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Reconsidering the concept of innovation

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# Reconsidering the concept of innovation

“We have become obsessed with an idea of innovation that is not only mistaken, but is also dangerous,” assures Dan Breznitz, Co-Director of the Innovation Policy Lab of the University of Toronto. He also affirms that reducing innovation only to technological inventions is increasingly distant from the true forces of innovation in today’s world. For Breznitz, innovation is the “updating of ideas at all levels of production of goods and services. It includes changes and improvements to an initial idea, and the different ways of producing or selling a product or service.”<sup>1</sup>

Thinking about these ideas in relation to our work at CEMarin, and in the Latin American context, opens up a huge range of possible strategies to consider in these times. The marine sciences -as a diverse and interdisciplinary field- and our oceans -with all the interdependencies they have with our models of development and our societies- require a broad conceptualization of innovation in order to manage and overcome the great challenges we are facing today. This is why we decided to dedicate this third issue of Sonar to the concept of innovation.

With one foot in Colombia and the other in Germany, we recognise that innovation can represent different things in different places. In 2021, Germany was ranked 4th on the Bloomberg Innovation Index, while Colombia did not appear among the 60 countries included in the list<sup>2</sup>. However, in order to understand, reassess, and ultimately promote innovation, a two-way dialogue is necessary to exchange experiences, knowledge, and ideas between our two countries because, without a doubt, both have much to offer the other. Our experience of joint working, both between researchers and with other actors, has taught us about the

capacity for adaptation and resilience that can be generated in the Colombian context, thus strengthening and directing innovation towards the most important areas and strategies.

Technical and engineering solutions are certainly key in orienting scientific research and political decision-making in the framework of the Decade of Ocean Science for Sustainable Development, but so are citizen science and traditional and ancestral knowledge and practices. Thus, a broad understanding of innovation is fundamental to a long-term strategic vision, to take advantage of technological advances in a timely and accessible way, and to ensure efficient and effective impacts for our oceans and societies.

This issue of **Sonar** includes diverse projects and actors involved in the broad spectrum of innovation in the marine sciences, with the aim of exploring what this concept means in the day-to-day work of the academic sphere as well as the daily life of the communities that depend on the oceans. We invite you to dive into this new issue, which seeks to stimulate the imagination of our scientific community and all those who work for the oceans.

<sup>1</sup>Barria, C. (22/09/21). “Nos hemos obsesionado con una idea de innovación que no solo está equivocada, sino que también es peligrosa.” BBC News Mundo. <https://www.bbc.com/mundo/noticias-58602232>

<sup>2</sup>European Commission (04/06/21). Bloomberg Innovation Index 2021. <https://ec.europa.eu/newsroom/rtd/items/713430/>

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## GLOBAL TENDENCIES

CEMarin staff

## Global tendencies in navigation: innovation for decarbonization

Global shipping, including international and domestic navigation as well as fishing, is a key pillar of the global economy, responsible for approximately 3% of total greenhouse gas (GHG) emissions<sup>1</sup>. In addition to the contribution of these GHG emissions to the global climate crisis, the shipping industry also creates other forms of air, water, oil, and acoustic pollution that negatively impact marine and coastal ecosystems. Despite circular economy and on-shore manufacturing initiatives that can reduce global transportation, the continued high demand for shipping services makes the transition to less-damaging forms of operating a crucial question for the industry, policymakers, and other stakeholders.

The International Maritime Organization (IMO) adopted an Initial Strategy on GHG Reduction in April 2018. Nevertheless, the industry's share of global anthropogenic emissions has continued to increase in recent years: predictions suggest that, by 2050, its emissions could be as much as 30% higher than in 2008, despite the strategy's objective of a 50% reduction in the same timeframe<sup>2</sup>. In addition to these global, multilateral strategies, there is also a huge and diverse range of initiatives being developed and led by actors including academia and civil society. Here we include a selection of innovative projects related to navigation from around the world, which collectively show how nature itself can be a source of solutions and the best ally of the shipping industry to achieve decarbonization.

### Wind propulsion & wind-assisted shipping<sup>3</sup>

Increasingly reliable software for weather and wind routing has made wind propulsion an important strategy of the shipping industry to reduce its dependence on traditional energy sources and transition away from traditional motor vessels, while at the same time achieving its time-dependent oper-



WP & WASP. Image: International Windship Association

ations. For example, *wind-assisted motor vessels*—that is, existing vessels retrofitted with auxiliary-wind propulsion systems—can reduce fuel consumption by 10-30%, limit wear and tear on engines and other machinery, and also reduce vibration. *Hybrid wind/motor vessels* can reduce fuel consumption by up to 60-70% in favorable conditions while maintaining the option of mixed wind/motor propulsion or only traditional motor propulsion when required. Overall, it is estimated that purpose-built hybrid vessels offer fuel savings of around 50% annually, representing an important reduction in GHG emissions if implemented on a sufficiently large scale. Finally, *purely wind vessels*, with an auxiliary motor in case of unfavorable weather conditions, can reduce fuel consumption by almost 100%, although their use is likely to be restricted to specific sailing routes with reliable conditions. According to the International Windship Association, a wide range of shipping companies, mainly based across Europe, the United States, Japan, and Australia are working on the development of a portfolio of innovative green technologies associated with wind.



## MS Porrima: uniting solar, wind and on-board hydrogen production technologies<sup>4</sup>

Incorporating some of the wind-related technologies mentioned previously, the MS Porrima is breaking records – it was the first ship to circumnavigate the globe powered only by solar energy – and drawing attention for its innovative combination of solar and wind energy, and on-board hydrogen production, three complementary energy sources which, according to its developers, can in theory maintain navigation in any conditions. Developed through cooperation between the Tokyo-based Zero Emissions Research Institute and the Belgian entrepreneur Gunter Pauli, author of *The Blue*

*Economy: 10 Years - 100 Innovations - 100 Million Jobs*, the MS Porrima is owned by the Swiss company Blue Innovations which focuses on so-called “moonshot” technologies, sometimes known as disruptive innovation, which seek to extend the existing limits of technology.

The MS Porrima has 516 square meters of solar panels and 8 tons of lithium batteries: with six hours of sunshine per day, the vessel can drive at five knots for 24 hours, around 240 kilometers. When the sun doesn't shine the batteries will run out in two days, so the vessel also has an artificial intelligence kite that harnesses the wind from 170 meters high and pulls the boat at 10 knots, twice the speed of the electric motors. At the same time, the propellers reverse and charge the batteries. The most novel aspect of the MS Porrima is that its combined solar and wind capabilities tend to generate a huge excess of energy, which is not wasted: when the boat is docked the surplus energy is used to produce hydrogen from seawater, storing up to 300kg of hydrogen that can provide as much as seven further days of energy.

As if that were not enough, the team behind the MS Porrima is also developing two revolutionary technologies to trial on-board: air bubble net fishing, to fish with air bubbles in the same way as dolphins and whales, allowing the capture of males only and the release of all females who may be carrying eggs, and the use of microfluidics which can remove nanoplastics from the bottom of the sea in a similar process to how human lungs eliminate CO<sub>2</sub> from our blood.



MS Porrima. Photo: MS Porrima

<sup>1</sup> International Maritime Organization (2021). Fourth IMO GHG Study 2020.

<sup>2</sup> Stone, M. (12/11/21). The shipping industry faces a climate crisis reckoning – will it decarbonize? *The Guardian*.

<sup>3</sup> International Windship Association (n.d.). Wind Propulsion (WP) & Wind Assist Shipping Projects (WASP)

<sup>4</sup> H2 Business News (19/04/22). Conoce el MS Porrima: primer barco que integra la producción de hidrógeno a bordo a partir de agua de mar.; MS PORRIMA [porrima.org](http://porrima.org)



Image: Giz

## The Marshall Islands: leading the way in low-emission sea transport <sup>5</sup>

Insular societies and countries, like the Republic of the Marshall Islands (RMI), located near the Equator in the Pacific Ocean, have specific navigation-related needs and dynamics that are not solely linked to the global shipping industry. For example, maritime transport is required for all types of economic activity, the connectivity of the population with public goods and services like education and health care, and the country's resilience and adaptation to the impacts of climate change. RMI is a world leader in advocacy for climate change action and is, to date, the only country that has explicitly included domestic sea transport in its Nationally Determined Contributions (NDCs) in the framework of the 2015 Paris Agreement, with a goal to reduce GHG emissions from domestic shipping by 40% by 2030 and achieve full decarbonization by 2050.

In collaboration with the Germany Society for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit*, GIZ), RMI is reducing its GHG emissions and transitioning to energy-efficient maritime transport via the development and testing of low-carbon propulsion technologies. The first phase of the project is focused on measuring the current economic efficiency and emissions of the RMI's domestic maritime activi-

ty to have a clear baseline against which to develop and analyze low-carbon propulsion technologies that are appropriate for the needs of the shipping sector. The second phase is then based on the design and construction of different propulsion technologies which are then tested by the Marshall Islands Shipping Corporation. Ultimately, the outputs of the project are shared with other Pacific Island countries, as well as countries with significant insular populations around the world –including Colombia– to promote innovative navigation-related actions in the fight against climate change for, and from, some of the nations most vulnerable to its impacts.



These prototypes and strategies for innovation in navigation demonstrate the efforts being undertaken in different parts of the world, and the need for more effective technologies and regulations in navigation is clear. Although they are not easy to implement on a large scale in the short term, their visibility contributes to promoting their commercialization and making them more affordable in other contexts. At the national level in Colombia, there are also initiatives in this field, we invite you to continue reading this issue of Sonar to learn about some of them.

<sup>5</sup> Giz (March 2022). *Transitioning to Low Carbon Sea Transport*.

## Let's talk about solutions to the climate crisis: blue carbon

One of the best-known mitigation strategies in the face of the climate crisis is the capture or “sequestration” of carbon. In this sense, one of the main actions in the climate fight is the protection of forests and jungles. However, those who work closely with marine-coastal ecosystems know that “close to 60% of the carbon accumulated in the world’s forests is in intertidal fringes,”<sup>1</sup> while marine-coastal ecosystems can store between 10 and 100 times more carbon than the planet’s forests<sup>2</sup>.

The term blue carbon refers, in general, to the carbon captured by the ocean. However, only three types of marine-coastal ecosystems—mangroves, seagrasses, and marshes or wetlands—are responsible for storing more than half of the planet’s blue carbon. Recent figures show that in the case of seagrasses, around 7% of this habitat is lost each year. In the case of mangroves, they are lost at a rate of 2% per year, while between 1 and 2% of marshes, estuaries, and coastal wetlands disappear annually. These losses are also a double-edged sword, because when these ecosystems degrade, not only do we interrupt the carbon cycle and its storage, but the CO<sub>2</sub> that has been sequestered in these ecosystems for millennia is also released. It is estimated that more than one billion tons of CO<sub>2</sub> are emitted annually from these degraded ecosystems.

From these figures it is easy to understand the huge importance of the protection of these ecosystems in

the climate fight. As the International Blue Carbon Partnership reports, protecting and restoring mangroves, seagrasses, and salt marshes and wetlands, has never been more important. The frameworks established by the 2015 Paris Agreement, together with the technical recommendations of the Intergovernmental Panel on Climate Change (IPCC), create a structure within which countries can establish national policies for blue carbon management. “However, gaps in science and data, lacks in technical capacity for measurement, reporting, and verification, or complex institutional arrangements, can present significant barriers to national policy development.”<sup>3</sup>



Photo: Mangrove. Blue carbon.

<sup>1</sup> Piedrahita Tamayo, N. (22/04/20). Colombia, despensa de carbono azul. UdeA Noticias. <https://bit.ly/3vUBIx7>

<sup>2</sup> <https://bluecarbonpartnership.org>

<sup>3</sup> Ibid.

<sup>4</sup> Ibid



Photo: Ballantyne Puin Castaño

The Colombian case is a great example of this. Colombia has the fourth largest extension of mangroves on the continent, with 300,000 hectares of coverage. According to Juan Felipe Blanco-Libreros, CEMarin Researcher and Professor at the Universidad de Antioquia, the national average is 527 tons of blue carbon per hectare above ground. Additionally, “recent research shows that the mangroves of the Pacific, in the south of the country—in the departments of Nariño, Cauca and Valle—, are considered among the highest in the world, as that area meets the necessary conditions—rain, constant discharge of river waters, and the absence of cyclones—for mangroves to grow and maintain a high production of blue carbon”<sup>34</sup>.

The recently ratified Law 2243 of 2022, which guarantees the protection, restoration, and conservation of mangrove ecosystems in Colombia, is an important advance in this regard. Likewise, the multiple mangrove conservation initiatives carried out in recent years in the country, like that of Cispatá and that in the Gulf of Morrosquillo, led by Conservation International, make it possible to establish work plans. According to CEMarin Researcher and Professor at the Universidad Nacional de Colombia, Ernesto Mancera, a recent study counted more than 80 mangrove protection and restoration initiatives across the country. However, for a transformation on the scale and speed required by the climate crisis, a systematization of these initiatives is necessary, as well as the construction of financing mechanisms that make this task feasible.

The National Oceanic and Atmospheric Administration (NOAA) of the United States emphasizes the usefulness of including marine-coastal ecosystems in the carbon market, through the purchase and sale of blue carbon bonds. Even so, the buying and selling of blue carbon bonds is still far from being part of national daily life.

According to Santiago Martínez, Director of Sustainability and Decarbonization at Ecopetrol, blue carbon bonds can represent an interesting opportunity within its ambitious energy transition program, but they represent a series of costs and technical limitations that are still to be resolved. The organization *Fondo Acción* (the Action Fund) launched its Green and Blue Carbon Unit (UCV&A, with its initials in Spanish) in 2020, with the aim of sharing the experience and skills developed in the design, implementation, certification, and commercialization of forest carbon projects in Colombia. *Fondo Acción* is currently the implementing agent of the Community REDD+ Portfolio, and hopes to support the issuance of carbon bonds for the national and international market in 2022—approximately 4 million tons—. *Fondo Acción* and its UCV&A are part of the first blue carbon project in the country.



## COLOMBIA

CEMarin staff with the participation of: Gordon Wilmsmeier, PhD, CEMarin researcher, Professor at the Universidad de los Andes Diana López, PhD, Professor at the Universidad Nacional de Colombia Medellín campus

# Innovation for sustainable navigation in Colombia<sup>1</sup>

**A**rtisanal fishing and piangua<sup>2</sup> collecting is tough work. On any given day, fishermen and women work up to twelve hours, facing the risk of encounters with snakes or rays and exposure to mosquitoes and the possibility of contracting illnesses like dengue fever. These risks increase over time, because over-exploitation means that the fishermen and women must travel to increasingly distant zones to find their catches. At the same time, as these risks increase, profits decrease due to the dependence on gasoline in traditional transport methods and the volatility of international oil and energy markets.

For areas on Colombia's Pacific coast like Santa Bárbara de Iscuandé, in the department of Nariño, and Guapi, just to the north in the department of Cauca, river navigation is a central part of life, not only for fishing and the commercialization of its products, but for daily activities to remain connected with surrounding areas, infrastructure, public services, and communities. In this article, we describe how these two communities are working hand in hand

with researchers from multiple universities across Colombia, to overcome their dependence on traditional energy sources, and the wide range of benefits these transitions can bring, both to the communities themselves and to the marine-coastal ecosystems they depend on.

### Renewable energy in Nariño

Santa Bárbara de Iscuandé was the perfect place to develop an electromobility project: an area with a strong history of mangrove conservation and a key role for piangueras (women who collect pianguas) in the local economy and society. The key issue facing this community was the high transportation costs associated with river navigation compared to the value of the pianguas in local and national markets. Of course, traditional motor vessels were also contributing to problems like greenhouse gas emissions, the contamination of the river, and acoustic pollution, all with differing degrees of local, national and international consequences.



Map of Colombia, departments of Cauca and Nariño. Populations of Guapi and Santa Bárbara - Iscuandé. Image: JMOD

Dr Gordon Wilmsmeier, Kühne Chair in Logistics at the Universidad de los Andes, Bogotá, a CEMarin researcher with a broad professional experience at universities across Europe and in multilateral organizations, with his team chose Santa Bárbara to pilot a program of electric motors powered by renewable solar energy. As an expert in maritime geography, international trade and logistics, and risk management, Wilmsmeier was focused on developing more sustainable methods of river navigation and improving the sustainability of fishing activities -both environmentally and economically- in some of the most remote and inaccessible areas of Colombia.

After discussions with the community, the project received funding from both the Colombian and German governments, and in 2019 the first four electric motors were purchased from their German producer, Torqeedo, and brought to Santa Bárbara. In February 2020, the first solar nautical electric charging station in Colombia was installed, in association with the local community leaders and fishing associations who administer its use, to take advantage of the solar energy potential in the zone. The project has shown that using solar energy decouples women's work and mobility from fossil fuels and has empowered the women to increase the previously depressed mobility within the community of Santa Bárbara.

These motors also have the benefit of reducing acoustic pollution, generating noise of only 45 decibels, equivalent to the background murmuring in a library. As well as benefits of reduced noise for the ecosystem itself, this almost-silent mode of transport also increases the potential for ecotourism because, for example, navigation with this type



*Santa Bárbara - Iscuandé. Photo: Centro de los Objetivos de Desarrollo Sostenible para América Latina*

of motor will not scare off birds or other species, making this type of activity more viable.

As of 2022, two motors from the project are being used by a women's group of piangueras in the community and the technology has become an integral part of their daily lives. The solution has been working well, but maintenance of the motors, for example, the replacement of seals, in this remote region has been a challenge, because of the significant time required for parts or technical support to reach the area. Thus, a challenge to overcome in this and in future projects is an in-depth training not only on the use and basic maintenance of the motors, but also to create the capacity for more

<sup>1</sup>Taborda, C. (2019). Gordon Wilmsmeier: el alemán que trabajó para implementar botes eléctricos en el Pacífico. *Seaonet*. Valenzuela, S. (09/03/20). Botes con energía solar en Nariño: Una lección de energía renovable. Centro de los Objetivos de Desarrollo Sostenible para América Latina. Facultad de Minas, Universidad Nacional de Colombia (2022). *Econavipesca del Pacífico avances y retos*. Facultad de Minas, Universidad Nacional de Colombia (2022). *Econavipesca del Pacífico: ecosistema para la navegación pesquera sustentable en el municipio de Guapi, Cauca*.

<sup>2</sup>Small bivalve molluscs found on the Pacific coast of the Americas, similar to clams.

technical revisions within the communities as well as the creation of a bank of spare parts nearby.

The research team continues to work on the implementation of these solutions and has recently inaugurated a new project to bring Colombia's first electric school boat to Bahía Málaga in the Valle del Cauca department. After teaming up with GivePower, over the next six months the group will build a new fully battery electric powered school boat and photovoltaic charging infrastructure to bring a fossil fuel free service to the children of Comunidad Negra de la Plata Bahía Málaga. The Kühne Chair in Logistics at the Faculty of Administration of the Universidad de los Andes will monitor the performance over the next 24 months.

### **Sustainable artisanal fishing management in Cauca**

Econavipesca del Pacífico: ecosystem for sustainable fishing navigation in the municipality of Guapi, Cauca, is an international project that unites community leaders and fishing associations in the municipality of Guapi with an interdisciplinary group of academics, with the objective of developing a sustainable artisanal fishing model that reduces the environmental, social, and economic impacts on the ecosystem caused by existing ves-



*Santa Bárbara - Iscuandé. Photo: Centro de los Objetivos de Desarrollo Sostenible para América Latina*

els' use of fossil fuels and other resources that increase the costs of fishing operations and cause environmental degradation.

Four universities and three fishing communities and associations participate in Econavipesca del Pacífico, and it is financed by the Swedish International Development Cooperation Agency. The communities that contribute their knowledge on artisanal fishing are the Nueva Bellavista Association of the Eperara Siapidara indigenous community who fish in the Guapi River and estuary, and two Afro-Colombian communities who fish in the sea, the Guapi Association of Artisanal Fisheries Services (Aservipesca) and the Renacer Guapiense Fishermen's Association. From the academic side, the project is led by the Universidad Nacional de Colombia, Medellín and Palmira sites; the Universidad del Cauca and the Swedish universities Lund and KTH also participate.

Dr Andrés Osorio, CEMarin Executive Director and one of the CEMarin researchers involved in the project, highlights that this project combines the conservation of the ecosystem and ancestral knowledge, scientific and technological innovation, and long-term sustainable economic development. Open innovation and co-creation methodologies are key, with dialogues of knowledge between the communities and the academics involved facilitating the analysis of the value chain as the basis of a sustainable artisanal fishing model. Dr Jairo



*Santa Bárbara - Iscuandé. Photo: Centro de los Objetivos de Desarrollo Sostenible para América Latina*

Tocancipá Falla of the Universidad del Cauca highlights the interdisciplinary nature of the team and the importance of sharing knowledge between the indigenous and Afro-Colombian communities that tend to employ different fishing techniques and navigation systems.

Dr Diana López, a Professor of Mechanical Engineering and the Project Director from the Universidad Nacional de Colombia, explains that the team is currently in the conceptual design stage of developing an innovative prototype of an eco-efficient vessel in order to strengthen the fishing organizations and elaborate business plans that allow the development of social enterprises. One of the key elements is the evaluation of the most appropriate energy source according to local conditions and needs. Despite being an engineer herself, Dr López underlines that the innovative nature of this prototype vessel comes from the interdisciplinary nature of the team, ensuring that the development of the prototype goes beyond a purely engineering point of view: the collaboration between the fishing communities and the academics involved is crucial to understand and reflect the characteristics of the value chain model presented in the project.

Finally, Sebastián Loango, representative of the Renacer Guapireño Fishermen's Association, emphasizes the valuable participation of the diverse actors involved and that the reductions in the high costs associated with the use of fossil fuels in fishing



*Workshops in Guapi. Photo: Facultad de Minas, Universidad Nacional de Colombia*

activities, among other outcomes, will directly and indirectly benefit many people in Guapi, an area often forgotten by the country's leaders.



Both of these projects demonstrate a commitment to preserving and facilitating the autonomy, interdependence, empowerment, and community appropriation of the use of innovative new technologies for navigation. Without this, long-term sustainability in navigation for artisanal fishing and daily life in the communities of Santa Bárbara de Iscuandé and Guapi would not be possible. However, as both of these projects show, uniting traditional and ancestral knowledge and practices with technological innovation is not only viable, it is already a reality in these remote parts of Colombia.



*The team in Guapi. Photo: Alfredo Valderruten & Sebastián Serna.*

# The Festival of Traditional Navigation of the Insular Caribbean: Innovation through traditional knowledge and culture



Flyer for the IV Festival of Traditional Navigation. Image: ProSeaLand.

The IV Festival of Traditional Navigation of the Insular Caribbean: Culture is what the hurricane couldn't take away, was held from the 29th September to the 8th October 2022, with the aim of highlighting and celebrating cultural resilience and the central role of navigation and fishing in Raizal culture. The Festival was organized by the Sea, Land & Culture Old Providence Initiative foundation (ProSeaLand), with support from the National Concertation Program of the Colombian Ministry of Culture and CEMarin, among other actors.

Dr Ana Isabel Márquez Pérez –born in Bogotá but raised on the island of Providencia-, anthropologist, Professor at the Caribbean Campus of the Universidad Nacional de Colombia, CEMarin Researcher, and a member of ProSeaLand, spoke with us after the III Festival, which had the theme “Connecting Islands, Coasts and Seas”, and told us about the connection between innovation and the traditional and ancestral practices of the Archipelago of San Andrés, Providencia, and Santa Catalina.

**Sonar:** Let's start with the Festival of Traditional Navigation, can you tell us a little about its history and objectives?

Ana Isabel Márquez Pérez: The Festival was born on the initiative of ProSeaLand, a grassroots organization made up of Raizales and residents of the archipelago, with the aim of creating and consolidating an annual space in which the maritime culture of the Raizal people can be made visible,

invigorated and resignified, and where vessels like catboats and cotton boats are featured as emblematic manifestations of navigation. Everything revolves around the relations of these societies with the sea, something that is sometimes forgotten in the scientific-academic context.

Personally, it has given me the opportunity to link my academic work with social and cultural issues, and particularly traditional forms of navigation. I have been working for around 17 years with *sabedores* and *sabedoras* from Providencia and Santa Catalina, which is to say, people with important knowledge of cultural manifestations like traditional navigation and artisanal fishing practices, and the overarching objective has always been that this accumulated knowledge has some use for the community and is not only locked away in academic articles. In this sense, the Festival fits within the interests at various levels regarding the safeguarding of the immaterial cultural heritage and culture of the Raizal people.

## Sonar: What is the relationship between the Festival and knowledge dialogues at the national level, and even beyond Colombia?

AIMP: The Festival has allowed us to create alliances with institutions and people at the local, regional, and national levels, and even internationally, while focusing on putting local sabedores and sabedoras in a central position within the activities. Thus, the entire Festival is characterized by being with and for them, as a commitment to strengthening knowledge dialogues both internally -towards the community of the archipelago-, and externally -towards places with similar practices and knowledge within Colombia and across the region and the world, as well as towards other parts of Colombia that are unaware of many of the peculiarities of the Raizal culture and the archipelago. Additionally, it is a bilingual space with activities in English, Spanish, and Creole, and we arrange events to make visible and recognize the linguistic diversity in Colombia, which is still little known by many people in the country.

It is a great achievement of the Festival that we have involved people with vast knowledge of navigation and artisanal fishing as well as musicians, painters, storytellers, traditional cooks, and cultural actors, and built links both among them and with international guests. In recent years, the obligatory shift to virtual events caused by the pandemic opened up the possibility for us to interact and dialogue with some international groups that would otherwise have been impossible. At the II Festival in 2020 we were able to create spaces for knowledge dialogues with people from the Cayman Islands, where catboats originated, and from other parts of the Caribbean with very specific navigation traditions. At the III Festival in 2021 we shared virtual spaces with a group of sabedores from Senegal, both fishermen and naval carpenters, as well as with people from Saint Vincent and the Grenadines and Antigua in the eastern Caribbean. All these opportunities for dialogue have been mutually enriching. Virtuality

and alliances with actors like El Isleño, the local newspaper of the archipelago, and the National Radio of Colombia, have also given us the possibility of achieving greater dissemination at the local and national level.

**Sonar: The main topic of this issue of Sonar is innovation in the marine sciences. Based on your personal and professional experiences, can you tell us about your vision of what innovation is?**

AIMP: I would say that, conceptually, innovation refers to any process in which new, different, transformative things are introduced to something that



*Preparing for the cotton boat racing. Photo: ProSeaLand.*

already exists. This applies in both science and knowledge, as well as in society and daily practices. Innovation goes beyond new, state-of-the-art technologies; throughout history human beings have always innovated in all fields, and this is what has led to social change and human societies becoming more complex.

**Sonar: What is the relationship between ancestral knowledge, for example, related to sailboat navigation, and innovation?**

AIMP: A perfect example of innovation in the area of navigation are catboats and cotton boats, the emblematic sailboat vessels of the Raizal people, which we call “traditional” despite the fact that societies have never been static. Although we can call them ancestral or traditional, to refer to the fact that they are particular to the archipelago and inherited from previous generations, they have been continuously transformed and adapted over time.

Catboats arrived in the archipelago in the first half of the 20th century with other peoples from across the Caribbean, particularly turtle fishermen from the Cayman Islands. They brought their catboats, which were the result of a union of European, indigenous, and African knowledge, and the vessels were continuously adapted by local builders in Providencia. The Cayman catboats had been specially designed for turtle hunting, to be maneuverable in coral reefs and in places where turtles -highly intelligent and agile animals- are chased, and were also used to transport passengers and cargo around the Cayman Islands. In Providencia at that time, people used canoes with three sails for similar purposes, but catboats gradually replaced them.

With the arrival of motors, catboats were further transformed and became what we know today as *lanchas*: they were originally made of wood but today this has been almost completely replaced by fiberglass. And on the recreational side, for racing, the catboats were adapted so much that today they are very distinct to the first catboats that arrived from the Cayman Islands almost one hundred years ago. Today, they are something unique to the people of Providencia. For me, this story perfectly illustrates what innovation is, a permanent process of transformation and adaptation.



**Sonar: Do you think there is a connection between these vessels, with their long history of adaptation and innovation, and the energy transition that is taking a leading role in the 21st century?**

AIMP: For years there have been debates about traditional vessels and their contemporary value, about whether sails are now useful only in recreational or artistic contexts but redundant in everyday life. But it is precisely in debates about a fair energy transition, raised by social movements, that it is possible to vindicate these practices, because all non-polluting energy sources take a vital role, and today we know that sooner or later we will have to transform our existing energy model.

We see an important point of reference in the Marshall Islands and the cooperation project they have with GIZ to return to sail-powered cargo fleets. Considering the ancient tradition of navigation of the people of Polynesia and Melanesia, this project goes hand in hand with the recovery of knowledge and practices that, although they have not been lost, have been left aside. Today they regain importance. There are even similar initiatives in the Caribbean related to a fair energy transition and fair trade, which lead us to ask: What role can sailboats play in these processes today?



We thank Dr Márquez Pérez for sharing her knowledge and experiences with us. For more information on low-carbon shipping initiatives in the Marshall Islands, see our article on Global Trends in Navigation. If you are interested in learning more about the Festival of Traditional Navigation of the Insular Caribbean, please visit the ProSeaLand foundation’s website, [www.prosealand.org](http://www.prosealand.org), where you can find access to the virtual content of the 2020 and 2021 Festivals on Facebook and YouTube.

## COLOMBIA

CEMarin staff

## Aboard the Argo: a journey to the depths of the ocean

*NatGeo's Pristine Seas program seeks to create and qualify Marine Protected Areas around the world. Recently, it has undertaken important research in three key regions of the Colombian oceans. A group of local researchers was invited to take part in the expedition. We spoke with Dr Paula Zapata, Professor at the Universidad Pontificia Bolivariana and CEMarin Associate Researcher, about the experience.*



Photo: Pristine Seas researchers / Argo Ship

### Sonar: How did Pristine Seas arrive in Colombia?

Paula Zapata: Pristine Seas tries to support governments around the world in the implementation and updating of Marine Protected Areas (MPAs). The Colombian government established a highly ambitious goal of designating at least 30% of the country's oceans under some form of MPA management by 2022. In this context, the delegation from the Ministry of the Environment met with Dr Enric Sala, Director of Pristine Seas, at the COP26 and they began to collaborate. The necessary arrangements were made with the Foreign Ministry, the Colombian Ocean Commission (CCO) and the General Maritime and Port Directorate (DIMAR), and from there, three priority areas were selected: Yuruparí - Malpelo, the oceanic part of the Pacific; the Gulf of Tribugá, due to its pristine condition but also the

problem of the much discussed creation of a port in the area; and the Serranilla and Bajo Nuevo keys in the Seaflower Biosphere Reserve.

Aside from the collection and processing of data, the objective of Pristine Seas is for communities to see the process and ensure media coverage. So, there are three work teams: a scientific one, led by Dr Enric Sala and Dr Alan Friedlander, a principal researcher who is also an ichthyologist, or expert in fish. There are also some individuals in charge of the socioeconomic and cultural component associated with the areas to be evaluated.

Second, there is a media team, which is essentially everything related to the production of the documentary: cameras, storytellers, filmmakers.

Additionally, Pristine Seas is associated with Deep Sea Hunters, the company that operates the submersible. There is also a boat, the Argo, which they have adapted for the operation of the program. Then there is a third team, the logistics team: the pilots of the submersible, the divemasters, those who accompany us with the boats and the diving and navigation equipment, as well as the kitchen equipment and general on-board logistics. Everything is prepared so that you only do exactly what you have to do. That's when one starts to see the concept of innovation, in how the entire process is organized. It was very interesting to see how compact the team is. It's like clockwork; if there is no cohesion, things don't work.



## Sonar: How do you participate in the program?

PZ: Traditionally, in each country they invite researchers or important local actors to participate. In the offshore part of the program, they invited Luisa Dueñas, Professor at the Universidad Nacional de Colombia and a CEMarin Researcher, Néstor Ardila, Professor at the Universidad Militar, an observer from DIMAR, a member of the National Natural Park Malpelo, and Sandra Bessudo, from the Malpelo Foundation. The Colombians traveled to Costa Rica and embarked there. Later, in the part I participated in, there was Robinson Mosquera, who works at CODECHOCÓ, who is very important for the social and fishing context of the territory and the management bodies that exist there, which are the Regional District of Integrated Management and the Exclusive Areas of Artisanal Fishing. Because we collaborate with the Center of Oceanographic and Hydrographic Research (CIOH with its initials in Spanish), I insisted to Juan Mayorga, who is Colombian and the Pristine Seas Data Manager, that Captain Julián Quintero –Director of Technological Development at the CIOH– should be included. He was also in Seaflower. Luis Chasqui, who works with marine biodiversity at INVEMAR, and again, Sandra Bessudo and me. How did they contact me? It was by word of mouth, looking for people with experience working in the area.

Robinson knows the territory like the back of his hand. It was really interesting, first, that he had the opportunity to board the submersible because he doesn't dive, and also that he could see his territory first-hand; of course, he knows so much about fish and fishing, but from above. There was a great interaction between him and the team. Later, they went to Seaflower, where there is Coralina, and Nacor Bolaños and Alfredo Abril. Julián continued the voyage and Diego Cardeñoso, who works with sharks, was also invited. In Seaflower, there was also a NatGeo Director for this program in Latin America, Alex Muñoz, from Chile.

## Sonar: And what was your role in the expedition?

PZ: I was, naturally, part of the scientific team. When the process began, we had some technical meetings before embarking, to get to know the dynamics and agenda, and so that we knew what data they had available. We made a significant effort to obtain the bathymetry data, that is, the depth and also the shape of the seabed. With that, I did a preliminary design of the sampling so that we could choose places with interesting geomorphological features, to go down in the submersible and send the drop cams.

Pristine Seas operates in three zones of the ocean. The first is the shallow or photic part, where you can dive, at around 30m deep. There we did scientific diving to collect standard data. Second is another layer, the mesophotic, from 30 to 120m deep. There they use cameras, both mesophotic and pelagic. The mesophotic cameras are for observing objects at a certain depth, and the pelagic ones are for capturing larger fish. And third is the deep ocean, from 120 to 6,000m. For this they have the drop cams, which they designed. The manned submersible can go as deep as 500m and it can fit three people: the pilot, a NatGeo cameraperson, and a researcher.



Photo: Pristine Seas researchers / Argo Ship

Let's say that, in the beginning, what you do is listen to the scientific plan. In the first meetings there was an interesting discussion, and this is cool because they listen to local knowledge. So, seeing that we could do more, we met with Luisa Dueñas and Yuley Cardona, another Professor at the Universidad Nacional, to develop a small project that supports decision-making by doing a connectivity exercise. We designed a small project that we sent to the team, and they said yes, but that they did not have funding for the genetics aspect, which is something that we are currently working out. However, we already conducted the sampling, which is the most expensive part. Our idea is to identify how three coral species are connected throughout the gulf, in order to understand

these biological corridors, this connectivity, so that it can be an additional tool when deciding a possible zoning that includes these corridors, this ecological and oceanographic connectivity within the territory. The idea is to be able to contribute to the work of Pristine Seas, and to achieve designation of MPAs more related to this connectivity, which is crucial.

### Sonar: How does Pristine Seas normally undertake sampling?

PZ: This is a classic sampling process. Shallow, mesophotic, and deep. With different cameras, different techniques, and different sensors. So, they basically take a transect and count what fish are there, where they are, and how abundant they are. Then there is the benthic, which is associated with the seabed, the reef, which they call the crag. In the crags, I carried out the benthic component with Dr Enrique “Kike” Ballesteros, an ecologist who works in Spain at the Centre d’Estudis Avançats de Blanes (Blanes Center for Advanced Studies), an institution of the Spanish National Research Council. Kike did everything related to coverage of algae, sponges, everything associated with the crags, and I was in charge of counting the corals, what species of coral, their abundance, their diversity, and the mobile organisms within the transect. That was every day, all the time, and in brutal cold. We had days with strong currents and poor visibility. So, it was hard, but cool. For me, it was a gift from life to have been able to work with Kike Ballesteros, he’s an important reference in the field, I don’t know how many times I cited him in my doctoral thesis...

We saw an organism called argonaut, which is a type of nautilus and no one on the ship had seen one of them before, so it was a sensation. There were many, many, many snakes, and they’re highly poisonous. So, it was a bit extreme in terms of diving. And well, what we saw from the submersible was simply wonderful. I had the opportunity to explore the canyons. I’m really interested in understanding underwater canyons,



Photo: Pristine Seas researchers / Argo Ship

since in Colombia they are little explored but very important, they are the connection between the continent and the deep ocean. It was a tremendous opportunity to explore them and to formulate new research questions.

### Sonar: What did you take away from the expedition?

PZ: I think that this work opens new doors, which for me is fundamental. It seems very important to me that the government in power, whatever it may be, understands that decisions should not only be policies made around a table, but that the decisions should be based on information and data. I believe that this is something Pristine Seas is going to leave us, that the management decisions that are made have baseline information on how to do it, and why.



Photo: Pristine Seas researchers / Argo Ship

## Ecopetrol, with energy transition in its sights

A key issue in the fight against climate change, which is today up for debate in many global scenarios, is that of energy transition and the decarbonization of the fossil fuel sector. What is the perspective and experience of Ecopetrol, the largest energy company in Colombia and the second largest oil company in Latin America? We spoke with Santiago Martínez Ochoa, the company's Director of Sustainability and Decarbonization, about its energy transition strategy and the possibilities that exist related to the ocean.

**Sonar: Although Colombia is not a major emitter of greenhouse gasses, it is a country highly vulnerable to climate change. From this perspective, what are Ecopetrol's priorities when proposing an energy transition strategy?**

Santiago Martínez Ochoa: From Ecopetrol's perspective, there is an interest in getting involved for reasons related to risk management, but also because of opportunities. In the field of adaptation, what Ecopetrol is looking for is to have more resilient operations in the face of phenomena like El Niño or La Niña. There is a whole area of work associated with understanding these climatic and physical risks, and with establishing a series of adaptation plans that allow us to face them.

In terms of mitigation, there are many reasons why a company like Ecopetrol should be included in these issues. One is the interest groups we respond to. We have, for example, the regulators –the Colombian state has increasingly strict regulations and legislation related to climate change– so it makes sense to be at the forefront of these changes and to go beyond the legal minimums in terms of preparation. There are authorities like the



Energy transition. Image: Jorge Mario Ordóñez Duque

National Environmental Licensing Agency, which is beginning to include climate change issues in its guidelines. Then there are the investors –the entire financial sector is increasingly active in this area– and the allocation of capital is increasingly taking sustainability criteria into account. At the local level, there are increasingly active communities and civil society actors, and climate change issues have become almost a license to operate. Finally, in general terms regarding energy transition, companies that do not adapt will, in the long run, simply stop being competitive and will be exposed to a series of risks. We must identify these risks to think about the Ecopetrol of the future, and this implies some changes that cannot be implemented from one day to the next.

**Sonar: Is the adaptation aspect being done in a purely anticipatory sense, or is Ecopetrol already suffering in some way the effects of climate change?**



*Drought, climate change. Photo: Patrick Hendry on Unsplash*

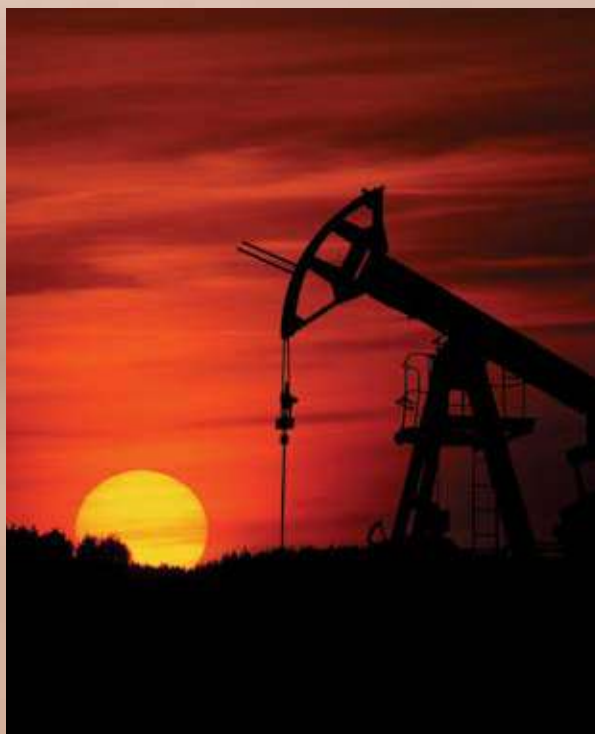
SMO: Some risks have been already materialized, yes. For example, in times of drought, in places where Ecopetrol has a series of discharges into bodies of water, it is basically forced to stop the discharges because the bodies of water cannot support the loads that can eventually be emitted. This has a direct impact on the company's production.

**Sonar: This makes me think that, although there is a kind of dichotomy in the imagination of many people between sustainability and economy, for Ecopetrol, does making this energy transition mean creating a more resilient company?**

SMO: If we go back to the decarbonization plan, many of the initiatives we are developing are cost-effective: it's good business to carry them out. And part of what we have been developing are these analyses of what these projects are, where on the one hand I decarbonize and on the other I generate efficiencies for Ecopetrol. I would say that there are two reasons: I do it because it's good business to move in that direction, but also because it is strategically convenient for me to avoid a risk, and there are legal risks, operational risks, reputational risks... Let's say that many of these measures aim to maximize the business opportunity or to mitigate one of the risks I mentioned. So, it is not necessarily a dichotomy, I can have projects that are beneficial from both the environmental and economic points of view.

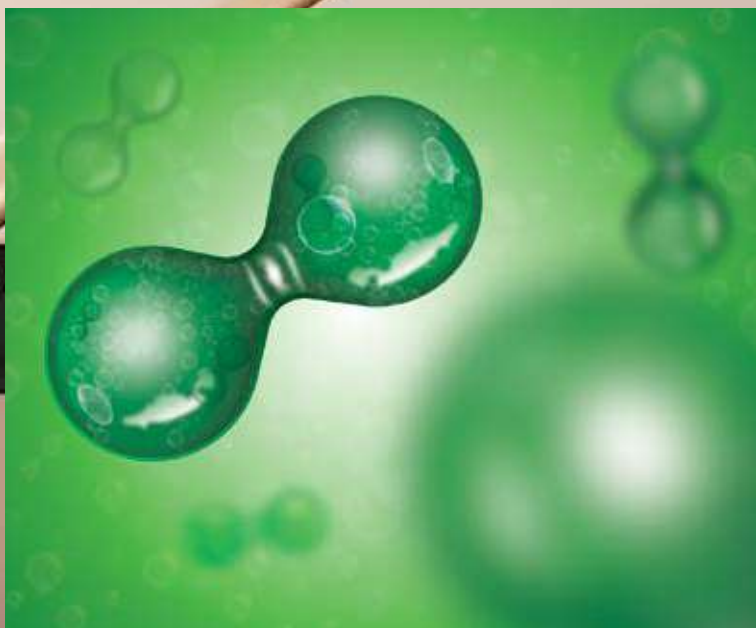
**Sonar: Can you tell me about the strategies you are implementing?**

SMO: We recently launched the 2040 strategy, in which we already see sustainability issues as a central part of the company. These issues are already contained within two of the main pillars of Ecopetrol's strategy. One is the pillar we call "Growing with the energy transition," within which Ecopetrol's proposal is to begin to diversify the company's sources of resources towards low-emission businesses. The second pillar is SosTECHnibilidad (SusTECHnibility), which includes a series of material issues, including climate change. Given the importance of this issue, the emission reduction goals were launched in 2020: we are committed to a 25% reduction in what we call scope 1 and scope 2 by 2030. When we talk about scope 1, we refer to direct emissions from our operations, and scope 2 refers to those emissions associated with the purchase of energy from the electricity grid. By 2050 we have the goal of reducing 50% of total emissions from scopes 1, 2, and 3. Scope 3 emissions are the largest emissions generated by a fossil fuel company, which are basically those generated by the use of the products the company sells, like gasoline.



*Extraction of crude oil. Photo: Zbynek Burival on Unsplash*

With this framework of targets, we have been setting up a decarbonization strategy that includes various initiatives. For example, we have a program associated with energy efficiency, which is highly important in the short and medium term. We also have a program associated with the reduction of routine flaring in operations, and we are a part of, among others, the World Bank's "Zero Routine Flaring by 2030" initiative. There is the whole issue of identifying and reducing methane gas emissions, and in this area, we have been working on a program: the issue of renewables, the idea is to also be able to replace the energy consumption that today comes from fossil fuels by generating renewable energy. There are some goals to increase installed renewable energy capacity in Ecopetrol, and we



Sun park. Photo: Jeremy Bishop on Unsplash

hope that, in the medium term, technologies will emerge related to hydrogen and the capture and use of carbon. All of this will lead to some degree of reductions, but it does not reduce residual emissions, and that is where the issue of offsetting carbon emissions comes into play, based on natural climate solutions. We are also very active in these areas, creating our own projects, and we will eventually be more active in buying carbon bonds, particularly those associated with ecological and forest restoration. This is where solutions like Blue Carbon take an interesting role and have interesting potential. These are the main initiatives we have been taking forward.

### **Sonar: Would you like to expand on the topic of SosTECnibilidad?**

SMO: Well, this started from a materiality analysis, trying to understand what the priority issues for Ecopetrol are. There is a first category of exceptional issues where we want to go further, and here arise topics like climate change, water resources, and what we call sustainable territorial development. A second category is outstanding issues, like biodiversity, circular economy, air quality, etc. Based on this prioritization, we are building roadmaps that allow us to establish specific goals for each issue, and technology is at the heart of all of them, hence the term. We think technology can be a level for many of these sustainability issues. To give you an example, we are in the process of building a tool to manage the issue of emissions as a whole in a more efficient way, to build emissions projections in a more dynamic way, and that is the type of technological tool that supports decision-making for decarbonization.

### **Sonar: Are we referring only to major technologies in the fossil fuels sector that come from outside, or also to technologies developed locally?**

SMO: I would say it's both. The first issue is what are the great programs behind Ecopetrol's decarbonization plan, all of them bring a series of technologies that I must implement to move forward in decarbonization.

And they are technologies that are not necessarily developed internally. For that reason, I go to the market and identify what is being done. But there are others that I do develop internally, and it depends on a case-to-case basis if I choose one route or the other. The tool that I mentioned before does not exist in the market, so we are doing the technological development directly. We have our Colombian Petroleum Institute, and they do some of their own development, specific to the Colombian context. Another example is in the field of natural climate solutions, with them we are beginning to develop the protocols and methodologies for measuring the carbon sequestration potential in Colombian ecosystems, so we now want

to take a much more specific look at the Colombian case and not necessarily apply generic global measurements or other types of methodologies.

**Sonar: This next question is about the challenges, and here I must ask about the new political landscape in Colombia, where it has been suggested that the issue of energy transition is entering a hyper-accelerated scenario. What reading do you have so far in terms of viability, timeframes, actors involved, etc.?**



Mangrove. Photo: Carina Marek, CEMarin photo archive

SMO: What I would tell you is that we are onboard with the energy transition. There are huge convergences between what the new government wants and what Ecopetrol wants in terms of transition. The challenge is how to balance the distinct interests and needs behind this context of transition. The first thing we must recognize is that a company like Ecopetrol generates around 10% of the national budget. When one measures the resources generated by Ecopetrol, how we advance in the energy transition without putting those resources at risk is highly relevant. So, I think the issue is more about gradualness and how we can guarantee that the company can continue to guarantee those resources to the nation, not only financial but also to guarantee energy security.

Colombia will continue to demand fossil fuels in the short, medium, and probably long term, so we must understand what the role of gas will be, and what our role at Ecopetrol will be in that supply. Importing these resources and not generating them internally could implicate substantial costs for the country. All of these are public policy debates that are very difficult to manage, but they are part of the answers we will have to generate along the way, and they are answers we don't yet have completely. I'm not sure if I'm answering your question, but I'm putting into context the different interests and priorities that must be balanced in this discussion, which is not easy.

**Sonar: I would like to ask you about the panorama related to the oceans. I know this topic is not so developed for Ecopetrol, but what potential exists in the sector, both in terms of energy and in terms of carbon capture?**

SMO: As I mentioned, the topic of Blue Carbon is very interesting, and we want to explore this type of projects more. The challenge is the costs, as these are the most expensive types of projects, but we are highly interested in being able to contribute to this area. From the energy point of view, there is great offshore potential that is being explored as well as the potential of gas for Colombia which may have a significant role, especially if we understand the role of gas in energy

transition. We believe that gas has a very important role to play in a country like Colombia, where there are still 1.2 million families that depend on burning wood to supply their energy consumption.

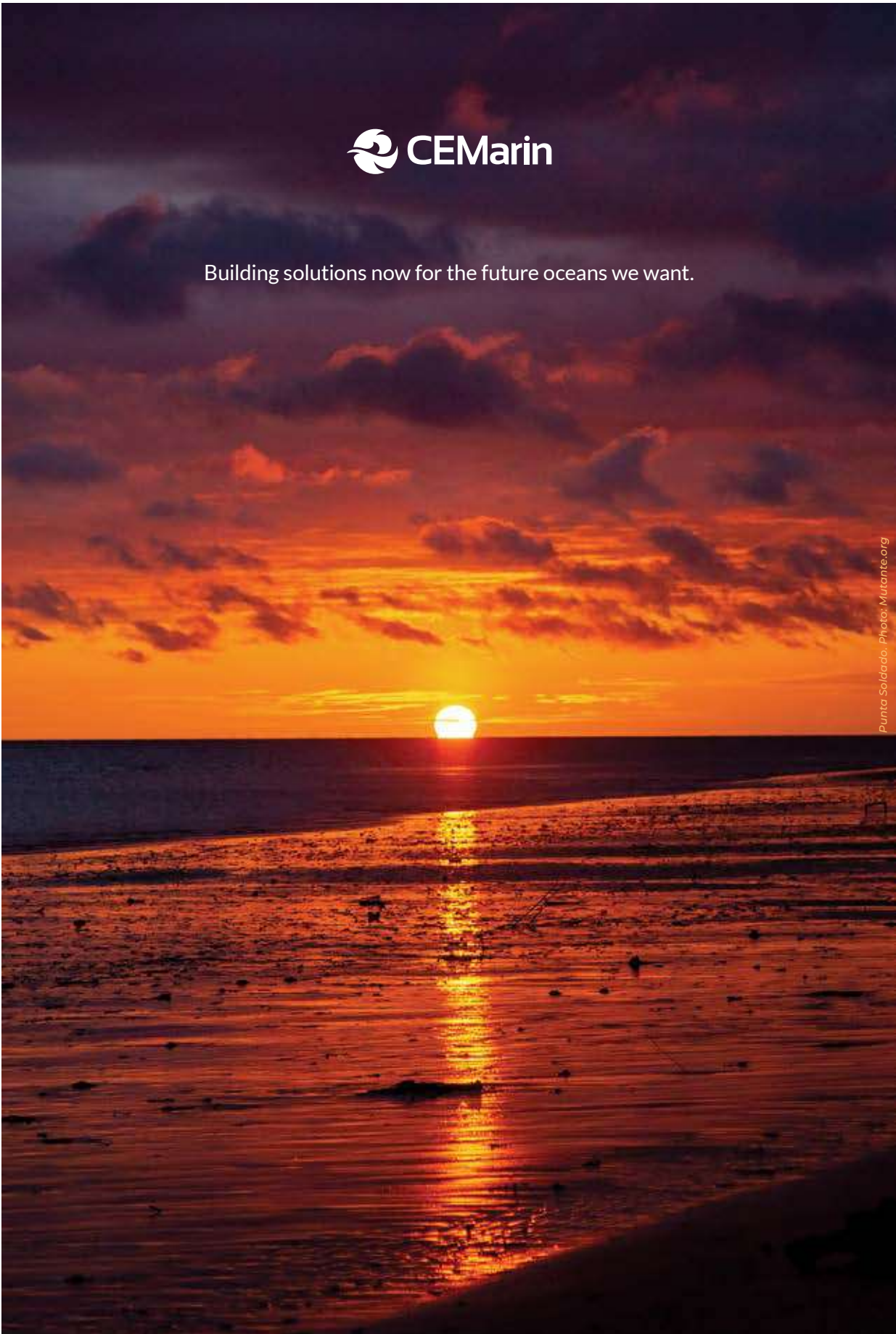
**Sonar: To close, how is the scientific perspective articulated throughout this process?**

SMO: Above all, the goals established by companies, including Ecopetrol, will all become increasingly based on science. In other words, I have to have scientific support behind me, both in terms of the goals I make public to the market, and in terms of the projects that will allow me to reach those targets. Science plays a fundamental role in all of that.



Building solutions now for the future oceans we want.

Punta Soldado, Photo: Mutante.org



## CEMarin PROJECTS

CEMarin staff with the participation of Manuel Sevilla PhD, CEMarin associate researcher, Professor at the Pontificia Universidad Javeriana Cali

# The Other Sea: Narrating science through art



Image: Poster, Otro Mar.

It may sound unlikely that doctors in Anthropology, Social Sciences, and Marine Sciences and Technologies would win a grant to put on a work of theater, but that is exactly how Otro Mar (the Other Sea) was born. It is a play developed through collective creation that combines music, dance, and theater in an attempt to innovate in scientific communication in Colombia. The co-creators of the project, Manuel Sevilla (Pontificia Universidad Javeriana Cali), Ana Isabel Márquez (Universidad Nacional de Colombia, Caribbean site), Andrés Osorio (Universidad Nacional de Colombia, Medellín site) told us a little about the project.

The work presents different characters, each with a different conception of how our relationship with the ocean should be constructed. There are Aquilino

and his community, who enjoy the benefits provided by the ocean, as their entire reality has been built around it and they work to guarantee its protection. There are also actors interested in investigating the ocean, others in exploiting it economically, and those who use it as an emblem in political campaigns. The interaction between these groups produces the climax of the work: little by little we discover the true interests of each actor. Parallel to these events, the spirit of the ocean is always present, represented by the figure of a female dancer with soft and fluid movements, accompanied by marimba melodies typical of the Colombian Pacific, and who is always with and looking after Aquilino and his community. The appearance of this being gives an ethereal atmosphere in which the audience can appreciate the majesty of the ocean, and the authenticity of Colombian coastal communities.

Otro Mar emerged as a proposal for a knowledge dialogue between the natural and social sciences and the arts, to represent the different visions and



Photo: Miguel Varona

knowledge that exist around maritime territories, and how sometimes they align and sometimes go against each other, but with the sea always being the central figure of the work. The participation of professional artists from the ConParsimonia company, based in Cali, and the integration of oth-



er participants from the Raizal community of the Archipelago of San Andrés, Providencia, and Santa Catalina, were key in the development and collective creation of the story. All members of the team contributed their artistic knowledge and local feelings to the dialogue around maritime cultural heritage, both in the Pacific and the Caribbean, while seeking to create a universal work on the threats to the oceans and marine-coastal communities.

After its premier on the island of San Andrés in May 2022, to date the work has been presented in four more cities around the country. Each city has had a different audience: high school students, university students, academics, and the general public. This



*Photo: Miguel Varona*

to these people and their knowledge. Currently, they are looking for funding to continue presenting the work across Colombia, and even in international festivals in other parts of the world. Stay tuned for future opportunities to see Otro Mar.

Otro Mar won a grant from the Investigarte 2.0 call by the Colombian Ministry of Science, Technology, and Innovation, and was supported by CEMarin, the Pontificia Universidad Javeriana Cali, the Universidad Nacional de Colombia, Caribbean site, the Senfol Foundation and the Sea, Land & Culture Old Providence Initiative foundation (ProSeaLand).

has implied different reactions. For example, in San Andrés, the audience showed their appreciation for how the work reflects the situation they live on a daily basis in that part of the country. In Buenaventura, many people identified with a character from Providencia, demonstrating connections between two distinct realities that share many challenges. And, in Cali, with an audience of university students, debates arose around the role of academia in these territories. In all cases, it was gratifying for the team to see how the public enjoyed the work and reflected on the messages it conveys.

The team hopes to soon take the work to the island of Providencia because, following the destruction caused by Hurricane Iota in November 2020 and considering the climatic threats the community continues to face, the work is also conceived as a tribute to the historical memory of these territories,



*Photo: Miguel Varona*

## CEMarin PROJECTS

Ballantyne Puin Castaño, student of the Masters in Environment and Sustainable Development,  
Universidad Nacional de Colombia

# Notes from the field: Mutual learning for climate resilience in Punta Soldado



Punta Soldado. Photo: Jorge Luis Rocha

**T**he island of Punta Soldado is only 30 minutes by boat from the Port of Buenaventura, the main seaport in Colombia and one of the most important in all of Latin America. This Afro-Colombian community of around 400 people has suffered at least three forced displacements, the most recent in 1998. At the same time, it has seen the disappearance of dozens of hectares of mangroves, beaches, and mud flats, which today puts at risk both their daily livelihood and their permanence in the area. A few decades ago, the town had a population of around 600 families, which has been reduced to only 110 today. It is not any easy life at all, it is an act of resistance and resilience by those who have decided to remain in their territory despite the risks of future extreme events and further displacements.

The current Punta Soldado has moved from its original location as a result of climatic events and the rise in sea levels in the last 40 years. The community has lost around 600m of coastline, that is, the limit between the sea and the land. This has also caused the emergence of the “mangrove cemetery,” an area on the coastline where this biotic area died after being buried by sediments, a clear visual representation of the vulnerability of the territory.

In July 2021, with Covid-19 restrictions and a turbulent social context across the country, I arrived in Punta Soldado for the first time. Despite the difficult conditions, this place stole my heart and gave my professional life a purpose. I went to Punta Soldado as a researcher and project officer from the OCEÁNICOS research group of the Universidad Nacional de Colombia which, since 2019, has worked on the island’s Climate Adaptation Plan thanks to the Coastal Solutions Fellowship grant obtained by Johann Delgado. In its first year, the main focus of the project was to study the physical variables that intervene in the erosion and sedimentation processes. To do this, different measuring equipment was brought and the modeling of the area began. However, in 2020, the need to expand the scope of the project was identified –the need to collaborate with the community leaders of Punta Soldado– and it was then that we jointly benefited from the Solidarity Extension call of the Medellín site of the Universidad Nacional de Colombia.

The main objective of the project is to increase the technical capacities of the community on the planning, execution, and evaluation of climate change mitigation and adaptation measures. This is done through an ecosystem-based management model based and the construction and application of scientific and community-based knowledge. In other words, while from the academic side we can make important contributions to the measurement and monitoring of different physical, ecological, and social factors, we also depend on the knowledge, experience, and participation of the community itself in order to achieve effective responses. The ancestral knowledge of the communities has allowed them to live in their territories for a long time, even centuries, and therefore it is a highly

important input for any scientific study. At the time, the decision to work hand in hand with the community could be considered innovative or unusual, but I trust that today it has become a fundamental element of this academic project.

On the mitigation side, and as a technical strategy against coastal erosion and extreme events in the future, we are prototyping a barrier on one side of the island. It works with the tide, so when the tide rises the permeable barrier drags sediments and, when the tide falls, a part of the sediments remains accumulated there. For now, we are monitoring the operation of the barrier –the prototype measures only 2 x 3m– to assess whether it achieves any results, and how this could later be implemented on a larger scale. This monitoring is being conducted jointly with the community, thanks to the knowledge we have shared in our workshops.

These workshops have mainly been held with 15 young people from the community, since they represent the next generation and, in many cases, are highly motivated to seek answers and solutions to the changes experienced by their territory and their people. In all the workshops, the starting point has been the knowledge of the young people of Punta Soldado: first, they tell us what they understand by concepts such as waves, tides, and coastal erosion, among others. From these discussions, we begin to introduce the concepts in a scientific way, and this has formed the basis of the knowledge dialogue. With this, we seek to promote observation and research skills in the young people, as well as jointly putting together guidelines on physical forces and the ecological and social aspects that form the basis for decision-making in the future.

Throughout the workshops, the young participants have expressed their desire to learn, to study, and to contribute to their island and a better future. So much so, that they have voluntarily organized themselves to create environmental groups focused on solid waste management, community tourism, risk management, and clean energy. Finally, I would also like to thank the team from Mutante.org, who



Punta Soldado. Photo: Jorge Luis Rocha

have accompanied us in Punta Soldado to raise the profile of our work and, above all, the struggle of the island's community.

Listening to the community of Punta Soldado and learning first-hand how difficult it has been to remain in their territory and rebuild their lives after past displacements has convinced me of the value of science in helping communities and, as far as possible, of the need to work with and learn from them. Communities need and deserve to be in the center of scientific and political discussions. I hope that the scientific strategies we have brought from academia will contribute to the permanence of Punta Soldado on the map of Colombia in the future, and that I can continue working with them in the long term, despite all the uncertainties they face.

### Climate displacement

According to the United Nations, of the world's 59.1 million displaced persons in 2021, climate change was the main factor in the majority of cases, far more than conflicts or other factors<sup>1</sup>. As long as the impacts of climate change become more frequent and ever stronger, the phenomenon will continue to increase and millions more will be affected. The World Bank estimates that, by 2050, there could be some 216 million people forced to migrate, and highlights that it is generally the poorest people who suffer the greatest possibility of displacement<sup>2</sup>.

<sup>1</sup> <https://www.ohchr.org/en/press-releases/2022/06/intolerable-tide-people-displaced-climate-change-un-expert>

<sup>2</sup> <https://www.worldbank.org/en/news/press-release/2021/09/13/climate-change-could-force-216-million-people-to-migrate-within-their-own-countries-by-2050>



## CEMarin REPORTS

**CEMarin Early Stage Researcher:** Jordan Estiven Ruiz-Toquica  
 Doctoral student in Marine Sciences, Universidad de Bogotá  
 Jorge Tadeo Lozano, Santa Marta campus  
**Director & CEMarin Researcher:** Andrés Franco Herrera PhD  
 (Universidad de Bogotá Jorge Tadeo Lozano)

### RESEARCH REPORT I

# Dynamics of the *Madracis aurentenra* (Scleratinia: Pocilloporidae) microbiome and phenotypic response to environmental stressors



Sampling of *Madracis aurentenra* in Bahía Chengue PNNT.  
 Photo: Catalina Gómez

organisms establish symbiosis provide part of this resistance. In this way, the probiotic hypothesis has emerged, and it has been proven that the addition of bacteria with special properties can benefit corals to face these serious threats.

This project explores the native microbial communities of corals in variable environments and their potential to help corals become resistant to certain conditions. The first part of the research seeks to describe the coral *Madracis aurentenra*-associated microbial communities in the Inca Inca beach sector of Santa Marta, Colombia, and their spatial-temporal dynamics through the metabarcoding of the 16S rRNA gene. Parallel, we seek to find bacteria within the cultivable fraction of these communities that show probiotic qualities such as antioxidant activity, antimicrobial activity,

Colombia is a highly biodiverse country, and part of this biodiversity is concentrated in the coral reefs that are today threatened by the effects of climate change and by local problems like pollution and the variation of the physicochemical conditions of the water. As engineers of this ecosystem, corals are one of the main species affected, but there is a proposed strategy that offers hope for their protection, involving the native microbial communities of these organisms. It is well known that coral formations that inhabit environments with a high incidence of stressors, especially those located between urban settlements, can harbor resistant phenotypes, and it seems that the bacteria with which these



Sampling of *Madracis aurentenra* in Inca Inca beach, Santa Marta.  
 Photo: Carolina Herrera



*Sampling of *Madracis auretenra* in Bahía Chengue PNNT.  
Photo: Catalina Gómez*

and UV protection, among others. By doing so, the candidate bacteria are identified at the genus level and according to their potential, a consortium-base (various strains) or a single-base formula (one strain) is proposed. Finally, this formula is evaluated through an experimental mesocosm under controlled conditions and in aquaria containing coral fragments of *M. auretenra* and other species. The experiments include the dosage, the route of administration, and treatments that involve separately the gradual increase in temperature and the addition of a contaminant. From this, the response variables of the fragments are measured and the effect of the formula is determined.

To date, we have characterized the sampling sites during the first dry season, and we have collected mucus, tissue and seawater samples and we are working on the isolation of total bacterial DNA that will be used in the metabarcoding analysis. Further, around 139 bacterial isolates have been obtained, 132 have been characterized, and there are 32 preliminary candidates. We are measuring quantitatively the probiotic properties of each candidate and we are selecting the strains showing the best activities to design the probiotic formulation to be tested in the mesocosms.

These advances have been enriching and highly promising, and throughout the process, I have gained new knowledge and have had the opportunity to share it. In May 2022, I presented these preliminary results at the Congress of Marine Sciences in Concepción, Chile, with the support of the CEMarin. I have enjoyed both the field and laboratory work involved in my research. It has been arduous, constant, and fruitful, and I have faith that with this project a window can be opened to consolidate research focused on the microbiology of corals, leading to new strategies that can be used in coral restoration techniques in both the Magdalena region and across the country. In this way, I hope that the impact of this research will allow growth in the applied sciences in Colombia and that it can contribute a grain of sand to the possibility of future generations enjoying the coral reefs and the beautiful and magnificent life they offer us.



*Teamwork. Jordan Ruiz and Carolina Herrera obtaining mucus and tissue. Photo: Alejandro Yañez*



## CEMarin REPORTS

**CEMarin Early Stage Researcher:** Margarita Eugenia López-Alzate  
(Doctoral student in Marine Sciences, Universidad Nacional de Colombia)

**Directors & CEMarin Researchers:**

Andrés F. Osorio Arias PhD (Universidad Nacional de Colombia),

Thomas Wilke PhD (Justus Liebig University, Giessen),

Alejandro Orfila PhD (Spanish National Research Council)

### RESEARCH REPORT II

## Mesoscale Dynamics in the Caribbean Sea

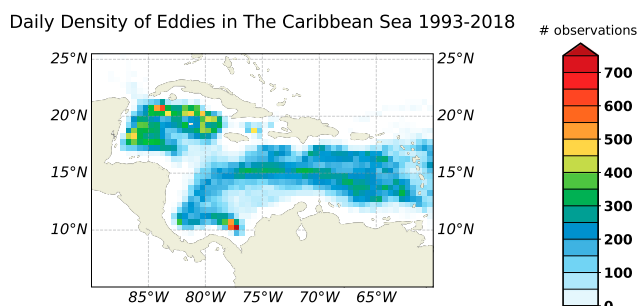
**W**hy does the ocean's water move – waves, currents, turns, eddies? And what is its relationship with biological processes and climate change?

The movement of water is a physical process that exists because there is an introduction, transfer, and dissipation of energy. The sun heats the Earth's surface in an uneven way. This heat is known as thermal energy and, along with the Earth's rotation, is responsible for driving circulation in both the atmosphere and the ocean. Here enters the transformation of this thermal energy into kinetic energy, or movement, where the quantity and distribution of this energy is mainly controlled by the balance between the atmosphere and oceanic dissipation. The rest of the energy input dissipates inside the ocean or at coasts and the bottom of the sea.

These physical processes in the ocean occur on a wide range of spatial and temporal scales. For example, if we talk about climate change we can describe processes in magnitudes of thousands of kilometers and centuries, all the way down to processes

associated with molecular dissipation that involve only centimeters and seconds. Between these two limits we can find many processes on other scales. There is the Global Scale, where we have basin-scale processes or the El Niño phenomenon, which spatially cover thousands of kilometers and can last for decades. All this energy is then transferred to the Mesoscale, which ranges from hundreds of kilometers and lasts for weeks or months; this type of process includes eddies or fronts. This transfer of energy in the ocean continues to the Sub-mesoscale level through internal waves or movements further into the ocean. In this case, the spatial dynamics are of hundreds of meters and the temporal dynamics are of hours and days. Finally, all this energy of ocean movement dissipates on the Microscale, in processes of centimeters and seconds, such as molecular diffusion. All of this is known as the direct energy cascade.

Our research is focused on the Mesoscale, in particular on mesoscale eddies, because they play a highly important role not only in the transfer of energy in the ocean but also in the transport of heat and in the redistribution of biological components such as phytoplankton (marine microalgae). These organisms sustain more than 95% of marine food webs and are responsible for half of the Earth's conversion of CO<sub>2</sub> into biomass through primary productivity (NPP). Therefore, the variability of various phytoplankton attributes –including biomass, abundance, and composition– would indicate changes in the productivity that can be used to study the effects of climate change.



Total number of eddy observations, in squared boxes of  $0.5^\circ \times 0.5^\circ$  side length.

888 eddies (47%) are cyclonic. 1006 eddies (53%) are anticyclonic.

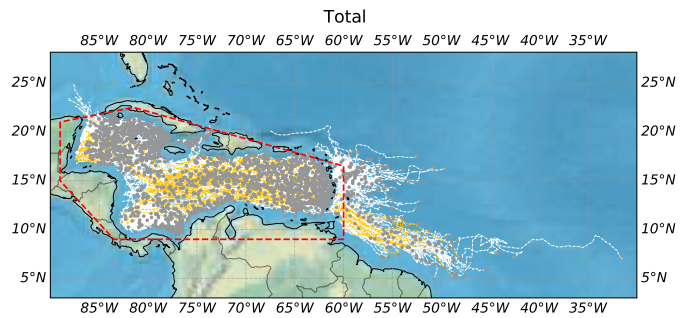
By eddy observations we refer to each available daily data of a given eddy track.

Data from AVISO Mesoscale Eddy Trajectory Atlas Product.

That said, we are working on the frontiers of physical oceanography, biology and the climate. Our hypothesis is that by understanding the variability of these physical processes, and energy dissipation routes and biological responses to these processes, we will obtain new knowledge regarding the variability and distribution of primary productivity in the Caribbean Sea, a semi-enclosed and highly oligotrophic sea which is also especially affected by global change, making it a laboratory for our study.

Due to the gap in data collection and data access in Colombia, we are using available remote sensing data that, together with concepts from Dynamic Systems Theory, will form the basis for this study. However, inter-institutional collaboration with the contribution of in situ data information will strengthen the results of our research.

Trajectory of Eddies in The Caribbean Sea



*By eddies we refer to the statistical average of all observations for each individual mesoscale vortex.*

*Total number of eddies between 1993 and 2016 : 1894*

*Gray dots indicate initial location (point of origin)*

*White lines: eddies westward trajectory*

*Yellow lines: eddies eastward trajectory*

*Red polygon: eddies formed inside the Caribbean Sea : 1684; eddies formed outside Caribbean Sea : 210*



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Expedición Científica  
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*Seaflower*



CEMarin has joined the Colombian  
National Expeditions Plan to strengthen  
its scientific component and to contribute  
to the achievement of its objectives!





## CEMarin REPORTS

CEMarin Alumnus: Ángela María Gómez García PhD  
German Research Centre for Geosciences (GFZ)

### ALUMNUS REPORT

# Analysis of geohazards associated with earthquakes and gas hydrates based on three-dimensional Solid Earth models

**G**eohazards are natural phenomena that include earthquakes, hurricanes, volcanic eruptions, and tsunamis, among others, and represent a risk to humans and their surrounding environment. In particular, earthquakes originate from the release of energy stored in highly dynamic regions of the Earth's surface, for example, in subduction zones or faults. In subductions, a portion of the solid Earth moves under another, and due to their great spatial extension, they affect oceanic and continental regions. Predicting the occurrence of earthquakes is still a challenge for society, as very little is known about the physical properties of the environment where they occur, including the type of rock present, the pressure, and temperature.

Tsunamis can be triggered by the destabilization of large volumes of mobile material on the seabed (submarine landslides), or by the rupture of the seabed due to the creation or activation of faults. Gas hydrates found at the bottom of the ocean are a key element in the stability of oceanic slopes, because they are found within the mobile sediments. Hydrates are solids, similar to ice, composed of gas molecules (methane, propane, butane, among others), surrounded by water molecules, and are stable at high pressures and low temperatures. These deposits can be found in all of the world's seas and oceans, and their stability is at risk from the increase in ocean temperatures because of global warming. If the hydrates become

destabilized, their gas molecules could be released into the atmosphere, with serious implications for climate change, since methane has a greenhouse effect 80 times greater than CO<sub>2</sub>. Therefore, knowing the extent and volume of hydrates in the world's seas and oceans is essential, when considering their potential contribution to global warming, due to the greenhouse gasses present in their structure.

The Caribbean region is exposed to various geohazards, including earthquakes and the destabilization of gas hydrates. In my doctoral thesis, I developed three-dimensional models of the first 200km of the solid Earth in this region, including the structure of the sediments, the crust, and the lithospheric mantle, integrating a large amount of available geophysical data. Various geophysical techniques were implemented in these models, including satellite gravimetry and thermal modeling. Among the most

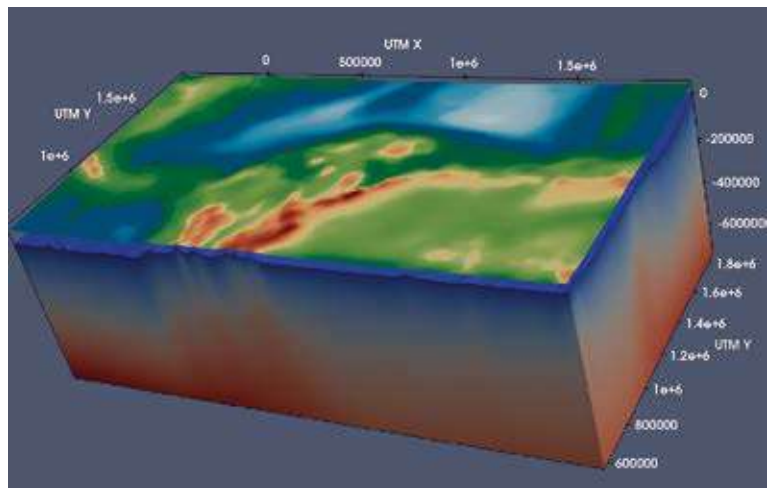
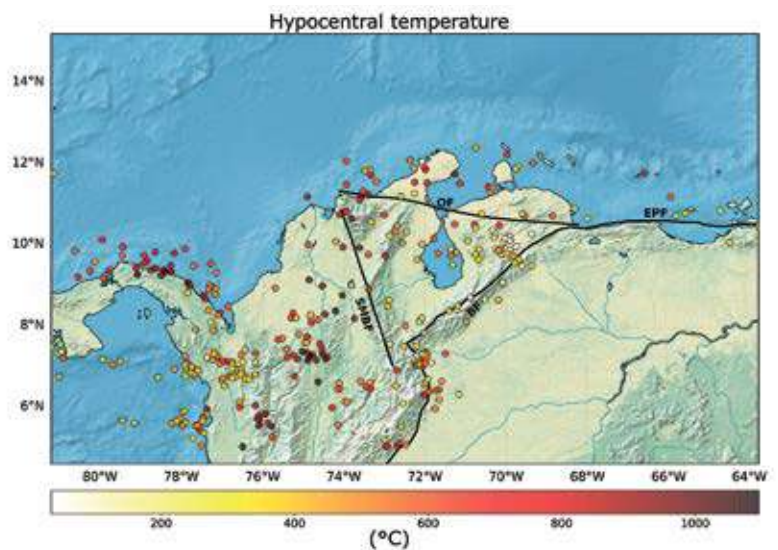


Figure 1. Three-dimensional thermal model allows the study of geohazards in the Caribbean and northern South America.



Figure 2. Potential temperatures at which earthquakes occur in the southern margin of the Caribbean.



Zonas potenciales para estabilidad de hidratos - Fuente termogénica



Figure 3. The seafloor of the Caribbean Sea has extensive potential to store gas hydrates (white polygons). The red and green polygons demarcate regions with direct observations of these deposits. The models help to predict the presence of hydrates in areas where direct measurements are scarce.

important results are the density distribution of the rocks that make up this region, which provide insights about their composition, as well as their potential range of pressures and temperatures (Figure 1). With these models, it is possible to estimate the main physical conditions under which earthquakes occur in the southern Caribbean and northern South America (Figure 2), as well as the potential zones for gas hydrate stability (Figure 3). I am currently developing dynamic models to predict the stability of hydrates in the Caribbean until the year 2100, considering different sea temperature scenarios included in the IPCC Sixth Assessment Report.

Dr Ángela María Gómez García developed her doctoral thesis at the Universidad Nacional de Colombia in cooperation with the Free University of Berlin and the German Research Centre for Geosciences (GFZ). For her doctoral research, she received scholarships from institutions such as CEMarin, DAAD, Erasmus+, Colciencias, and the Foundation for the Promotion of Research and Technology of the Central Bank of Colombia. Her results have received two international awards: the “Outstanding Student Poster and PICO (OSPP) Award” from the European Geosciences Union in 2019, and a special mention for the best thesis in geophysics undertaken at a university in Ibero-America, awarded by the Spanish foundation J. García-Siñeriz in 2021.

## Ecosystem services: How do we understand the value of nature?

The issue of ecosystem services (ES) is crucial in terms of well-being, economics, and governance. The term was coined in the 1990s but began to gain strength and recognition in public policy in 2005, with the publication of the United Nations' Millennium Ecosystem Assessment. This global analysis of human impact on ecosystems aimed to understand and quantify the benefits humanity receives from these ecosystems. In the case of marine-coastal ecosystems, like mangroves, seagrasses, coral reefs, and sandy and rocky shorelines, some examples of ES include the mitigation of coastal erosion, and the capture and retention of organic carbon, or Blue Carbon. Of course, these ecosystems are increasingly threatened by human activities.

In this context, CEMarin Executive Director Dr Andrés Osorio invited three experts from different areas of the marine sciences in Colombia to the first episode of season three of our Podcast for the Oceans, to discuss ES and the strategies necessary for their management. We thank CEMarin Researchers Dr Ernesto Mancera (Universidad Nacional de Colombia) and Dr Juan Armando Sánchez (Universidad de los Andes), and Dr Paula Zapata (Universidad Pontificia Bolivariana), a CEMarin Associate Researcher, for accepting the invitation and sharing their ideas. Here, we share some of the main ideas of the discussion.

All three guests agree that ES are a way of relating to the ecosystems that surround us, a social construct made by human beings. We must consider that the concept of ES does not have a fun-

damentally utilitarian purpose, but rather that ES contribute to understanding the value of the services we receive from nature in terms of well-being and human health, and the regulation of the global climate, among other benefits. Dr Mancera states that although he did not initially like the concept of ES, over time he has become convinced of its merit when talking with decision-makers and other actors who work with ecosystems. Along similar lines, Dr Sánchez comments that ES appear 33 times in the chapter on oceans and hydrobiological resources of the Misión de los Sabios (Mission of the Wise)

-a fundamental report on the future of science, technology, and innovation in Colombia- which reaffirms the importance of the concept in the public sphere.

**“ES contribute to understanding the value of the services we receive from nature in terms of well-being and human health, and the regulation of the global climate, among other benefits.”**

As an example of the importance of marine-coastal ES, Dr Zapata emphasizes the case of coral reefs in the Seaflower Biosphere Reserve, the world's third largest barrier reef in the world. Dr Zapata has worked to determine the role of this ecosystem in mitigating

and preventing risks in the face of extreme events like hurricanes, a role that represents a quantifiable value, but one that goes beyond purely monetary terms. The aim is to provide inputs to the comprehensive management of the territory and ensure the sustainability of the barrier so it can continue to provide ES in a future in which there will be more frequent and increasingly stronger extreme events due to climate change.

Regarding the strategies we need in the short term to reverse the negative impacts that are evermore visible in our ecosystems, the three experts agree

that knowledge is key to taking informed decisions: there will always be anthropic interventions, the question is how to manage ecosystems intelligently. In this area, Dr Zapata adds the theme of knowledge dialogues, as the ecological knowledge of all actors is important in the construction of a holistic knowledge that truly serves as an effective input for informed decision-making. Without listening to the communities that depend directly on marine-coastal ecosystems for their livelihood, we increase risks related to food security, as well as to the genetic materials necessary for pharmaceutical products, among many others.

Related to this need for knowledge, Dr Zapata speaks of a study from the United Kingdom which concluded, after many years of fossil fuel exploitation in the North Sea, that the protection of these sedimentary seafloors would have had a greater value in terms of carbon sequestration compared to the economic profits from extractive activities. Colombia also requires comprehensive analyses that consider the short- and long-term impacts of this type of activity, given that more and more areas are being designated for deep-sea mining exploration.

Dr Sanchez deepened the case of carbon bond markets, in which Blue Carbon has been taking a leading role due to the enormous potential of marine-coastal ecosystems in this area. He explained that one ton of sequestered carbon per year can have an economic value of between \$20,000 and \$4,000,000 USD, if it protects, recovers, or generates a form of carbon capture, we must focus on

quantifying how many carbon bonds we are capturing and how we can promote this strategy. Once again, this demonstrates the importance of science in providing knowledge on where and how carbon can be sequestered, in order to achieve the transformation that both human beings, and the ecosystems on which we depend, greatly need.

We thank the three guests for sharing their expertise, and we invite everyone to listen to the full conversation in the latest episode of our Podcast for the Oceans (in Spanish only).



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**Dr Martin  
Visbeck**

Head of the Physical  
Oceanography Research Unit  
GEOMAR Helmholtz Center for  
Ocean Research, Kiel



**Dr Fernanda  
Adame Vivanco**

Senior Research Fellow  
Australian Rivers Institute,  
Griffith University



**Dr Arnaldo  
Valle-Levinson**

Professor and Graduate Coordinator  
of Coastal Engineering,  
Herbert Wertheim College  
of Engineering,  
University of Florida



**Dr Oscar  
Puebla**

Joint professorship on Fisheries Ecology  
Institute for Chemistry and Biology of  
the Marine Environment, Universität  
Oldenburg and the Leibniz Center for  
Tropical Marine Research  
Affiliated to the Smithsonian Tropical  
Research Institute in Panama



**Dr Joseph  
Pawlik**

Frank Hawkins Kenan Professor  
of Marine Biology,  
University of North Carolina  
Wilmington



**Dr Richard  
Meissner**

Associate Professor, Department  
of Political Sciences  
University of South Africa

