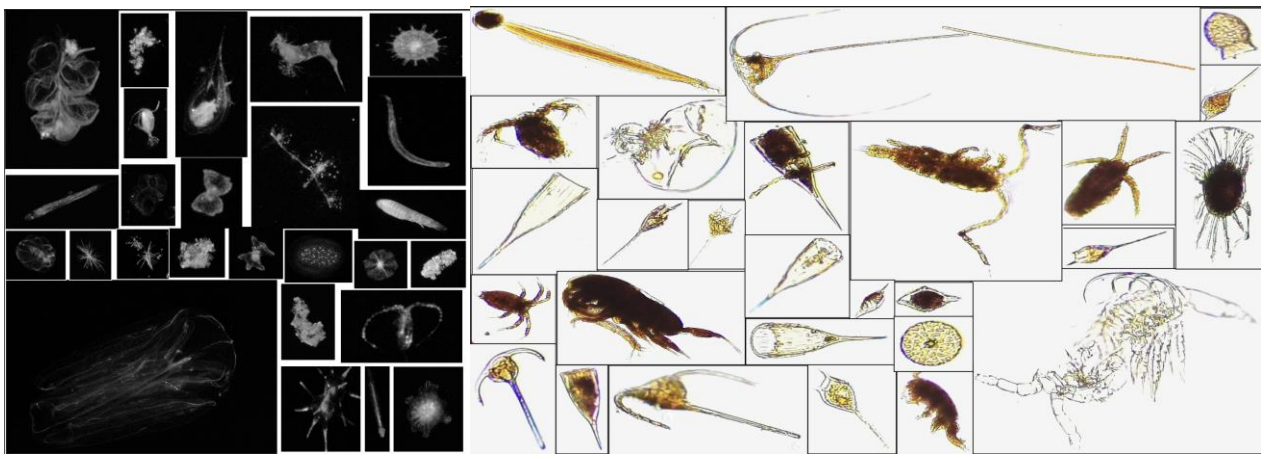

Figure 1: Marine particles and zooplankton images taken by the UVP on CTDs (left) and plankton images taken by the Planktoscope (right) during the M203 expedition.

As nice as this is, the UVP does not catch everything! To enhance our sampling, we combined the UVP with collection from a family of 5 bottle nets which are lowered into the ocean on the CTD rosette. Unfortunately, it is now a family of only four bottle nets due to the loss of the 1000-600m bottle during the first bottle net deployment. These nets are no ordinary plankton nets; they can be opened and closed at specific depths which makes it easier to study the distribution of plankton in each layer instead of only having an integrated value from a deep depth up until the surface. Each of the 4 bottles collected samples from a different water layer, 0-100m, 100-20m, 200-300m and 300-600m, with a sampling that is alternated between night and day. We conduct the alternating night and day sampling because zooplankton are like party animals — they head to the surface at night to eat and sink back down during the day to hide from predators in deeper waters. The nets help us study their vertical distribution and the migration pattern, one water layer at a time. Once the samples are collected, we preserve the plankton in a Lugol's solution, filter them by size, and scan them using the Planktoscope (which is like a fancy plankton scanner). And voilà! Tons of images of zooplankton and particles, courtesy of the UVP and Planktoscope. Everything captured on the images will be classified once we get back to our labs on land, and we will be able to make statements about the distribution of species. So far, our samples have been dominated by *Copepod* and *Trichodesmium* zooplanktons. Figure 1 shows a sample of zooplanktons captured on camara during M203 from FS METEOR.

Our second type of biogeochemical measurement also uses a UVP to take photos of plankton but does so on a continuously sampling instrument that we deploy for days at a time; the Wire-Walker. On Wednesday and Thursday, we successfully recovered our autonomous oceanographic instruments after their second deployment during this campaign and were able to secure a week's worth of measurement data. Five instruments were deployed on Friday, September 6, 2024: two gliders and a drifter at 7.93°N, 38°W, near the PIRATA buoy, as well as another glider and the Wire-Walker further north at 8.5°N, 37.9°W (Figure 2).

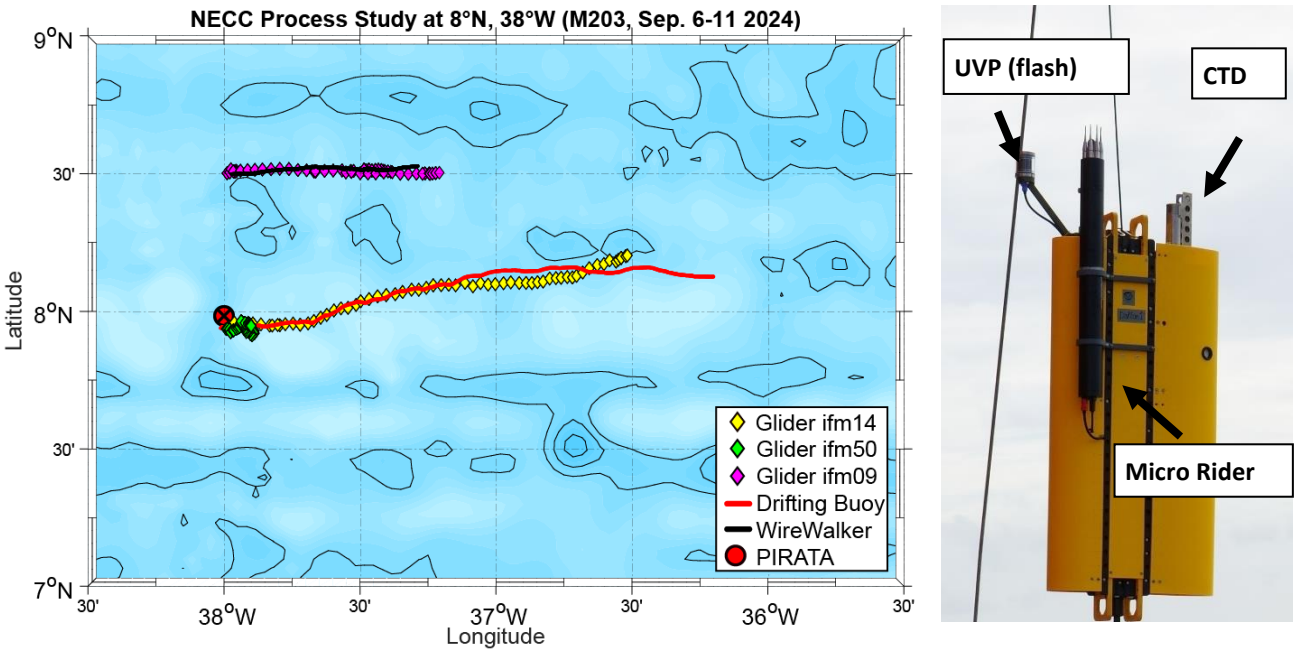

Figure 2: Positions of the deployed oceanographic instruments and overview of the sensors on the Wire-Walker

The Wire-Walker is operated by the "Biological Carbon Pump"- working group of the Helmholtz Centre hereon. It is a profiler that moves up and down in the water column, driven solely by wave energy along a vertically suspended 750m-long wire. The device is equipped with a CTD, a Micro Rider turbulence sensor, and a UVP6 camera. A simple but ingenious clamping mechanism ensures that the device initially descends due to wave motion until it reaches the end of the wire, which has a weight at its bottom. Upon hitting the 'turn-around-bumper', the clamping mechanism is reversed, allowing the profiler to glide upwards, measuring micro-turbulence in the water column.

Like the UVP camera on the CTD rosette, the UVP6 camera on the Wire-Walker enables the detection of particle flux and the distribution of zooplankton. The aggregation of smaller particles ("marine snow") increases their sinking velocity (Figure 3a). Zooplankton communities also contribute significantly to vertical carbon transport. Many species migrate to the euphotic zone at night to feed and return to deeper layers during the day to avoid predators, thus exporting organic material. This daily vertical migration can be tracked through our continuous measurements over several days. In addition to the commonly observed zooplankton taxa (Figure 3b-e), we also captured a significant number of images of *Trichodesmium*, nitrogen-fixing cyanobacteria (Figure 3f). Although these organisms are not the focus of our investigation, they are of particular interest to the working group at the Max Planck Institute for Microbiology in Bremen. The combination of the UVP6 camera and the microstructure sensor on the Wire-Walker and one Glider during this campaign allows us to investigate the influence of micro-turbulence on the distribution of marine snow and zooplankton and will help us to better understand the role of physical processes in biological carbon transport.

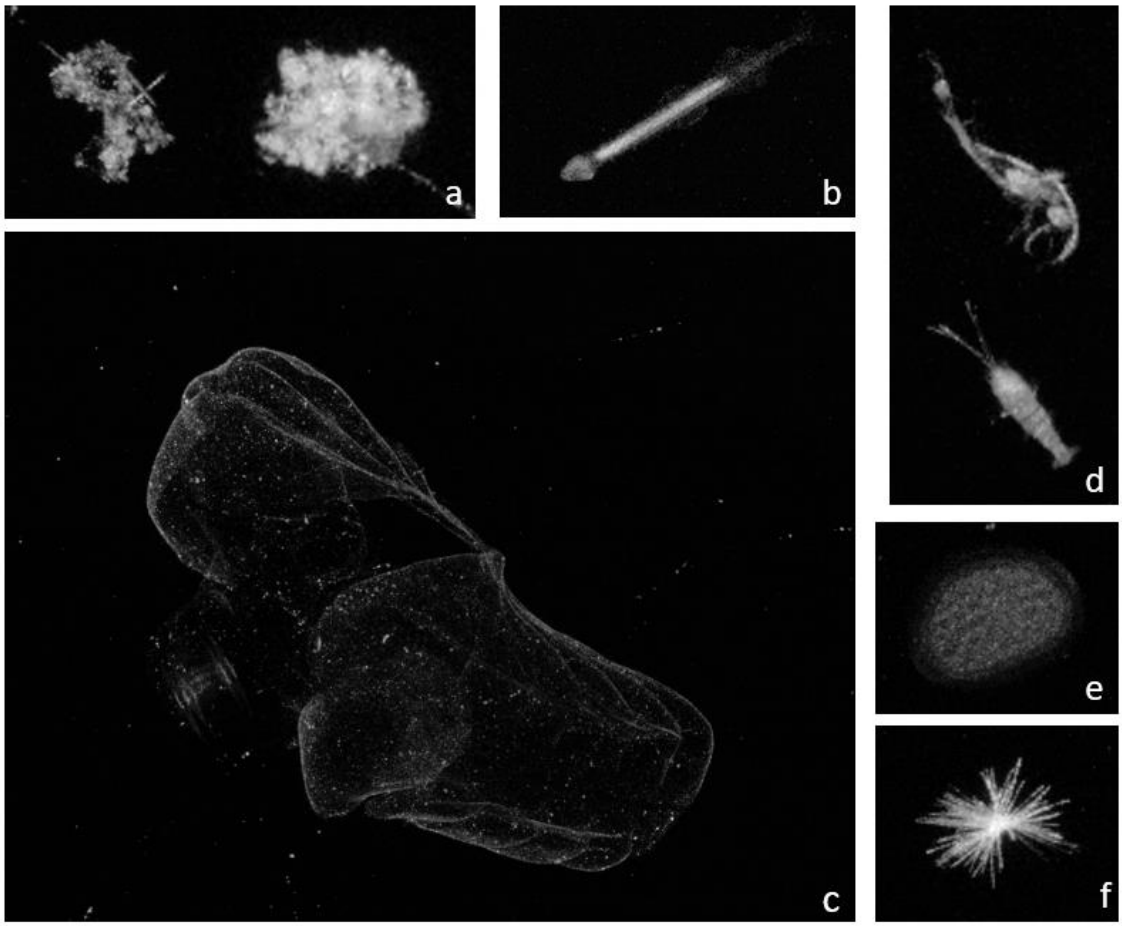

Figure 3: Example images from the UVP6 camera during the Wire Walker's first deployment. (a) *Marine snow.* (b) *Chaetognatha.* (c) *Appendicularia.* (d) *Copepoda.* (e) *Collodaria*. (f) *Trichodesmium*.

Our third type of biogeochemical measurement leverages water samples taken during CTDs. Since the start of the cruise, water samples have been collected from nine of our stations to investigate how environmental factors such as nutrient availability influence methane production by microorganisms, and to assess the activity of nitrogen-fixing microorganisms (for example, *Trichodesmium*). The study aims to determine their contribution to new nitrogen and carbon dioxide fixation fluxes in this region and examines how iron availability, particularly from sources like Saharan dust, impacts the activity of these microorganisms.

To address these questions, at 6 out of 9 stations two consecutive CTD (Conductivity, Temperature, Depth) sensors were deployed:

- **The first CTD** collected high-resolution *in situ* water samples for methane and nutrients (i.e. phosphate, ammonia, nitrate, nitrite) concentrations at 10-meter intervals from the surface down to depths of 100 or 150 meters.

- **The second CTD** focused on discrete depths, collecting water samples from 10m depth, below the deep *chlorophyll* maximum and from an intermediate depth between the 10m and the surface for stable isotope incubation. Additionally, water samples from these depths were collected for DNA and RNA analysis to identify the microorganisms present in the incubated water.

At 3 stations only, water was collected at 10m depth in order to conduct experiments that need higher water budgets (for example, bigger incubation bottles, filtering phytoplankton from high water volume

to concentrate in smaller water volume, more variation of nutrient addition experiments.) To measure methane production, water samples were supplemented with ^{13}C-methylphosphonate and eventually extra amended with nutrients (i.e. phosphate, nitrate). Sub-samples were collected from the experimental bottles at regular intervals over a 24h period to assess methane production rates through phosphorus uptake by microorganisms. Another incubation setup involved the addition of $^{15}N_2$ gas, $H^{13}CO_3^-$, and ^{57}Fe to measure nitrogen fixation, carbon dioxide fixation, and iron uptake after 24 hours of incubation. At the end of the incubation period, water samples were taken for rate measurements (methane production, and labeling percentages for N_2, CO_2, and Fe) and filtered for further analysis. Furthermore, for all experiments, at 24h a water sub-sample was taken and fixed with paraformaldehyde before filtering on microscopy filters for microscopic and unicellular analysis.

The samples from both the profiling CTDs and the incubation experiments will be transported to MPI Bremen where most of the analyses will be conducted, including nutrient measurements, stable isotope analysis, and microscopy. The outcomes of these experiments will enhance our understanding of methane production, a potent greenhouse gas in surface ocean waters, and allow us to estimate the CO_2 uptake and new nitrogen fluxes (input) into the ocean from the atmosphere by N_2-fixing and associated microorganisms in this region.

In the coming week, we will continue transect the Western ITCZ and plan coordinated measurements with the German research aircraft HALO and the EarthCARE satellite before we make our way to Barbados.

Greetings from all participants of the M203 expedition now in the western tropical Atlantic.

Daniel Klocke[1] (Chief scientist, M203), Joelle Habib[2], Celine Imker[1,3], Daniel Blandfort[3], Judith van der Giessen[4] and Abiel Kidane[4] (Scientists, M203)
[1]Max Planck Institute for Meteorology, Hamburg, Deutschland
[2]Laboratoire d'Océanographie de Villefranche, France
[3]Helmholtz-Zentrum (HEREON), Deutschland
[4]Max Planck Institute for Marine Microbiology