What are these tiny oceanic creatures that could save our oceans?

Mar Benavides

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[Eloi Choplin] Hello everyone, my name is Eloi Choplin and I am delighted to be here with you today, in the front row, to listen to who you will see is an extraordinary researcher.

Let us embark on a journey of discovery, to find out about a project supported by the BNP Paribas Foundation as part of its Climate & Biodiversity Initiative: the NOTION project.

Together, we will discover how this project is aligned with several of the Sustainable Development Goals (SDGs) and, like any large-scale initiative, how it has highlighted the interdependence of these goals and the essential as well as holistic approach required to fully understand sustainable development issues.

The project being discussed here demonstrates the impact of the infinitely small on the infinitely large – it is quite a journey.

From rue Rossini to Marseille – from *BivwAk!* to the IRD in Marseille – there is only a short distance we are always willing to cross during these conferences. Now, please allow me to introduce Mar Benavides, who is here to talk to us today.

The best way to present a guest in 2021, to get straight to the point, is to have a look at their Twitter account; it gives you a general idea: "Microbial oceanographer, linking spatio-temporal scales of microbial processes in the ocean".

My understanding is that Mar is on a quest for knowledge. Her research aims at understanding the interactions between marine microbes and their environment. Mar is an IRD researcher at the Mediterranean Institute of Oceanography in Marseille (MIO) and she is going to explain how the very small, tiny, microscopic things that we usually do not care about can have an impact on a colossal scale.

Mar will be discussing nanotechnology, molecular biology, geochemistry and space-time scales, and if, like me, you struggled with natural science, maths and physics at school, you should still be able to understand everything, because of Mar's fundamental and effective talent for making science accessible.

We will hear about how the NOTION project, supported by the BNP Paribas Foundation, can improve our understanding of the role of marine phytoplankton in creating resources for humanity and how the infinitely small can provide essential services to ecosystems.

I hope that you are sitting comfortably; take a deep breath, and, together with our guest, let us immerse ourselves in this unfamiliar world.

Mar, you'll be our guide, we're ready to dive straight in, and I'm sure that, by the end, we'll have a better understanding of the role of the infinitely small in climate regulation.

So Mar, I will now hand over to you.

[Mar Benavides] Hello everyone.

As you are probably aware - because you learned it at school - the Earth is known as the blue planet. And for good reason, because the oceans cover 71% of the Earth's surface. But I bet you knew that too.

I am sure you have also heard about the oceans' role in climate change. Oceans capture 1/4 of the CO_2 in the atmosphere, CO_2 that is generated by humans because of our industrial activities. So far, this is nothing new to you.

But do you know how the oceans capture CO_2? And once they've captured CO_2 what do they do with it?

What we do know is that the oceans are currently changing. And if the oceans are changing, given that they cover 71% of the Earth's surface, then the whole planet is changing. Why are they gradually losing their capacity to absorb CO_2? What is their role in climate change today, and what will it be in the decades to come?

We still do not have definite answers to many of these questions.

I have always been interested in the oceans, seas and water. My father managed a Spanish sailing team and my name is Mar (which means 'sea' in Spanish)! Maybe it was fate.

I decided I was going to study the ocean at a young age, and that is exactly what I do now at the Mediterranean Institute of Oceanography (MIO). I invite you to join me and immerse yourself in the ocean to understand it better.

But before we take the plunge, I'd like to ask you a question: do you know how many drops of water there are in 1L of water?

There are about 20,000 drops of water in 1 litre of water, which means that in a small 50-litre aquarium, there are a million drops of water!

So, imagine how many there are in a swimming pool, a lake, a river, a sea or an ocean! Billions upon billions of drops of water.

But what fascinates me the most is to take one of these drops of water and to examine what's inside. What would we find?

Well, this: yes, there is life inside a drop of water.

There are zooplankton such as copepods, phytoplankton such as diatoms, millions of tiny bacteria and even viruses. They all live together, sometimes they get along well, they make life easier for each other, they work together, or they compete.

Of course, they cannot talk, at least not in words like us. However, they do have ways of communicating, like through chemical signals or movement.

For example, small bacteria can sense when a large copepod passes by it. Amazing, isn't it?

However, today we are going to focus on phytoplankton. Phytoplankton are micro-algae, which are small plants that live suspended in water. Most phytoplankton species are 100 times smaller than the ants in your garden and much smaller than a single hair from your head.

That is why they're not visible to the naked eye or even with a magnifying glass, but they are definitely there. When you take a dip into a river, swim in a lake or go to the beach, they are there. Billions upon billions upon billions of phytoplankton in billions upon billions of drops of water.

It makes your head spin just thinking about it, doesn't it?

These phytoplankton are everywhere but nobody ever talks about them. When I go to an aquarium, I always write in the visitor's book at the end of my visit "what happened to the phytoplankton?". They are never mentioned! I encourage you to do the same next time you visit an aquarium so that we can fight this injustice together!

So, why am I talking about these organisms that are invisible to the naked eye? Because they have an amazing power. They can absorb CO_2 from the atmosphere. CO_2 causes global warming. All this power to absorb CO_2 can benefit the planet and the climate.

Of course, some CO_2 dissolves directly into water, without the involvement of phytoplankton. It is a bit like how a *Sodastream* machine makes carbonated water.

But phytoplankton also have the capacity to capture some of this CO_2. They transform it and incorporate it into their tiny bodies in order to reproduce. Without CO_2 and sunlight, these cells could not reproduce. Therefore, they photosynthesise just like land plants.

All these phytoplankton weigh less than 1% of all the plants on Earth -– so they are very small. Yet every year they photosynthesise as much as all the terrestrial plants put together. They are very small but very powerful!

However, to achieve this, phytoplankton need the sun as well as nitrogen. Just as growing crops on land requires fertiliser, nitrogen provides the nutrient value that phytoplankton need to grow in the ocean.

And that's where things get tricky. There is very little nitrogen in the oceans.

Look at this map: there is more nitrogen along the coasts and in the Polar Regions. Nitrogen is also found in the lowest depths of the sea; ocean upwelling could thus feed our phytoplankton. However, there is almost no nitrogen at the surface: the purple area demonstrates that there is no nitrogen on 60% of the oceans' surface. 60%! That is a lot.

In the central areas of the oceans, huge masses of water form superimposed layers. This water does not move in a vertical direction, or minimally. These layers form strata, which act like a kind of plug. Water from the lower depths cannot rise to the surface and thus supply phytoplankton with nitrogen.

These 'ocean deserts' are large expanses of water with very low nitrogen levels: the water is very dark, as you can see in the image on the left. Whereas, in the image on the right, you can see clear blue-green water, quite rich in nitrogen as you are used to seeing near the coasts.

At this point, if you have understood me correctly, you must be wondering how phytoplankton living in the middle of the ocean, where there is no nitrogen, are able to reproduce and capture CO_2?

Well, this is made possible thanks to the best type of plankton in my opinion, the focus of my research and my personal favourites: the diazotrophs.

Diazo-what? Put simply: "di" means "two", "azo" represents nitrogen, and "trophos" means "food" in Greek. Then diazotrophs are simply microbes that eat nitrogen.

Nitrogen is everywhere. Our atmosphere is composed of 70% nitrogen, but in its inert form. Diazotrophs are the only organisms capable of using atmospheric nitrogen. Incredible, right?

This image shows some examples of diazotrophs. On the left is the circle-shaped *Crocosphaera*. The other stick-shaped ones on the right are called *Trichodesmium*.

Only two species are shown here, but it is believed that there are hundreds, if not billions, in existence.

As for my little diazotrophs, they invest a great deal of energy in converting nitrogen, in order to provide the community with this transformed nitrogen. This makes diazotrophs the true Samaritans of the ocean. It serves as a natural fertiliser.

But remember, the oceans are changing: will pollution, acidification, oxygen loss and warmer temperatures help or inhibit diazotrophs? How will climate change affect diazotrophs activity and diversity?

It's difficult to say at this time, as their exact number and the extent of their diversity remains unknown. Only five species have been studied in the ocean, and only two have been the subject of climate change simulation experiments.

My NOTION project therefore aims to deepen our understanding of diazotrophs and to anticipate their behaviour in the future.

Diazotrophs are tiny but their impact on the planet is huge. That is why, in order to study the "very, very large", such as the oceans, we must first consider the infinitely small.

To achieve this, I have begun conducting laboratory tests where we recreate the conditions of climate change and observe how diazotrophs respond.

On this picture, you can see that we made these cylinders ourselves. It is an entire system of tubes, valves and lights that simulate sunrise and sunset. I won't bore you with the details, but believe me, it is pretty complex!

So, we take diazotrophs and we run simulations.

For example, in one potential scenario, the plugs I mentioned earlier would harden due to global warming. In other words, the stratified water would mix even less. In this case, diazotrophs, which are capable of transforming nitrogen from the air, would be essential to the survival of phytoplankton.

In a second scenario, diazotrophs could actually benefit from climate change. If the average temperature of the oceans increases, could it have a positive effect on their proliferation? However, we would have to take into account other consequences for the ecosystem as a whole!

Studying these phytoplankton has therefore raised crucial questions for our future: will the oceans still be able to capture CO_2? If the diazotroph population were to suddenly decline, what would be the consequences? If the temperature were to rise or the ocean were to become more acidic, what effect would this have on their behaviour?

To find answers to all these questions, we need expert help from a range of disciplines, such as chemistry, biochemistry, and fluid physics, etc.

Remember that we are studying microscopic cells in drops of water in the middle of huge oceans. The cell itself already has its own chemistry and biochemistry. The water in which these cells are found contains varying levels of oxygen, salt, etc. In addition, these drops of water are moving around in the ocean, which makes our work even harder!

Together with my research team at the Mediterranean Institute of Oceanography (MIO), I aim to establish connections between the tiny and the global.

The findings from our lab experiments will be inputs for global ocean models that can help make predictions. Just like a weather forecast for the coming days, but over the longer term, even over decades as in the case of climate change.

To achieve this, we work with specialists from a variety of disciplines, which is a positive, since it means that we are tackling complex subjects. And our story has only just begun because we launched the project in July 2020 and our research will take 3 years.

This complexity is a driving force for me, because I believe it should encourage people to be more intellectuality curious and to get informed. I am certain that the more we find out about how the planet works, the more responsible our behaviour will be.

The same applies to the NOTION project. Do you remember the picture of our blue planet?

It is not enough to know that the oceans are essential to climate change; we must understand why, the mechanisms at play, the challenges to overcome and the efforts that need to be made.

I hope that I have convinced you that to achieve this, we need to examine the infinitely small to understand certain consequences on a global scale, which can explain the overall functioning of our planet.

It is a bit like the *butterfly effect* : it is the *phytoplankton effect* !

So, next time you hear about ocean acidification or rising sea temperatures, remember that one part of the answer that hold the key to our understanding of all these phenomena and their consequences in the decades to come are organisms that actually are invisible to the naked eye.

What we can see is a result of what we cannot see!

[Eloi Choplin] Thank you Mar, thank you for this brilliant presentation and for taking us on this journey. I've no doubt that the next time we visit an aquarium, we will ask in the visitor's book "what happened to the phytoplankton? ", especially your favourites, Mar, the diazotrophs.

This was very didactic and interesting. Well done for simplifying the subject. It is definitely a very complex topic, yet approached simply and with a smile: it was great and we have learned a lot.

Thanks so much Mar for spending this time with us.

Many thanks to all the teams that made this event happen so we could spend this moment together learning about nature: the BNP Paribas Foundation, BivwAk!, BNP Paribas Group Communication, the technical team and We Demain.

Thank you all for taking up the distance challenge, and thanks a lot again Mar Benavides.

Let us keep in touch on social media: follow us on all the BNP Paribas Foundation accounts.

See you soon, thanks again, and have a great day.

You can find a replay of this conference on the BNP Paribas Foundation's YouTube channel

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