International Conference on Marine Science

ICMS 2023

CARTAGENA COLOMBIA

WORKING TODAY FOR THE OCEAN OF TOMORROW

21st – 23rd February 2023

Book of Abstracts

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International
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The International Conference on Marine Science 2023:
Working today for the ocean of tomorrow is an event organized by the Corporation Center of Excellence in Marine Sciences - CEMarin.

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Foreword

The International Conference on Marine Science 2023: Working today for the ocean of tomorrow, was the third in this series of international conferences organized by the Corporation Center of Excellence in Marine Sciences, CEMarin. Following the successful virtual ICMS in 2020, the opportunity to meet again in person with colleagues from around the world was truly enriching, both professionally and personally. The ICMS 2023 was the first to take place during the United Nations' Decade of Ocean Science for Sustainable Development (2021-2030), and took the Sustainable Development Goals as its central theme.

The ICMS 2023 brought together over 90 in-person participants with many more connected virtually. We were delighted to welcome renowned experts and early stage researchers from institutions in Algeria, Aruba, Australia, Austria, Belgium, Cameroon, Chile, Colombia, Germany, Russia, Saudi Arabia, South Africa, Spain, the United Kingdom and Venezuela. A key aim of the ICMS 2023 was to connect academics with other stakeholders working for the sustainability and protection of the oceans and marine-coastal communities, and in this sense we also brought together policymakers from different public institutions, and representatives of non-governmental organizations, established private enterprises, and startups for productive discussions aimed at fostering real solutions and actions.

We would like to thank all the participants in the ICMS 2023, both those who were able to attend in person and those who joined virtually, all of the team from the CEMarin and our partner institutions who helped in the preparations for the event, as well as the sponsors and partners who gave us different types of financial and logistical support: Nortek, WWF Colombia, the Universidad de Cartagena, and Milla Náutica magazine. We must give a special thanks to the Universidad de los Andes who provided us with their marvelous facilities in Cartagena.

While the scale of the many problems facing the world's oceans is daunting, we strongly believe that the ICMS 2023 will help to facilitate multidisciplinary projects and strategies to face these problems and to contribute to the achievement of the Sustainable Development Goals.

With pride, we can truly say that we are working today for the ocean of tomorrow, and we invite you to join us.

Sincerely,

Dr. Jenny Leal Flórez, ICMS 2023 Conference Leader and Professor at the Universidad de Antioquia
Dr. Andrés Fernando Osorio, CEMarin Executive Director and Professor at the Universidad Nacional de Colombia
Louise Lowe, CEMarin Communications and Project Support Professional

Aims and objectives

The ICMS 2023 aimed to bring together academics, practitioners, and stakeholders from all disciplines of the marine sciences to exchange and share their experiences, ideas, and research results on present and future aspects of the world's oceans and coastal regions.

In this edition, the conference focused on the achievement of the Sustainable Development Goals (SDGs) of the United Nations, highlighting the importance of marine-coastal ecosystems and the needs of the communities that depend on them. Thus, in line with the CEMarin Strategic Research Plan, the main topics addressed were distributed in the following sessions:

Session 1 - Environmental change in the ocean: Monitoring and mitigation

The environmental crisis in general, and climate change in particular, affect all global ecosystems, but marine and coastal systems are especially vulnerable because of intensive human activities in and around these areas. According to the Assessment Report 6 of the Intergovernmental Panel on Climate Change, the impacts of climate change on ocean and coastal ecosystems, and their services, threaten the achievement of the UN SDGs by 2030.

The ocean can contribute substantially to the attainment of mitigation targets, aimed at limiting global warming. But in order to assess this potential, we need to know how marine ecosystems have changed over time, to establish the relationships between human activities and their impacts, to understand past environmental changes in order to predict future outcomes, and to assess ocean-atmosphere-land interactions, all supported by adequate technology, data and infrastructure.

In this session, we had contributions on understanding and monitoring environmental changes and their effects in key ecosystems, paleoenvironmental reconstructions, processes governing changes in population and range dynamics of key coastal and marine species, marine and coastal geomorphological and biogeochemical processes, modeling of ocean-atmosphere-land interactions, and climate change and natural hazard adaptation strategies.

Session 2 - Promoting the sustainable use and protection of marine resources

When addressing the rational or fair use of marine resources in a sustainable manner, it is crucial to recognize the importance of biological knowledge of diversity and the environment, and the actions being taken by the scientific community to contribute to effective management tools. For instance, Nature-based Solutions (NbS), when implemented and managed effectively, contribute to the achievement of the SDGs by preserving biodiversity, thereby benefiting marine-coastal ecosystem services and increasing the sustainability of marine fisheries and aquaculture.

This session covered issues related to sustainable fisheries and aquaculture, marine bioprospecting, marine energy production, circular economy around the oceans, and blue carbon.

Session 3 - Understanding the interactions between ocean and society

The oceans cover 70% of the planet's surface, providing food, regulating climate, and generating a good part of the oxygen we breathe. However, increased coastal development and use of marine resources are impacting negatively on marine life and the communities that depend on it. A deeper understanding of the interactions between the oceans and society allow us to develop new forms of prevention and action. Thus, increased awareness, effective public policies, and education strategies generated by and for marine-coastal communities are key for a healthy coexistence between society and the oceans.

This session focused on socioeconomic processes affecting the marine resource management, impacts on coastal communities, participatory and multi-stakeholder approaches, agreements, policies, standards and incentives related to the management and assessment of marine resources and ecosystem services, risk assessment of natural and anthropogenic threats, food security and sovereignty of marine-coastal communities, preservation of the traditional and cultural practices of local communities, social appropriation of knowledge, and dialogues between traditional knowledge and interdisciplinary knowledge.

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Keynote Speakers & Special Guests

In alphabetical order by speaker surname

Myths, Expectations, and Realities of Blue Carbon

Dr. María Fernanda Adame Vivanco, Griffith University

As we start to experience the effects of climate change, we urgently need to keep the climate under the 2˚C threshold. Blue Carbon (BC), or the management of mangroves, saltmarsh, and seagrass, has emerged as an attractive way of reducing carbon emissions. Through the management of coastal wetlands, carbon credits can be awarded and traded to offset emissions elsewhere or counted toward national carbon emission reduction targets. BC is attractive because it can reduce carbon emissions while providing multiple environmental and socioeconomic co-benefits. Additionally, BC aligns well with multiple international programs, such as the Sustainable Development Goals, Aichi Targets, and the Ramsar Convention. BC projects, like any mitigation strategy, have limitations that need to be acknowledged to avoid misleading or false promises. False statements such that BC can "slow climate change" can create unrealistic expectations and raise concerns over BC being used for greenwashing with unsupported claims of carbon neutrality, for example, by planting a few hectares of mangrove trees. In this talk, I will clarify what BC is, what is a BC project, and what it can and cannot achieve as a tool for climate change mitigation. I will also show with some examples from Australia and Mexico how even though BC will not slow climate change, and by no means will offset our global fossil fuel consumption, it can still reduce emissions while providing environmental, economic, and social opportunities for vulnerable coastal communities.

The United Nations' Water and Ocean Governance Focus Area: Towards a Multi-Disciplinary Research Agenda

Dr. Richard Meissner, University of South Africa

The resilience of the planet's oceans depends on human activities and practices such as ocean governance. Governance requires a wide range of people involved in ocean management and is the result of interactive forms of socio-economic and political governance arrangements that create opportunities and solve problems. That said, the governing of the oceans is directly linked to the social sciences. Governance is impossible without the knowledge on how and why people interact with the oceans. The social sciences investigate economic, political, and socio-cultural factors that determine the use of oceans as natural resources. Because of this, social perspectives and practices influence ocean governance and management. To study the impact of human activities, it is, therefore, necessary to not only understand the oceans from natural science perspectives. The social sciences can, and should, also play a central role in understanding how to develop and implement policies to regulate the use of ocean resources. For this to be achieved, it is necessary to understand human behavior and how this affects the oceans and, ultimately, humans' interaction with oceans through an eclectic social science lens.

The chemical ecology of sponges on Caribbean reefs: Natural products shape natural systems

Dr. Joseph Pawlik, University of North Carolina Wilmington

Sponges are now the dominant habitat-forming animals on most Caribbean reefs, where the combined effects of climate change, pollution, and disease have decimated reef-building corals. Natural products chemists have been isolating novel secondary metabolites from Caribbean sponges for many decades, but relevant studies of the ecological functions of these compounds have been more recent. Bioassay-guided surveys have revealed sponge chemical defenses against predators, competitors, and pathogens, but many common sponge species lack chemical defenses and appear to have followed a different evolutionary trajectory, investing instead in greater reproduction or growth. Additionally, some sponge species have the ability to absorb dissolved metabolites directly from seawater, including cyanobacterial organohalides. Differences in the abundances of fish- and sponge-eating fishes on Caribbean reefs have a cascading impact on the sponge community, with indirect effects on the benthic community of corals and seaweeds.

Biodiversity science at the core of monitoring, management, sustainable use and protection of marine tropical resources

Dr. Oscar Puebla, University of Oldenburg and Leibniz Centre for Tropical Marine Research

The monitoring, management, sustainable use and protection of marine tropical resources rely heavily on biodiversity science, as do strategies for mitigation and adaptation. In terms of monitoring, we must not forget the value of low-tech approaches, and when dealing with new approaches, it is necessary to evaluate their accessibility. Despite vast amounts of research, when considering monitoring it is clear that we still know very little about marine biodiversity. Using examples from our research at the Leibniz Centre for Tropical Marine Research, this talk focuses on both traditional methods such as taxonomy and visual surveys, and new methods such as environmental DNA and genomics.

The sea surface microlayer, where the ocean meets the sky

Dr. Mariana Ribas Ribas, University of Oldenburg

The sea-surface microlayer (SML) forms the boundary layer between the atmosphere and the ocean, and is a ubiquitous feature of the ocean surface (Wurl et al., 2011). The SML, which usually has a thickness of < 1 mm, is characterized by its strong exposure to UV radiation in contrast to other ocean compartments. Due to its recurrent biofilm-like features (Wurl et al., 2016) and unique position at the atmosphere–ocean interface, the SML is central to a range of global biogeochemical and climate-related processes (Wurl et al., 2017; Engel et al., 2017), including marine

carbon cycling (Reinthaler et al., 2008), air–sea gas exchange (Mustaffa et al., 2020), physical surface processes (Gade et al., 2013), and aerosol production (Wilson et al., 2015; van Pinxteren et al., 2017). Despite the fact that processes occurring in and across the SML have received increased attention in recent years, our knowledge about such processes remains rudimentary.

Can predictability of ENSO and sea-level variability help in adaptation strategies to coastal hazards?

Dr. Arnoldo Valle-Levinson, University of Florida

The prediction of El Niño-Southern Oscillation (ENSO) is one of the greatest scientific and societal challenges because of its impacts on lives, food, water, health, and economy. Traditionally, ENSO has been considered a phenomenon that is mostly influenced by the interactions between oceanic and atmospheric processes. In other words, it has been attributed to the internal variability in Earth's ocean-atmosphere system. However, records of climate indices and some variability in ENSO have been linked to solar activity (sunspots). Sunspots have been shown to influence air temperatures, atmospheric pressure, cloudiness, and other atmospheric variables. Furthermore, dendrochronological reconstructions of ENSO and of other climate indices have identified statistically significant variance at periodicities that can be attributed to sunspots and also to lunar orbits (precessions). Those findings suggest that astronomic forces may influence ENSO. In fact, a fit to well-established periodicities from lunar precessions, solar activity and their interactions explain 66% and 86% of the variance of an ENSO index smoothed at 3 and 5 years, respectively. Satisfactory results are also obtained for the representation of interannual sea-level variability. With such results, one can venture a projection into the future of smoothed ENSO and sea-level variability. Such projection might help in preparations for adaptation and mitigation measures caused by ENSO-related coastal hazards and sea-level rise.

Digital Twins of the Ocean - Opportunities to Future Proof Sustainable Development

Dr. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research, Kiel University

Digital twins are fine-grained digital replicas of physical objects and systems which have been widely applied in the engineering realm for tasks such as engine optimization and port management. Recently, digital twins have also caught the attention of marine scientists as a solution to socio-environmental problems. By bundling and providing access to observational data, models, and simulations, digital twins allow users to explore current and future 'what-if' scenarios, especially related to human interactions with the ocean. High-value application areas include fisheries and mariculture, marine protected areas, ocean-based tourism, ecological forecasting, nature-based solutions, marine infrastructure development, and the

interactions between all of these with an ever-growing collection of data streams. In the context of the UN Decade of Ocean Science for Sustainable Development, we launched the international program “DITTO - The Digital Twins of the Ocean“ (ditto-oceandecade.org) in May 2022. DITTO’s mission is to develop and share a common understanding of Digital Twins of the Ocean, to establish best practice examples and to advance a digital framework to empower ocean professionals to effectively create their own application-focused digital twin. This powerful framework will enable users to visualize and explore ocean knowledge and empower ocean professionals and models, forecasts, citizen scientists, policymakers, and the general public alike.

A successful regional implementation of a Digital Twin depends on four aspects: A) a capable ocean observing system with covers ideally a wide range of dimension and subjects from dynamics, biogeochemistry, ecology, ocean-land interactions, coastal communities and the socio-economic dimension. B) An innovative ocean modeling and prediction capability with new opportunities provided by AI and ML methods with the possibility to ingest data and changes in boundary conditions representing interventions. C) An interoperable, shared and easily accessible data environment could be cloud based, networked cover all elements observations and model results which is sometimes called a ‘data lake’. D) An interactive user interface to visualize, process twin results but also ‘ask’ the ‘what if’ questions.

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Regular Talks Session 1

Environmental change in the ocean: Monitoring and mitigation

Abstracts in alphabetical order by speaker surname

Health status of two reefs of Islas de San Bernardo, Colombian Caribbean

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Coral reefs are highly diverse ecosystems, as well as of great ecological and economic importance; however, they have suffered extensive degradation in recent decades as a result of anthropogenic activity that has resulted in reduced coral cover, presence of diseases and signs of degradation. In this study we aimed to update the knowledge of the coral reef health at San Bernardo Islands, in Colombia, and to evaluate if there is any difference in the health status and present diseases. For a period of eight months, we monitored the benthic cover and health of two reefs located in the San Bernardo Islands, one of them within the protected area Parque Nacional Natural Corales del Rosario y San Bernardo (PNNCRySB), and another outside the protected area. The benthic cover between both zones was different, having a significant difference in live coral cover (P=0.001). Reef deterioration was recorded, evidenced by a decrease in coral cover, an increase in dead coral and algal cover over time. Although the diseases were the same found inside and outside the protected area, there was an increase in the number of coral colonies with disease between February and October. Seven diseases were observed: dark spots, yellow band, white plague, white syndrome, black band, red band, and ciliate infection. For areas outside the PNNCRySB, this work represents the first report on diseases in corals. Following the pattern that has already been observed in recent decades, the dominant species registered in this work, included those of the genus *Orbicella*, as well as species considered pioneers of high calcification such as those of the genera *Porites* and *Agaricia*. The islands of San Bernardo have the largest coral area in the Colombian continental Caribbean, however, studies on the deterioration of these ecosystems and their general health are few, especially in the area outside the PNNCRySB, so this new information could be useful for the development of conservation strategies.

Linking remotely-sensed data and tea bag decomposition experiments to understand mangrove response to persistent droughts (Sucre State, Colombian Caribbean)

Juan F. Blanco-Libreros, Juan J. Ruíz-Roldán, Ana M. Valencia-Palacios, Juan C. Mejía-Rentería, Sara R. López-Rodríguez
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Hydrological droughts in mangroves are induced by anthropogenic and natural drivers, mostly in arid lands worldwide. Upland and local constructions reduce water inflow to mangrove areas promoting cascading ecosystem-wide effects. Water stress on mangrove trees translates in reduced leaf production, canopy

shrinking, and individual mortality. Canopy opening increases ground temperature thus causing rapid drying and compaction of surface sediments, thus altering decomposition rates of organic matter. The reduction in mangrove tree cover and overall "greenness" can be quantified using satellite- and drone-borne sensors and spectral indices, but field surveys and experiments are required to understand fine-grain ecosystem responses to droughts. A study in progress is measuring mangrove responses to land-use-change-driven persistent droughts in the central part of Sucre State (Colombia). The objective of the first phase was to identify hotspots of mangrove drying, according to a remotely-sensed loss of "greenness". Landsat and Sentinel 2 imagery time series (long- and short-term retrospections, respectively) were used to detect persistently-dry mangrove areas, according to both Normalized Difference Vegetation Index (NDVI) and Mangrove Vegetation Index (MVI), and to identify linkages to anthropogenic modification of surface hydrology. A hotspot of anthropogenic-driven drought was found in Rincón del Mar. Here, cumulative disturbances (infilling of a former mangrove lagoon, closure of the connection with sea, diversion of temporary streams, and construction of a dirt road) were responsible for gradual mangrove die-off during the past 30 years. Long-term trends (1989-2021) showed many areas of low to mid MVI, confirming the sensitivity of mangroves to water stress in the region. However, mid and high green mangrove extent has declined during the past 10 years within a core area of 17 ha. Cumulative disturbance within this area has promoted an extended and persistent drying area of 3.2 ha to the South (2017-2021 negative NDVI trends, not observed in reference areas). Field work (January, July and August 2021; March 2022) confirmed that tree mortality and stress are confined, and they are seemingly better-explained by the above-mentioned human factors rather than by regional atmospheric droughts (e.g. El Niño). A second phase is aimed at understanding soil responses to droughts by quantifying mass loss rates of a standard plant litter. In October 2022, a small-scale (100 m2), 30-day field experiment of litter breakdown using green tea bags was set to test effects of three levels of drying conditions induced by anthropogenic modifications. In November 2022, a large-scale (30 ha), 1-year experiment will be set-out to compare decomposition trajectories and stabilizing mass between areas of persistent drought and reference conditions. We advocate for combining remote sensing and field measurements and experiments to understand spatial patterns of droughts in mangroves and their consequences on a key ecosystem process such as plant litter decomposition.

Remote sensing as support for the study of coastal erosion mitigation provided by mangrove forests in the Pacific and continental and insular Caribbean of Colombia

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In order to determine the dynamics of the coastline based on the physical characteristics of the mangrove forests, the coastal geomorphology, the meteomarine conditions and the forest structure complexity, we used remote sensing techniques and a field study in Tumaco, Buenaventura , Bahía Málaga, Ciénaga Grande de Santa Marta and Isla San Andrés. We perform a multi-temporal analysis of the position of the coastline by photo-interpretation of aerial images from different years. In the field, we measure the volumetric density of the mangrove roots, we monitor physical variables of waves and tides detected by pressure sensors installed inside, on the edge and outside the mangrove, and we take samples of soil and suspended sediments. We found a high variability of the coastline that occurs on open coasts exposed to waves, driven by the action of the sea and the discharge of sediments from the rivers that flow into it. This variability affects the mangroves located in the coastal front, disappearing fringes, which in turn promotes the loss of sediments due to wave action. We find that there is a bidirectional relationship, as mangroves are not only a passive component of coastal sedimentation, but also depend on it for survival. The coasts protected by bays, lagoons and ecosystems such as coral reefs present stability of the coastline and the front of mangroves. Non-intervened forests have a higher root density, 1.91% (SD±0.58), against 1.24% (SD±0.52), with an inverse relationship between volumetric density and height and period of growth. waves, and a direct relationship with its frequency. In non-preserved mangroves, the wave period is 7% higher, with a 19% lower frequency. The combination of remote sensing techniques with field sampling and analysis of secondary information makes it possible to identify on a large scale, both spatially and temporally, coastal dynamics (accretion, erosion or stability) and its physical and biological forcing as well as the resulting effect of same. The hydrodynamics depends on a series of factors that include the biological characteristics of the mangrove, the physiographic characteristics of the terrain, and the behavior of the currents and waves and the discharge of the river. The importance of root density in non-degraded forests and their influence on wave energy transfer are highlighted, demonstrating their ability to mitigate coastal erosion.

Warming trend in Antarctic Bottom Water in the South Atlantic

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Abyssal basins of the Atlantic Ocean are filled with cold and dense Antarctic Bottom Water (AABW). Propagation of this water plays an important role in the heat transport of the ocean and influences the Earth's climate. AABW is formed mainly in the Weddell Sea near the Antarctic slope as a result of cooling and ice formation. When AABW reaches the ocean floor, it propagates to the north, flowing from one basin to another. The strongest flow of bottom water is observed in the Vema Channel in the Southwest Atlantic. This channel connects the Argentine and Brazil basins and provides propagation of the coldest part of AABW.

Measurements of thermohaline properties in the Vema Channel since 1972 show decadal warming of AABW. The goal of this work is to report our latest oceanographic measurements carried out onboard research vessels "Akademik Sergey Vavilov", "Akademik Ioffe", and "Akademik Mstislav Keldysh" of the Institute of Oceanology (RAS). The linear trend computed for the entire length of this time series is approximately 0.002°C/year based on the CTD data. Spatial structure of the current was studied based on the regional version of the ocean circulation model. These simulations reveal new pathways of AABW spreading in the Southwest Atlantic and emphasize the importance of direct measurements for studies of abyssal circulation in the Atlantic Ocean.

This research was supported by the Russian Science Foundation (project 22-77-10004).

Identification of a core microbiota in coastal sites perturbed by human action

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The sustained exploitation of natural resources and the intensive use of ecosystem services have produced significant impacts on marine environments leading to a new scenario of chronically perturbed oceans, mainly influencing trophic processes (such as primary production) and biogeochemical cycles. In this current landscape, coastal zones -representing the interstice between continental and oceanic territories- are one of the most affected areas due to the combined action of industrial and domestic activities resulting in shifts in nutrient concentration and bioavailability. These imbalances primarily affect photosynthetic picoeukaryotes (PPE), a fraction of the most abundant microorganisms present in coastal areas, and are recognized as key components in several biogeochemical cycles and primary production as

well. One of the most studied micronutrients related to imbalances produced by anthropogenic activities is Copper due to its presence in antifouling paint and mining industries. Copper is used by cells in different biological processes at a relatively low concentration. At higher concentrations, copper exerts cytotoxic effects. In both cases, these are reflected in the composition of community structure. Nonetheless the underlying mechanisms governing these changes are still unclear. Shifts in community structure can be examined/studied through the analysis of 18S rRNA gene sequences allowing the characterization and quantification of the changes. In this work, we aim to identify a core of PPE from chronically perturbed sites with high levels of metallic micronutrients like Copper. We propose that identifying this core not only will help us to understand the mechanisms governing the shape of community structure. Finally, we will verify if this core of taxa can be used as bioindicators for pollution levels of these nutrients by checking their presence or absence from globally available datasets like Ocean Sampling Day (OSD) and TARA oceans. Samples were collected from chronically disturbed Chilean coastal sites with pollutant concentrations of metallic micronutrients. Amplicon sequence variants (ASV) were characterized and quantified using 18S rRNA gene sequences. 108 ASVs were identified as shared sequences across all sites. The abundance difference of these shared sequences at each site was ascertained to be due to metal concentrations. In addition, network analyses were performed to identify the association of these ASVs. Finally, a search for the presence/absence of these 108 sequences in OSD and TARA datasets was carried out to demonstrate the ubiquity of this taxa and emphasize their importance as biomarkers when facing steady-state concentration increase of metallic micronutrients due to anthropogenic activities.

Looking for the present in the past: Paleo-environmental analyses and social-ecological memory to explore changes in the Ciénaga Grande de Santa Marta, Colombia

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Compound anthropogenic pressures are driving critical mangrove degradation worldwide, threatening the wellbeing of coastal human populations historically associated with these systems. The Ramsar and Biosphere Reserve, Ciénaga Grande de Santa Marta (CGSM) is located in the northern part of Colombia and is the largest coastal lagoon-delta in the Caribbean. It is inhabited by stilt communities who have developed intricate livelihood and cultural relationships with the mangroves. The CGSM has experienced sustained social and ecological

degradation during the last six decades, triggered by land-use change and disruption of hydrological connections. This study integrates Social-ecological Memory from fishing communities and Paleoenvironmental frameworks to develop a historical perspective of the biophysical and social dimensions of environmental change in the CGSM. Integrating X-ray fluorescence (XRF) geochemical sediment analysis, C14 radiocarbon dating, and demographic inferences from archaeological evidence revealed three distinct periods over the last ~5000 years where sea level rise and hydroclimatic variability shaped the transition between freshwater to prevailing marine conditions, and modulated human occupation patterns in the area. Specifically, the period with the highest hydroclimatic variability and precipitation minima (4000 – 2500 yr BP) is consistent with lowest human population estimates, whereas sea-level increase (~ 2000 yr BP) corresponds with sustained increase in estimated population growth. In connection, participatory oral reconstructions conducted in the stilt-house communities of Buenavista and Nueva Venecia, offered nuanced descriptions about the spatial, temporal and contextual aspects generating and reinforcing hypersalinization of the system, and their profound social-ecological consequences over the past several decades. The interdisciplinary approach of this study indicates that the CGSM is a highly dynamic socioecological system that has been changing and reconfiguring across different time scales in response to both natural and human-induced processes. Finally, it reveals the relative effects of biophysical and social drivers on driving social-ecological change on millennial to decadal time scales.

Hurricanes Eta and Iota in San Andrés, Providencia and Santa Catalina Islands: Focus on urban and coastal flooding

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Hurricanes Eta and Iota were the most intense events during the Atlantic hurricane season 2020 and their passage led to serious building affectations and 3 fatalities in the archipelago of San Andrés, Providence, and Santa Catalina (SPSC) due to the extreme winds, storm surge flooding and rainfall flooding. Numerical modeling and field measurements were used to reconstruct the effects of these events on SPSC. The numerical modeling was conducted by implementing the WAVEWATCHIII, SWAN, XBeach, Storm Water Management Model (SWMM), and a parametric model for hurricane winds. A differentiated contribution of each hazard on physical infrastructure, coastal ecosystems, and population is represented through winds up to 50 m/s, significant wave heights (Hs) ranging between 1 m and 6 m associated with flood levels in the order of 2 m on the coast, and flood distances varying between 12 m and 904 m. A spatial distribution of Hs and the contribution of wave run-up and storm surge in some areas of SPSC showed the importance of mangrove and coral reef ecosystems to mitigate the intensity of Eta and Iota on the coast.

Finally, the physical and social vulnerability was assessed for SPSC, considering the most probable or most frequent hurricane categories. This study encourages science-based decision-making and provides useful information to policymakers to consolidate risk assessments in vulnerable zones like SPSC.

Marine ecosystems' restoration maps for prioritizing actions after hurricanes at San Andrés, Providence and Santa Catalina Islands, Seaflower Biosphere Reserve, Colombia.

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The Seaflower Biosphere Reserve's marine ecosystems, such as mangroves, seagrasses and coral reefs, are vital for the well-being of the people who inhabit the islands of the Archipelago of San Andrés, Providence and Santa Catalina, Colombia. The safety of human life, food security, coastal protection and other Ecosystem Services (ES) key for economy on the islands depends on those ecosystems. Nevertheless, those are exposed to many pressures including hurricanes, which according to the AR6 IPCC report are increasing in frequency and strength due to climate change, putting at risk the biodiversity and the ES they provide. The need to have tools for better preparation, response and restoration actions after a cyclonic event to protect and recover shallow marine ecosystems (mangroves, seagrasses and coral reefs), generated an interdisciplinary and interinstitutional collaboration lead by the local government environmental agency CORALINA, to construct marine ecosystem restoration protocols. Whether it is a tropical storm or a hurricane category 1 to 5, it is of great importance to be able to act promptly and effectively in terms of time and financial and personnel resources, since corals, seagrasses and mangroves are living beings and primary attention will be helpful for their recovery. In order to prioritize actions on an extensive marine territory, it is important to be able to focus on certain pre-established areas for damage assessment and restoration response. As an alternative for a quick and more efficient response we have developed maps as tools to geographically identify those possible areas more susceptible to being impacted by hurricanes in San Andrés, Providencia and Santa Catalina islands. These maps were constructed by a joint interdisciplinary work including oceanographic analyses for wave modeling, marine biology, and community knowledge about ecosystems, and Geographic Information Systems (GIS) techniques. Maps included a layer with wave modeling results for both islands (using SWAM model) with wave height and direction, under two hurricane conditions, category 1 (winds of 110 km/h) and category 5 (winds of 250

km/h), from eight (8) main directions (N, NW, W, SW, S, SE, E and NE), for a total of 32 scenarios. Relative depth to wave height was included to consider exposure to hurricane's wave impact. Marine ecosystems' type and locations were also included for map construction as the exposed elements. Maps could be complemented with areas prioritized by the communities of San Andrés and Providencia to include those ecosystem areas they consider to be a priority given their importance for their well-being, due to the ES provided. These maps become a helpful tool for management and more effective response facing hurricanes in the Western Caribbean, especially after the Category 5 Hurricane Iota (November 2020), and the recent Category 1 Hurricane Julia (October 2022) when the maps were used for the first time, showing accuracy according to preliminary damage results. These tools could be improved with new experiences and validations, as well as providing a pioneering guiding light in the Caribbean and Atlantic Region for hurricane response protocols to restore marine ecosystems.

Microbial shifts associated to ENSO-derived thermal anomalies reveal coral acclimatization at holobiont level

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The coral microbiome conforms a proxy to study effects of changing environmental conditions. However, scarce information exists regarding microbiome dynamics and host acclimatization in response to environmental changes associated with global-scale disturbances. We assessed ENSO-derived thermal anomalies shifts in the bacterial microbiome of *Pacifigorgia cairnsi* (Gorgoniidae: Octocorallia) from the remote island of Malpelo in the Tropical Eastern Pacific. Malpelo is a hotspot of biodiversity and lacks direct coastal anthropogenic impacts. We evaluated the community composition and predicted functional profiles of the microbiome during 2015, 2017 and 2018, including different phases of the ENSO cycle. The bacterial community diversity and composition between the warming and cooling phase were similar, but differed from the neutral phase. Relative abundances of different microbiome core members such as *Endozoicomonas* and *Mycoplasma* mainly drove these differences. An acclimatized coral holobiont is suggested not just to warm but also to cold stress by embracing similar microbiome shifts and functional redundancy that allow maintaining coral's viability under thermal stress. Responses of the microbiome of unperturbed sea fans such as *P. cairnsi* in Malpelo could be acting as an extended phenotype facilitating the acclimatization at the holobiont level.

Integrating ROVs technologies with an Artificial Intelligence module to support the Queen Conch (Aliger gigas; Linnaeus, 1758) monitoring in deep-sea ecosystems in the Colombian insular Caribbean

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Deep marine ecosystems are increasingly important in the world due to their great biodiversity and the importance of fisheries in food security, making it necessary to identify the spatial distribution and population structure of stocks to contribute to the management of fishery resources. The integration of an ROV and an Artificial Intelligence (AI) based component was developed to support the identification, recognition and measurement of species such as the queen conch *(Aliger gigas)*, in real time during the monitoring of deep ecosystems in the Colombian insular Caribbean.

The first results have allowed the measurement of the length of the juvenile and adult queen conch in a controlled and natural environment. The developed prototype could have other applications in the identification and measurement of fish and crustaceans in deep ecosystems such as mesophotic coral reefs, seagrass beds and sandy bottoms, promoting better management of actions for the protection, conservation and sustainable use of fishery resources and Environments in the Seaflower Biosphere Reserve, Colombian Insular Caribbean.

Adaptive potential of coral-associated microbiota through the lens of holobiont engineering

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Reef-building corals and the ecosystems they build are immediately endangered by climate change and other anthropogenic activities. While the adaptive potential of corals is expected to be low given their long generation times, their association with diverse microbiota in the so-called coral holobiont represents an underexplored source of genomic innovation. Thus, functions conferred by these more flexible microbiota may aid the rapid environmental adaptation of corals. While some coral-microbe associations are known to tolerate distinct environmental stressors, the potential range of host-symbiont combinations, their phenotypes, and the role of environmental conditions in shaping the holobiont composition are less well understood. Here we introduce three holobiont engineering approaches that are being applied in the CEMarin Ocean2100 aquarium facility to untangle the link

between environmental conditions, holobiont composition, and its phenotype. First, we use environmental preconditioning and passively select holobiont compositions to investigate the potential of microbiome transplantation in aiding environmental adaptation. In this approach, environmental preconditioning consistently results in stress-tolerant phenotypes across a wide range of coral holobiont compositions. Second, we study coral performance in differing environmental scenarios to understand long-term trade-offs between holobiont traits. Third, we use coral model system approaches and a biobank of matching coral host and algal symbiont cultures to create selectively engineered host-symbiont compositions that allow for the systematic investigation of microbiome functions in the coral holobiont. Together, these approaches shed light on the potential of microbiota in aiding adaptation of the coral holobiont, thus contributing to the growing field of active intervention and assisted evolution approaches needed to confront the coral crisis.

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Regular Talks Session 2

Promoting the sustainable use and protection of marine resources

Abstracts in alphabetical order by speaker surname

Valorization of Reverse Osmosis Brines in Small Islands

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With increasing populations and increased water scarcity in different regions, people have looked to the ocean to help meet their fresh water needs but there's a significant amount of energy and infrastructure invested in isolating the H2O molecule in seawater to make it useful for human consumption. Furthermore, this increased reliance on desalination can be seen as a threat to the marine environment. Some of the environmental effects may come from the construction of the plants, the use of fossil fuels for the operations or the constant brine discharge in nearshore ecosystems (Panagopoulos & Haralambous, 2020). Islands, in particular while becoming more and more dependent on desalination to meet their water needs could benefit from a more integral approach towards a circular economy by recovering multiple raw materials from the ocean (Osorio et al., 2016). Aruba, an island in the Southern Caribbean, is completely reliant on desalination and is considered a pioneer in desalination technology with ongoing experience for over 100 years (Marchena & Halman, 2018). This research focuses on the extra economic value that can be recovered from desalination plants in coastal areas like Aruba beyond the production of fresh water alone.

Reverse Osmosis (RO) is quickly becoming the dominant water desalination technology, thanks to its relatively low energy need and the decoupling from thermal sources for its use. Decoupling from thermal sources for desalination avoids the need for combustion and allows for electricity sourced from renewable energies to power the process. RO technology works by using a pressure gradient that pushes a solution through a non-permeable membrane in which only the solvent is allowed to go through. After this process only a purified water stream and a more concentrated brine solution are obtained. Approximately 2-7 kwh/m3 of electricity plus the necessary large scale piping and processing equipment is needed to obtain fresh water from the sea (Kim et al., 2019)(Shemer & Semiat, 2017), this processing then leaves behind a concentrated brine that is currently discarded as a 'waste' product back into the sea. One of the mitigation strategies proposed to avoid environmental damage due to brine discharge involves the recovery of valuable raw materials from these desalination brines, this reduces the salinity and amount of effluent back to the ocean and at the same time the increase in overall economic value of processing seawater can serve as a financial support for more responsible effluent management techniques.

When looking at desalination systems, an alternative viewpoint is thus suggested in which fresh water is seen as only one of the by-products of sustainable seawater processing plants. Recovery of valuable and critical elements like Magnesium, Lithium and even Chloride and Sodium from brines in distributed locations around the world can form a sustainable alternative not only to minimize local environmental impact (due to brine discharge) but also to the negative impact of centralized mining

practices, including the transport impacts associated to these different resources. SISSTEM Program in Aruba: This project forms part of the SISSTEM (Sustainable Island Solutions through Science, Technology and Mathematics) program at the University of Aruba in collaboration with the KU Leuven.

The Magdalena River Estuary: Lessons learned from the physics of the system for a more sustainable use

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The Magdalena River is the largest source of fresh water and sediment in the Caribbean Sea. Its estuary and delta are sites for developing multiple human activities, from ports, tourism, and water intake to renewable energy generation and valuable ecosystems preservation. Additionally, the river effluents on the ocean drastically impact the morphodynamics and ecosystems along the Colombian coast. Numerous studies have been conducted recently and are under development to evaluate the hydro-sedimentary dynamics of this relevant system. These researches reveal several new lessons about the fundamental physical dynamics taking place in this system. These lessons should be included in the management practices of the system to ensure more nature-friendly interventions in the future. This talk presents a summary of such lessons that include (but not exclusively): i) the influence of tides in the hydrodynamics of the system has been largely underestimated; ii) Mechanisms dominating mixing (and therefore the distribution of water, nutrients, and pollutants in the estuary and ocean) are very diverse in time and space; iii) Bedforms dynamics seems to largely influence hydro-sedimentary dynamics in the estuary although the recurrent dredging; iv) The connectivity of the river with the near coasts is more significant than expected given the human efforts for controlling sedimentation.

Establishment of viable cell cultures of Colombian aquatic mammals suitable for future studies

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Cell cultures can be used as model systems of tissues, organs, or even entire animals for an almost unlimited quantity of tests that can be done whenever necessary and under very precise and controlled conditions. Hence, aquatic mammals cell cultures can become an "irreplaceable, multifunctional instrument in physiological, biochemical, genetic, and ecotoxicological studies replacing the use of whole animals" (Boroda et al., 2020). Implementing aquatic mammals cell culture banks in Colombia represents a huge opportunity to improve aquatic mammal investigation and conservation, opening doors for more directed research. In this study we aimed to develop a protocol to obtain, transport and generate viable aquatic mammal cell

cultures useful for future research based on a literature review and afterwards execute and validate the proposed protocol. Convenience sampling from skin biopsies was performed. Each sample was transported from its sampling side to the lab between the first 72 hours since it was taken. Samples were digested using trypsin and afterwards cultured in complete media (DMEM/ RPMI1640) in an incubator at 37°C with 5% CO2. Isolated cells from humpback whale *(Megaptera novaengliae)*, amazon pink dolphin *(Inia geoffrensis)* and amazon manatee *(Trichechus inunguis)* were obtained, and cell survival was observed but no confluency. Sample transport duration and culture contamination were encountered as the main problem, therefore, to determine a proper methodology, a faster transportation method, better cleaning and sample processing on field must be evaluated. In conclusion, aquatic mammals' cell cultures were established but optimal cell growth was not observed. To improve the viability of the culture, it is suggested to evaluate other transport and initial cleaning methodologies.

Insect-based sustainable shrimp aquaculture

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Aquaculture – the fastest growing food production sector worldwide – is considered essential to meet the demand for animal protein of the growing global population. However, aquaculture is often accompanied by the destruction of important habitats (e.g. mangroves), high energy consumption and the lack of animal welfare standards. In order to improve the sustainability of aquaculture, we are currently constructing a smart and innovative insect-based aquaculture (InA) pilot facility in Germany for the flexible, modular, and scalable inland production of the pacific white-leg shrimp *(Litopenaeus vannamei)*. Following the principle of circular economy, local biogenic side streams such as apple pomace and cocoa bean shells are used as feed for our insects (black soldier fly, *Hermetia illucens*), which in turn serve as feed additive for our shrimps.

Based on life cycle assessments (LCA), the pilot facility will be operated under two scenarios – a "high sustainability" scenario (IPCC Mitigation Pathways Compatible with 1.5°C) and a "moderate sustainability" scenario (IPCC Mitigation Pathways Compatible with 2.0°C). Since the facility is based on a holistic view of sustainability (i.e., ecology, economy and society), semi-quantitative and qualitative criteria such as animal welfare, species protection (% reduction of fishmeal consumption) and environmental protection (% reduction of plastic, % reduction of freshwater consumption) will be included in addition to the quantitative sustainability criterion of CO2 reduction. We expect high value creation from the pilot facility, especially in three areas: 1) refinement and use of side streams as feed for insects, 2) sustainable production of insect-based feed for aquaculture, and 3) sustainable and smart technology for the aquaculture sector. The expected high prospects for economic success will be supported by patent applications in all three areas.

Whatever makes coral happy: Differential survival of coral fragments of multiple species propagated under different nursery conditions

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Coral gardening is recognized worldwide as a low-cost and effective tool for recovering degraded coral reefs. This technique can rapidly increase live coral cover and the structural complexity through outplanting adult coral colonies, mainly when local stressors are controlled or mitigated in these ecosystems. Accordingly, the coral gardening concept is the cornerstone of the first nationwide coral reef restoration program in Colombia. Led by the Ministry of Environment, Conservation International, and over 19 other national partners, this restoration program will grow a stock of one million corals to replenish the live coral cover of 200 hectares of reefs across 13 areas in Colombia. Corales de Paz is a partner to the project and is in charge of raising a stock of 100,000 corals from different species in Providencia and Santa Catalina Islands.

Two different field-based coral propagation techniques are used to achieve this goal. First, large coral fragments (~6 cm long) of branching species are grown in midwater (~5 m deep) floating rope nurseries. Second, small coral fragments (~1 cm2) of branching, massive and encrusting species are affixed onto small cement structures (~25 cm2) and left to grow in fixed table nurseries. On the latter, two different shapes for the cement structures were used, concrete flat "cookies" and pyramids. Coral clonal fragments of various species were grown on the two nursery types and substrate shapes to identify the best propagation method for survival and growth. For this, survival was measured by each fragment's percentage of living tissue.

In the first seven months, 41,357 fragments of 16 different coral species were raised; 75% of them were branching species grown in nine floating rope nurseries, and 25% of massive species were grown in six table nurseries. Rope nurseries hold three species, *Acropora cervicornis*, *A. palmata and Porites porites*, with a mean survival rate of 91.9%. The mean survival rate in the fixed table nurseries is 85,4% across all 13 grown species. Individual species assessments showed a survival rate of 88.2% in ropes nurseries, 63.6% in flat "cookies" and 32.3% in pyramids for *A. palmata*. These results differ from *P. porites*, which presented 95.4% survival in ropes and 98% in concrete pyramids on the tables. The encrusting species, *P. astreoides*, did not show differences between both types of concrete substrates, whereas the massive species, O. faveolata, slightly preferred “flat” cookies as survival rate was 94.1% and in pyramids 82.5%.

These preliminary results suggest that each species performance is dependent on the nursery type and substrate shape. Furthermore, tendencies are observed even in species with the same growth type, suggesting restoration projects should, when possible, consider specific propagation requirements for each species. In doing so, we expect to increase the survival and growth of coral fragments to restore the populations of hermatypic coral species in Colombia and the region.

From the lab to the real world: In situ application of a probiotic consortium elicits response in the microbiomes associated with the inoculated corals but not on the surrounding environment

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The use of Beneficial Microorganisms for Corals (BMCs), or coral probiotics, has been proposed as a microbial therapy to restore and enhance coral health and resilience. However, its efficiency in real world applications and effects on non-target organisms is still a subject of further studies. Here, we tested, for the first time, the *in situ* application of a probiotic consortium for the hard coral *Pocillopora verrucosa*, in the Red Sea. For this, bacterial strains (n=350) were isolated from healthy corals, of which six (one *Halomonas sp.*, two *Pseudoalteromonas spp.*, two *Cobetia spp.*, and one *Sutcliffiella spp.*) were selected based on their BMC traits, such as Dimethylsulfoniopropionate (DMSP) degradation, reactive oxygen species scavenging, and role in the nitrogen cycle. To evaluate the effect of the probiotic inoculation in non-target microbiomes, thirty colonies of *P. verrucosa* were inoculated with either placebo or probiotic. The bacterial communities of the inoculated corals and surrounding sediment and water were then analyzed overtime, covering seasonal variations (T1, in late August, before the inoculations; T2, in mid-October; T3, late November). Bacterial communities associated with *P. verrucosa* showed significant differences between treatments in T3 (Adonis test, p-value 0.025*), as well as in Shannon diversity, which was significantly lower in control treated corals (Kruskal test, p-value 0.0058**). The bacterial communities in the sediments did not show significant differences across time or treatments (Adonis test, p-value 0.073), however, Simpson diversity was significantly lower in control-sediments in T3 (Kruskal test, p-value 0.027*). The water bacterial community rather showed a significant seasonal variation regardless of the treatment (Adonis test, p-value 0.001***) and did not show differences in T3 between treatments (Adonis test, p-value 0.319). Our results indicate that the *in situ* inoculation of corals using selected BMCs elicit changes in the composition and abundance of the coral-associated bacteria, indicating the feasibility of its application in the real world. Moreover, our data indicate that the probiotic application did not cause significant changes in the microbiome surrounding the inoculated corals. Together, our data suggests that the BMC uptake seems to be restricted to the inoculated corals, when comparing it with the surrounding environment, and it is a first indication of its potential safety and efficiency as a tool for inoculation for active coral restoration and rehabilitation in real-world conditions.

Currents and circulation patterns in a Caribbean Island and their influence on effluent discharge. Case study: San Andrés, Colombia

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Several phenomena can drive shallow-water circulation. Current circulation patterns control vital processes in shallow water, including sediment and suspended particle transport, as well as the dispersion and concentration of nutrients and pollutants. A coupled wave-current numerical model (Delft 3D Wave-Flow) was used to understand currents circulation induced by waves, wind, tide, and density variations in an insular zone such as San Andres Island. Results were compared with measurements collected in the field; salinity and temperature profiles, sea level, and currents. Sensors to record the field data were strategically placed in the north-eastern part of the island towards the Johnny Cay islet side before crossing the barrier and on the western side. Results indicate a spatial flow distribution since currents have less magnitude variability (0.15 - 1.2 m/s) at the northeast side, with directions predominating towards the northwest and southwest of the island. On the other hand, the variability of the magnitude (ranging from 0.2 to 1.5 m/s) and the direction is more random on the west side. These spatial patterns are associated with the influence of wave energy, its variability around the island, and the tide's effects. On the other hand, stratification processes become essential between 20- and 70-meters depth where the temperature gradient is greater (6°C). Although the variation of salinity is negligible at these same depths, the greatest gradient is (1 PSU), which suggests that alterations of these properties can generate density changes that generate vertical currents. Of the forcers considered in the numerical modeling, the processes experienced by the waves on the northeast side of the island (energy dissipation by depth, dissipation by bottom friction, reflection, among others) could be strongly associated with the flow circulation in this area. In turn, the circulation on the west side would be strongly induced by the tidal variation since the energy in this area is regularly lower compared to the east side.

Mangrove as a blue carbon source for coastal food webs

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The carbon sequestration capacity of mangrove forests has been extensively investigated worldwide. Along with seagrasses and salt marshes mangroves are one of the blue carbon ecosystems and thus hotspots in the global carbon cycle. However, large variability in carbon stocks estimates is evident, making it difficult to generate clear patterns of mangrove-mediated carbon flux. Although different types of mangroves are known to produce different goods and services, for management proposes it is important to improve knowledge of blue carbon budgets between different forests. Our objective was to evaluate a conceptual model of mangrove detritus utilization that describes how patterns can vary depending on biophysical typology. To test the model, we collected from three mangrove types with different blue carbon stocks, macro-invertebrates and fish to estimated organic matter utilization using carbon (δ13C) and nitrogen (δ15N) isotope ratios. Open-coast forest showed the highest total carbon stock (1724±254 MgC/ha), followed by the estuarine (1234±61 MgC/ha) and lagoon (604±186 MgC/ha) mangroves. The δ13C values of macro-invertebrates found within mangrove forests were not significantly different between environmental settings. On average, carbon isotopic values were –20.0 ±1.1; –23.0 ±1.2; and –22.7 ±1.2 ‰ for open coast, lagoon, and estuarine forest, respectively. Mean δ13C values for invertebrates collected outside the forest in the open coast (–13.9 ±0.4 ‰) were significantly higher than those collected in the lagoon (–17.8 ±0.5 ‰), and estuarine mangroves (–23.0 ±0.5 ‰). Likewise, mean δ13C values for fish collected from the open coast were significantly higher (–13.1 ±0.3 ‰) than species from the lagoon (-16.4 ±0.3 ‰) and estuarine mangrove (–24.8 ±0.5 ‰). In general, δ13C values of consumers collected outside the forest parallel phytoplankton δ13C signature rather than mangrove δ13C signature. Results obtained using mixing-end member models suggest that mangrove-derived carbon utilization differs across mangrove biophysical types. Consumers collected in estuarine mangroves have more depleted δ13C values than those collected in lagoon and open coast, indicating that mangrove is an important source of energy for some of these consumers. The δ13C signatures of consumers and the mixing models in the lagoon and open coast suggest limited trophic dependency on mangroves.

Renewable energies exploration using spatial analysis and multicriteria methods to identify potential energy areas in Colombia Offshore

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Modern society faces key challenges to swiftly mitigate global warming and massify clean energy sources to create a circular economy and sustainable development. National and international authorities are implementing policies to ensure decarbonization and access to safe, sustainable, and multiple source energies.

The Technology and Innovation Center – ECOPETROL-ICP group in Offshore Renewable Energies Studies tries to identify the feasibility of sea energy technologies in Colombia's maritime domains. We work continuously to identify potential areas to generate energy and to implement a spatial multicriteria evaluation of technical, environmental, and socioeconomic variables that impact the implementation of renewable energy technologies in the sea. According to these goals, we propose a unified vision of energy technologies that can coexist in the same geographical distribution, using the conventional analysis of play for hydrocarbon exploration, and identifying the probable location of a renewable energy farm in the sea.

Our methodology is based on six offshore renewable technological pillars: wind, floating solar, thermal gradient, saline gradient, sea currents, wave, and tidal energy. Each technology was weighed depending on its availability using related information such as Wind velocity, solar irradiation, sea temperature gradient, saline gradients, currents velocities, and tidal changes. Additionally, we included restrictive variables such as protected areas, electrical infrastructure, or geomorphological conditions of the marine seabed to identify key potential areas and include a weighted assessment of potential conflict with sea use.

First, we compiled relevant and available spatial information to identify potential locations in Maritime areas, including international metocean databases, international data, and Colombian government datasets. The second stage includes data correction and multiple data generation, some data nature is discrete, and density or distance assessments were employed. The third stage includes categorization and information weighing, expert assessment, and multicriteria analyses. Lastly, after completing multiple multicriteria analyses, we use a final spatial analysis of the different technologies to identify sites with the most significant potential for installing offshore energy. These promising areas could be the basis for detailed analyses, and a new evaluation might be required. The previous analysis integrates known interpolation and distance analysis methodologies, commonly used in raster and vector models; it also includes a multicriteria assessment methodology that integrates different variables and applies a value weigh for various influencing

factors to generate an optimally integrated analysis with tools that are commonly available to all geoscientists.

The initial results include promising maritime areas neighboring the administrative Departments of Atlántico, Guajira, San Andrés, and Bolívar with significant potential for wind, solar, salt gradient, and temperature gradient technologies, and there are plenty of sea users and potential environmental conflicts. The Pacific coast has energy potential related to tidal energy, but also fishing and potential environmental conflicts.

Ecopetrol is now expanding its exploratory fronts and includes new energy resources by identifying potential technologies from the sea and applying the experience of play concept methodologies known in O&G, thus strengthening itself as a pioneer company in new energy technologies to advance with the energy transition and reduce carbon emissions.

National Coastal Resilience Laboratory: Achievements, challenges and opportunities in coastal areas of Mexico

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Mexico has a privileged geographical position, with coasts in the Pacific Ocean margin, as well as in the Gulf of Mexico and the Caribbean Sea, with 7,828 and 3,294 km of coastline, respectively. Due to climate change and accelerated coastal development, coastal resilience is a crucial issue at a planetary level and its study must necessarily follow an interdisciplinary perspective, understanding resilience as the capacity of socio-ecological systems to absorb disturbances and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker, 2004).

Since its inception in 2015, the National Coastal Resilience Laboratory (LANRESC; www.lanresc.mx) was created as a virtual laboratory, constituted by 7 academic institutions in Mexico, focused on studying and providing scientific-technological solutions, through different research groups dedicated to coastal resilience, with emphasis on seven coastal socio-ecosystems (SECs) in which Coastal Observatories for Resilience (OCRs) are being implemented: two in the Pacific basin (Agiabampo, Sonora, and Copalita, Oaxaca), and five in the southern Gulf of Mexico (Dos Bocas-Paraíso, Tabasco; Laguna de Terminos, Campeche; Celestún, Sisal and Alacranes, Yucatán).

Since 2017, LANRESC has been mainly promoting three projects in each of its OCRs:

1) Creation of Report Cards, which through transdisciplinary workshops with members of the academy, civil organizations and government, and

supported by scientific data, propose socio-environmental indicators at different scales for each OCR, resulting in an evaluation of the state of health and a baseline of the SECs, useful for decision makers and society in general;

2) Semi-simultaneous annual campaigns in the seven OCRs to evaluate the Water Trophic State Index (TRIX), which integrates the variables related to the productivity of the system that are chlorophyll, dissolved oxygen, dissolved inorganic nitrogen and phosphorus;

3) Monitoring of socioeconomic and governance processes and indicators in the seven OCRs (2022);

4) Monitoring of physical-environmental variables of the coastal zone of the seven OCRs (2023).

All these activities are published in different forums and journals, at the applied research and science dissemination levels, as well as communicated through different social networks focused on different audiences, with the intention that the knowledge generated does not remain within the academy, but rather permeates to the community, allowing informed decision-making.

LANRESC is a broad, non-profit academic group that aims to consolidate itself as a national and regional reference for studies on marine-coastal issues associated with resilience. The adhesion of new OCRs from the Latin American region and the design and implementation of organized and systematic activities in each one of them is one of the medium-term objectives of LANRESC to better understand and promote the consolidation of resilience in coastal socio-ecosystems.

CEMarin

ICMS 2023

Regular Talks Session 3

Understanding the interactions between ocean and society

Abstracts in alphabetical order by speaker surname

Use of artisanal fishery resources related to mangroves by Afro-descendant and indigenous Embera communities of the Colombian Pacific Coast

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Human population communities settled in coastal regions have a tight bond with marine and coastal ecosystems, as well as nearby freshwater ecosystems. Marine environment can play a role as an alternative source of benefits for Embera indigenous communities of the Colombian Pacific Coast, when freshwater resources are scarce. In order to evaluate the relationship between the Afro-descendant and indigenous communities of the Embera ethnic group and the mangrove ecosystem, semi-structured interviews were conducted in the localities of the departments of Nariño (Bocagrande - Tumaco), Valle del Cauca (Punta Soldado, La Bocana , San Pedro, PNN Uramba - Archipiélago de La Plata), and Chocó (PNN Ensenada de Utría), in the Colombian Pacific. Among the most relevant results, it was found that 100% of the respondents recognize that they receive direct benefits from the goods and services offered by the mangroves. Additionally, the fishing resource is used by both focus groups, where the fishing gear used by Afro-descendants includes gill nets, bottom longlines, and simple handlines, while the indigenous people interviewed use only handlines. Afro-descendant communities carry out fishing as an economic activity, while in indigenous communities, fishing is carried out mainly for self-consumption and a very low proportion for trade within the community. A significant reduction in the capture of all the species that are normally fished was evidenced, due to various causes such as the increase in the population, pollution and the misuse of the fishing activity. The state of the mangrove can affect the fishing resource, which leads to an impact on the economy of the Afro-descendant fishing community. In addition, the scarcity of bushmeat consumed by the indigenous people has led to changes in their diet, economy and ancestral cultural practices such as hunting and river fishing, so learning about ocean fishing has become an activity of their new reality. Therefore, in order to manage effective conservation and restoration strategies for coastal marine ecosystems, it is needed to understand the current state and the change over time in the availability of resources and how their culture and traditions can influence that condition.

The need for a participatory GIS-based Environmental Information System: The Ciénaga Grande de Santa Marta as a case study

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The importance of basing the social development of a region on both universal and specific scientific knowledge has been sufficiently demonstrated. In order to

access the knowledge society, it is essential that science be open, which implies that research, publications and scientific data are not only up-to-date, but also accessible, easy to consult and can be widely disseminated, in order to be able to use them in the best possible way. In Colombia, a country proud of its biodiversity, where natural capital constitutes the main development potential, there is no sufficiently successful management model that allows, based on scientific information, to take advantage of the large number of services provided by the different existing ecosystems in the territory for national development. The Ciénaga Grande de Santa Marta (CGSM) ecoregion offers the opportunity to develop such a model. Due to its national and international importance, the CGSM is one of the most extensively studied socio-ecosystems in the country. The CGSM comprises two National Natural Parks, is a Ramsar wetland, an International Biosphere Reserve, and a Montreux Record ecosystem. Unfortunately, it also provides a dramatic example of negative anthropogenic effects where the loss of an extensive mangrove area and a significant reduction of fish, bird and commercial invertebrate populations were induced by hydraulic alterations caused by poorly planned infrastructure projects. The CGSM has been used as a basis for the development of different national initiatives with international support, such as Ecodesarrollo and Pro-Ciénaga. The latter, a Colombo-German project, has been the largest mangrove restoration program in Latin America and allowed in the 1990s the strengthening of several Colombian institutions. However, it is paradoxical that being such a productive, recognized and studied ecosystem, it does not provide the expected benefits to the current society and is in a high state of deterioration. A large part of the problem lies in not using specific knowledge and information for ecosystem management, which in turn is due to the fact that the extensive scientific literature on the CGSM is scattered in reports, theses, books, articles and other non-digitized materials. The high dispersion, lack of systematization and restricted access to data and information explain the disarticulation between knowledge and environmental management. With a view to improving this situation, which is not exclusive to the CGSM, it is proposed to develop and maintain, as a pilot project, a public, updated and user-friendly CGSM environmental information system (Sí-CGSM), based on a geographic information system (GIS), open for participatory studies form local actors. This prototype model can be used for similar regions and projects. It is based on a document base that currently exists in the Zotero system and already contains more than 1,400 bibliographic references, of which approximately 55% have the respective documents digitized.

Integration of bio art and speculative design in the artistic composition based on mangroves and lichens

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From a perspective that goes from the Biological-natural environment to fix gazes on the meaning of the natural-wild-landscape, the body, fauna, food chains, and remote

islands, confronting to rewrite technology with the possibility of other fictions. This article is a compilation of a work of art based on mangroves, compared with a speculative hypothesis about sculpture exercise based on lichens joining biodesign could become to think in the ecology of the design field. This study established speculative design aligned with biodesign and found a relation for interrelationships challenge, the place where asking about it and walking on the border of sci-fi has been a way to design the future about far worlds.

The boundaries of art, technology, and science as new pathways to express new definitions of world challenges. The ecology of the processes that in practice could be thought of as complex species or those that survive in extreme territories leave a study gap that can be addressed from hypotheses and speculations with which art gives impetus to science to be vertices of reflection, of this that interdisciplinarity for the Latin American context is necessary to think introspectively of ecologies from other dynamics to shape meeting points. In the development of the works the set of oceanography, biomimetics, and fiction; the study proposed from the experiences of approaches to the sciences. It is the idea that water shapes the temporalities of the routes in communities; accordingly, this concept combines the spheres of ability and memory.

Agreements for the management of coastal artisanal fisheries in Colombia: contributions to co-management and fisheries governance

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In Colombia, the importance of addressing the problems and solutions of fisheries management has risen during the last decades, through the active participation of users in decision-making to strengthen the fisheries governance. Therefore, joining efforts between fishing communities and government institutions is an urgent task. Based on this need, the Research Group on Socioecological Systems for Human Well-being (GISSBH) at the Universidad del Magdalena has led a participatory research process (Phase I: 2008 – 2012 years, Phase II: 2014 – 2015, Phase III: 2020 – 2021) to co-generate management initiatives based on collaborative work with nine "pilot" fishing communities in the country. On the Caribbean coast: fishing community of Ahuyama (State of La Guajira), Taganga (Magdalena), Las Flores (Atlántico), San Antero (Córdoba), El Roto (Antioquia), and on the Pacific coast: Bahía Solano and Pizarro (Chocó), Juanchaco (Valle del Cauca) and Tumaco (Nariño). As part of the process, in 2021 we applied qualitative methodologies in workshops with fishers, community leaders, officials of the *Autoridad Nacional de Acuicultura y Pesca* (AUNAP) and other local actors in each community. Through dialogue of knowledge and democratic vote, participants validated management measures previously chosen along the second phase of the research process, and

now (third phase) these measures could be transformed into fisheries management agreements based on regulatory and non-regulatory measures (AUNAP Resolution 586 of 2019). Each chosen measure arose from the Local Ecological Knowledge (LEK) of the communities as a strategy to start solving problems that are affecting the local fishing sector. Approximately 466 people participated in the voting in person and 590 virtually. Voting results show that the communities of Caribe, Ahuyama, Las Flores, and El Roto ratified the 3.5 inches *Minimum Mesh Eye Size* (MMES) tool. Additionally, Las Flores proposed *Exclusive Artisanal Fishing Areas* (EAFA), meanwhile, San Antero chose the *Temporary Fishery Closure*. In the communities of the Pacific coast, Bahía Solano chose the *Minimum Catch Size*, Pizarro selected the AEPA, Juanchaco the *Minimum Hook Size* and MMES. And finally, the piangüa collectors in Tumaco chose the *Rotation of Fishing Areas*. Each measure was proposed together with the technical specifications: timing, geographic area and non-regulatory measures. The findings obtained in this last research phase demonstrate the relevance of the fisher's LEK as an instrument for decision-making in the fishing sector, ratifying the will of the communities to continue working on fisheries management processes in the country. In conclusion, the strategy of participatory fisheries management in Colombia continues to be seen as a transversal solution to improve the quality of life of fishers, the conservation and sustainable use of fishery resources and the maintenance of the social and economic benefits generated from the fishing activity. However, the communities make an urgent call to the AUNAP so that the agreements formulated can be enforced in the short term and thus be able to rely on legal support that allows them to advance in the management that the communities have been trying to implement informally in their territories.

Can artisanal fishing continue in crisis or could we turn the side of the coin?

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Despite the multidimensional relevance of artisanal fishing and subsistence fishing in the context of Latin America and the Caribbean (LAC), the States of this region have historically failed in its sustainable management. In most LAC countries, fisheries management has historically been exercised with a "top down" centralist approach, through state controls focused mainly on fishery resources. Unfortunately, these administration regimes have rarely been characterized by successful resource management outcomes. Consequently, there is currently a growing worldwide trend to manage the fisheries sector with an adaptive co-management approach, based on the understanding of the complexity of Socioecological Systems (SES). This has emerged as a solution to natural resource crises, as it has led to more cases with tendencies to success rather than failure. Consequently, in recent decades there has been a global trend to manage the fishing sector from adaptive co-management. Due to this context, the Universidad del Magdalena and Conservation International in Colombia decided to create an alliance to find fishing communities in the LAC region

that independently or in alliance with external actors (from governmental or non-governmental institutions), have managed to begin processes of self-organization that have allowed them to transform moments of crisis into opportunities and to envision a better tomorrow.

It finished in a book called "Communities with voice. The future of artisanal fisheries in LAC". This book brings together 14 case studies located in seven LAC countries that seek to convey a message of hope for the fisheries sector by sharing their adaptive learning processes in which the voices of the communities have contributed to strengthening governance in each of these countries. Based on the understanding of the complexity of Socioecological Systems (SSE) and the application of the eight principles postulated by Ostrom (1990), this book aims to provide solutions to the crisis faced by fishery resources and their users. The positive experiences of local empowerment are made visible in communities of marine, coastal and continental artisanal fisheries, which allow evidence of fisheries management processes as a product of decision-making and intrinsic collective efforts (of the community) or in alliance with external actors, for the purpose of conservation and sustainable management of fishery resources. The book is divided into sections that present the case studies for each country. It covers cases in the Caribbean (one case in St. Vincent and the Grenadines), four cases in Central America (two in Mexico, one in Honduras and one in Costa Rica) and nine cases in South America with (six in Colombia, one in Ecuador, and two in Brazil). Finally, each of the cases include lessons learned and makes visible the importance of recognizing weaknesses as a starting point to empower each community.

The Ciénaga Grande de Santa Marta Ecoregion in public media 1990 to 2020

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The Ciénaga Grande de Santa Marta (CGSM) is an ecosystem of great importance for Colombia and the world. This importance is not only due to its high biological production, which is among the highest on the planet for ecosystems of its type and has sustained important populations of fish and invertebrates of ecological and commercial importance, the basis for the economy of seven neighboring populations. Unfortunately, the CGSM Ecoregion also provides a dramatic example of negative anthropogenic effects where the loss of an extensive mangrove area and a significant reduction of commercial fish and invertebrate populations were induced by hydraulic alterations. Just as the scientific literature on the CGSM is extensive, so is the publication of news in the Colombian press. During the last three decades, the media have published 874 news items, that is, approximately one news item every two weeks. This average has increased in the last five years with 2 to 3 news items every week. However, to date, the role played by the press in the environmental intervention of the ecosystem has not been analyzed. Our aim was to organize the news published by the Colombian press from 1990 to 2020,

identifying and summarizing some of the most salient topics. A general analysis shows that although it is not possible to establish the direct influence of the news generated by the media on timely decision making for the adequate environmental management of the ecoregion, making the facts publicly known, mentioning those responsible, has most likely been an important factor in attracting the attention of the control entities and exercising social control. Unfortunately, the news itself shows that the socioenvironmental management of the ecoregion has not been sustainable over time. Maintenance and management actions have been partially advanced at times, in which the CGSM has become news, but then the attention is lowered and again almost completely forgotten. This pattern, in which public funds destined to the environmental sector are invested under an emergency scheme, contrasts with the results and recommendations of the academic sector. It has been known for decades that the CGSM requires constant and permanent hydraulic monitoring and maintenance, since only with favorable water conditions can the ecosystem provide society with important ecosystem services such as fisheries, biodiversity, and organic carbon absorption and retention. Neglecting these maintenance recommendations has generated serious social and economic impacts. We hope that this paper will be the basis that will allow diverse analyses and above all, help citizen control over the sustainability of the environmental measures that are recommended from the technical-scientific level. Many of the environmental risks in the GCSM are predictable or mitigable. Risk management, although proactive and perhaps not newsworthy, is much more economical than emergency actions resulting from disasters. The question then arises: why does the pattern of half-hearted action persist, with important economic investments that are then neglected and years later become new emergencies? Are there those who benefit from this bad model of environmental management?

Comprehensive preparedness and response framework for tropical cyclone emergency in marine ecosystems

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On November 16, 2020, Hurricane Iota, category 5, hit the archipelago of San Andrés, Providencia and Santa Catalina, Colombian Caribbean islands, causing severe damage to coastal marine ecosystems. The local environmental authority faced multiple challenges, including the absence of guidance and procedures for disaster preparedness, response, and recovery, lack of clarity of roles and legal competencies, and weak operative and technical capacity to perform a rapid damage evaluation in marine ecosystems. The central problem was the poor articulation between disaster risk and ecosystems management. In this context, the environmental authority CORALINA and the National University of Colombia, Caribbean campus, developed a comprehensive framework to improve the preparedness, response, and restoration

processes to face a tropical cyclone event. This applied research uses a qualitative method that uses literature review, expert review, community tabletop discussion, and policy analysis. The framework addresses steps to be taken in all disaster management sub-processes based on integrating multisource information that comprises hazard characteristics, ecosystem exposure and ecology, legal aspects, and disaster planning. The framework seeks to maintain institutional alertness and prepare to serve quickly during an emergency. Pursuing the integration of both approaches disaster risk and ecosystem management the framework will enhance policy development to meet global sustainability goals. It will provide decision-takers the awareness about what is needed to prepare for, the ability to prioritize response activities, and the capacity to anticipate the possible risk scenarios in marine ecosystems. It will prevent Coral reefs, seagrass, and mangrove losses and increase marine ecosystem management collaboration throughout the San Andrés archipelago institutions.

Unconventional times call for unconventional water resources: Reproducing water injustices in the San Andres Island water crisis

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Water crises persist despite the employment of technical mitigation strategies, and, indeed, an alarming cycle is growing in impact and frequency. Caribbean islands are particularly vulnerable to extreme events, like droughts, co-occurring with groundwater pollution, water inequalities, and weak governance. Consequently, many island communities that rely on tourism experience ongoing and deepening water crises. Technical solutions, like desalination, are regularly called upon to contend with the crises; it has become a mainstay for more than 14 Caribbean islands. Since 2016, San Andrés, a Colombian Caribbean Island, has experienced multiple water crises, with cumulative impacts on more than 14,000 people, mostly the Raizales, an ethnic minority group, and people from poor neighborhoods. Water truck distribution and desalination expansion have been adopted as the primary solution to the crises. This research identifies factors influencing perceptions of desalination and how this technology facilitates the reproduction and escalation of persistent water injustices, thereby maintaining the crisis. Rather than adhering to top-down understandings, this study uses the social constructivist approach to understand how different stakeholders perceive the crisis and water justice. This study took place between 2016-2021, involving field observation, interviews, and reviews of official reports. Based on 79 semi-structured interviews with various stakeholders, this research reveals that the crisis produced uneven impacts due to pre-existing social inequalities in water access, quantity, and distribution. Results show that multiple factors enable the reproduction of water injustices through desalination. First, organizational leaders portrayed the cause of the water crisis as induced by a natural hazard (climate change). Second, there was strong

support from all participants around the use of desalination, which rests on the following rationales: the historical presence of desalination, the sense of threat to the island's water resources, the belief of the ocean as a limitless water source, and the perception that desalination is a conflict-free and low-risk technology. Third, water injustices are reproduced by creating and maintaining separate water markets and geographical spaces characterized by differences in water access, frequency, quality, and storage. San Andrés is moving toward technological water dependence disconnected from traditional local forms of collecting water. Desalination technology fosters circumstances where islanders lose control over water, where people lack recognition of the island's natural water limits, and where massive tourism growth occurs accompanied by disproportionate protection from water shortages compared to other residents and sectors.

Mainstreaming coastal nature-based solutions for climate change adaptation

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Accelerating adaptation measures globally at the scale and speed needed to meet the looming challenges of climate change is a priority. Nature-based solutions (NBS) for adaptation are grounded on the role of nature in reducing human vulnerability to the effects of climate change. In addition, NBS deliver multiple benefits for biodiversity and human wellbeing by protecting existing habitats, restoring degraded ecosystems, improving the sustainable management of landscapes, and creating novel habitats. Although NBS for climate change are gaining political attention globally, coastal habitats have received far less interest than terrestrial ecosystems. In this way, there is an urgent need to create awareness and demonstrate the potential of coastal habitats in supporting adaptation, enhancing biodiversity, and promoting human wellbeing. This study gathered and analyzed evidence on coastal NBS by conducting a non-systematic literature review. Additionally, semi-structured interviews with experts from the United Kingdom, the Netherlands and Bangladesh led to identifying lessons, barriers, reflections on the benefits assessment, and critical aspects for the future deployment of coastal NBS. As a result, a set of recommendations were provided to advocate for the rise of political awareness and scaling up of coastal NBS as an entwined synergetic solution to address the climate and ecological crises.

Posters

Abstracts in alphabetical order by surname

Exotic Marine Fishes Known from the Colombian Caribbean

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Colombian marine fish richness is over one thousand species. To date, it is known that five exotic fish species have been detected in marine and estuarine habitats in the Colombian Caribbean. Without any doubts, the most important is the scorpaenid *Pterois volitans* (Linnaeus, 1758), the red lionfish, which occupies a wide array of continental and insular shelf environments, going even to the upper slopes. The lionfish, probably a hybrid species, comes from the Indian and western Pacific oceans, and has been widely introduced in Florida at least since the 80s as collateral damage of the aquarium business. This species is clearly deleterious for marine biodiversity in shallow waters as well as a constant danger to divers and bathers because of its venomous fin spines. Another totally marine species that has been found in Colombia is the muzzled blenny *Omobranchus punctatus* (Valenciennes, 1836), family Blenniidae, which was collected in Bahía Portete in the Alta Guajira. Its original distribution includes the Indian and western Pacific oceans as well. Recently, the presence of the milkfish *Chanos chanos* (Forsskål, 1775) was established; this species, the Ostariophysi (familia Chanidae) with the widest natural world distribution, appeared in a fishers capture in the coast of the Córdoba department. The milkfish grows over one meter in length and it is known from the Indian and Pacific oceans. The existence of the north African cichlid *Oreochromis niloticus* (Linnaeus, 1758), the extensively introduced Nile tilapia, and the Asiatic *osphronemid Trichopodus pectoralis* Regan, 1910, the snakeskin gourami, at the estuarine environment of the Ciénaga Grande de Santa Marta is well known.

Contributions to the feeding ecology of *Isostichopus badionotus* and *Isostichopus* sp., as determined by stable isotope variation f $\delta^{13}C$ and $\delta^{15}N$

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Isotopic ratios of carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$ were determined in order to analyze the feeding ecology of sea cucumbers *Isostichopus badionotus* and I*sostichopus* sp.. Dates were compared between the bay of origin (Taganga Bay and Rodadero Bay) and the climatic season (dry and rainy). The $\delta^{15}N$ isotopic signatures showed that when both sea cucumbers come from the same bay, their tissue nitrogen originates from a common food source. Similarly, the $\delta^{15}N$ isotopic signatures did not vary significantly between dry and rainy seasons indicating that season does not significantly affect the food sources that provide nitrogen. However, sea cucumbers from Taganga Bay showed significantly more enriched $\delta^{15}N$ isotopic signatures than individuals from Rodadero Bay, a finding that corresponds with a higher $\delta^{15}N$ enrichment in the Taganga Bay sediment. These differences indicate that in

Taganga the food of sea cucumbers is composed of additional sources of nitrogen, probably of anthropogenic origin. This could be due to wastewater discharges from the submarine outfall near Taganga Bay caused by the Taganga population. On the other hand, the $\delta^{13}C$ isotopic signatures of both sea cucumbers in Rodadero Bay did not vary significantly, indicating that they share a common food base, while in Taganga Bay *Isostichopus* sp. showed a significantly higher depletion than I. *badionotus*, suggesting that one of the species has a food source to which the other has access to a lesser degree or not at all, and in both scenarios this difference is accentuated during the dry season.

Effect of density, temperature and diet on the growth, survival and development of larvae and juveniles of *Isostichopus* sp.

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Isostichopus sp. is a variety of *Isostichopus badionotus*, proposed as a new species, which has been intensely fished in the Colombian Caribbean, arousing interest for its aquaculture. This study evaluated the effect of two culture densities (1 and 3 larvae ml-1), two temperatures (23 and 26°C) and two microalgae diets (*Isochrysis galbana*, *Chaetoceros calcitrans*, *Nannochloropsis oculata* 1:1:1 and *I. galbana*, *C. calcitrans* 1:1) on the survival, development and growth of its larvae. Larval culture lasted 22 days until metamorphosis to doliolaria larvae, 7 days later the first juveniles were observed with a size of 621.8+12.7 µm (+SE). The highest growth rates, survival and percentage of doliolaria larvae were obtained with 1 larva ml-1 (29.2 µm day-1 and 31.5% doliolaria larvae) and 26°C (28.4 µm day-1 and 10% doliolaria larvae). However, in the two diets examined, the larvae showed low growth rates (between 1.3 and 8.5 µm day-1), stagnation in development and high mortality. Our results indicate that it is feasible to culture larvae from *Isostichopus* sp. to juveniles, recommending the use of 1 larva ml-1 and 26 °C. However, to meet the nutritional needs of the larvae the inclusion of microalgae Pavlova sp. and *Tetraselmis chuii* in the diet is recommended. This paper reports for the first time the successful production of sea cucumber juveniles of this species in Colombia.

Black soldier fly as a sustainable shrimp feed

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The whiteleg shrimp *(Litopenaeus vannamei)* is globally one of the most important aquaculture species with an estimated annual production volume of about 6 million tonnes. Recently, attempts have been made to increase the overall sustainability of shrimp aquaculture. One of the targeted factors is the feed, which often uses fishmeal as the main protein source. As fishmeal is a driver of global overfishing and increases the risk of foodborne marine pathogens, non-marine protein sources such as insects may provide a safe and sustainable source of protein. The use of insects as feed could be a possible solution here. To test the performance of insects as aquaculture feed, we conducted a feeding trial in which we supplemented 25% of the standard compound feed with fresh black soldier fly (BSF) larvae *(Hermetia illucens)*. During the experiment, we recorded growth rates (size and weight) as well as amino and fatty acid profiles of the shrimp, and compared the data to a control group (compound feed only). While growth rates were significantly higher in the control group, survival rates were higher in the group fed with BSF larvae. This resulted in a similar total biomass for both treatments. The amino acid profile of BSF-fed shrimps had significantly lower levels of alanine, histidine, serine and tyrosine. The fatty acid profile of the shrimps showed no significant differences between the treatment and control groups. These results show that fresh BSF larvae can successfully replace portions of the standard fishmeal-based compound feed in an attempt to conserve the natural resources of the ocean. Moreover, preliminary life cycle assessments (LCA) indicate that the use of locally produced BSF may improve the carbon balance of shrimp aquacultures.

Benthic communities from Navigator Bank, Yuruparí Ridge, Colombian Pacific

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The Malpelo and Yuruparí oceanic ridges play a very important role in the ecological connectivity of the Tropical Eastern Pacific Marine Corridor. Particularly, the Navigator Bank, located on the Yuruparí ridge, is one of the most remote seamounts in the Colombian Pacific. Species of great importance – both ecologically and economically – including tuna, sharks, sea turtles and cetaceans, inhabit and migrate between the waters of the region that includes the Galapagos Islands (Ecuador), Cocos (Costa Rica), Coiba (Panama) and Malpelo (Colombia). Although preliminary

studies consider this bank to be a key piece in the connectivity of pelagic megafauna, little is known about its benthic structure.

In order to expand the baseline on biodiversity in the region and provide solid scientific information as input to decision makers, the National Geographic Pristine Seas-Colombia expedition was carried out between March and April 2022. During the expedition, we explored the Navigator Bank as the first of a total of three phases that included also the Tribugá region, in the Colombian Pacific, and the Seaflower Marine Sanctuary, in the Colombian Caribbean. On board the Argo vessel and the DeepSee manned submersible, 5 dives were made between depths of 150 and 268 m. During the dives, the benthic and benthopelagic fauna were recorded. Four of the dives were directed to the visual characterization of the communities, while in the last dive some of the most representative benthic invertebrates were collected using a hydraulic arm.

The exploration of the Navigator Bank revealed unique deep ecosystems, where six main habitat types were found, that included: 1- rock and sand (180-220 m), 2- boulders (150-260 m), 3- sand (190-200 m), 4- hard bottom (230-250 m), 5- rocky walls (240-255 m), and 6- sand with pebbles (160-270 m). In total, we report 79 taxa belonging to 9 phyla. Numerous slow-growing corals and sponges were observed; these taxa are considered to belong to Vulnerable Marine Ecosystems (VME) according to international standards due to their vulnerability to different fishing gear. Although this study presents some preliminary results, the great biodiversity, uniqueness and endemism of the area is evident, as well as the threats it currently faces, thus justifying its conservation.

Denim microfibers released from industrial washing processes as a s ource of marine microplastic pollution

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Domestic washing of denim garments releases over 4 million microfibers per wash that can potentially reach marine environments even after passing through wastewater treatment facilities. Among the released microfibers, microplastic fibers or synthetic microfibers are classified as an emergent pollutant recognized by the U.N. in the Sustainable Development Goal number 14.1. Although 2 studies in Latin America, excluding Venezuela, have focused on quantifying the microfiber release in domestic washing machines of textiles, little is known about the microfiber release from industrial washing processes, with emphasis on the lack of available information for denim garments. Said information is required to establish a life cycle assessment (LCA) of denim garments and their impacts to the environment, in particular the marine Caribbean ecosystem that presents a high degree of biodiversity that can be negatively affected by microfiber pollution. The aim of this study was to quantify the microfiber mass released from 3 common denim industrial washing processes (rinse

wash, acid wash & enzymatic wash) that present increasing abrasive properties to the denim garments. Furthermore, the annual microfiber emission of an average denim industrial laundry was estimated as a proxy of microplastic fibers released to marine environments. The full effluent (20 L) of 3 industrial washing processes of denim garments were collected in stacked metal sieves (1 mm, 500 µm, 250 µm, 125 µm & 45 µm). The microfiber mass was obtained via a gravimetric procedure. Strict QA & QC protocols were followed to prevent airborne microplastic contamination. The enzymatic wash released the highest microfiber mass of all the industrial denim washing processes, which coincides with the most abrasive washing process, with 0.15 g/L of washing machine effluent (equivalent to 2.12 g/Kg of denim garment), followed by the acid wash with 0.083 g/L of washing machine effluent (0.83 g/Kg of denim garment) and concluding with the rinse wash with 0.033 g/L of washing machine effluent (0.42 g/Kg of denim garment). Furthermore, the highest mass of microfibers was recorded in the 1 mm – 500 µm size fraction for the rinse wash and in the 250 µm – 125 µm size fraction for both the acid and enzymatic washes, which appears to indicate that the more abrasive washing processes tend to produce smaller microfibers than milder washes. Furthermore, it was estimated that on an average year, a medium sized industrial laundry can produce 21.4 Kg of microfibers for the rinse wash, 10.6 Kg of microfibers for the acid wash and 9.1 Kg of microfibers for the enzymatic wash that can potentially reach marine environments. In conclusion, industrial laundries are a relevant source of synthetic microfiber pollution to marine environments, which highlights the need of studying microfiber emissions from industrial laundries, as most studies focus on domestic washing emissions. The quantification of microfibers is necessary in the context of LCAs that provide critical information needed to develop national and international regulations on microfiber and microplastic pollution from the textile industry.

Experiences in restoration trials of *Thalassia testudinum* in San Andrés Island, Colombian Caribbean

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The conservation of seagrass meadows, ecosystems that, due to their ability to retain organic carbon for long periods of time, are part of the "blue carbon ecosystems", is essential to mitigate climate change. The aim of this study was to explore the efficiency of two planting methods for the restoration of *Thalassia testudinum* meadows in the Colombian insular Caribbean. In Old Point, San Andrés Island, Colombian Caribbean, three areas were selected at the edge of a meadow that have different depths (0-2m, 2-4m and 4-6m), in each of them 12 quadrants of 1m2 were placed, using two different planting techniques: anchorage stems (hook) and live cores. Results after two years of monitoring show a survival of 26% of the initial sowing, being more effective in the shallowest zone (60%). The core method (67%) and the hook method (55%) are positively established, while in the other zones it did not reach 10%, indicating that physical factors such as depth, sedimentation

or grain type, and chemical factors such as Organic Matter and inorganic nutrients (silicates and orthophosphates), analyzed would be determining the establishment and development of steams of this species in sandy bottoms adjacent to mature meadows. We have now restored 4.7 m2, 2.1 times what we initially planted. Our projections indicate that, if its rate of development continues, after the eighth year of planting, the first hectare restored in the area could be reached, which would be happening faster than what has been recorded in other areas with similar techniques.

Short-term water flow changes may mitigate effects of long-term ocean acidification in reef-building corals

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Ocean acidification (OA) can act as a major threat to reef-building corals. Although water flow variability is common in coral reefs and modulates coral physiology, the interactive effects of flow and OA on corals remain poorly understood. To address this gap, we performed a three-month OA experiment investigating the effect of changes in water flow on coral respiration and photosynthesis. We exposed the reef-building corals *Acropora cytherea*, *Pocillopora verrucosa*, and *Porites cylindrica* to control (pH 8.0) and OA (pH 7.8) conditions at constant moderate flow (6 cm s-1) and measured their growth to monitor OA effects on growth. During the experiment, we exposed the corals to low flow (2 cm s-1) for 1.5 h and compared their immediate responses in respiration and photosynthesis with those under moderate water flow. Corals in the OA treatment calcified on average 21 % less and grew 25 % less in surface area than those at ambient pH (maintained under constant moderate flow). OA had an increasing effect on respiration relative to rates prior to the start of the experiment, except in *A. cytherea* under low flow. Net photosynthesis was unaffected by OA with the exception of *A. cytherea*, in which relative values decreased more under moderate than low flow. We also found time-delayed responses in photosynthesis:respiration ratios (P:R), which showed complex interactions with flow. After 10 weeks of OA, P:R decreased in *A. cytherea* and *P. cylindrica* only in moderate flow. Overall, our results suggest that short periods of changed flow conditions may aggravate or mitigate OA effects, depending on coral species and point to short-term water flow variability as a factor to consider in assessments of long-term climate change impacts.

Spatiotemporal distribution of the partial pressure of CO_2 in the Mediterranean Sea in 2011: Air-sea CO_2 fluxes estimate

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This study aims to reconstruct the seasonal cycle of the partial pressure of CO_2 (pCO_2) in the Mediterranean Sea during the year 2011 for a better estimation of this little-measured parameter.

The method used consists of the determination of linear regressions linking in situ measured parameters (Sea Surface Temperature, Salinity, and Apparent Oxygen Utilization) with Total Alkalinity (AT) and Dissolved inorganic carbon (DIC), based on data from oceanographic cruises carried out in 2011. These equations allowed us to build, first, a surface distribution of these two carbonate system properties, then a surface distribution of pCO_2 and air-sea fluxes of CO_2.

The comparison between our results and measured pCO_2 data in the Mediterranean Sea, from the SOCAT dataset (version 2021), yields the estimation of a Root Mean Square Deviation (RMSD) between 24.7 and 27.7 µatm. Nevertheless, from one season to another, the error is relatively close, so the estimated seasonal variability should be correct since the errors cancel each other out. Another comparison test was carried out between our results and those of CMEMS model outputs (MEDSEA_MULTIYEAR_BGC_006_008) (RMSD = 26.5 µatm); the latter has an RMSD of 20.9 µatm compared to the SOCAT dataset.
Our results showed that the pCO_2 in the Mediterranean Sea is characterized by a very marked seasonal cycle with a minimum in winter (349 ± 27 µatm) and a maximum in summer (428 ± 37 µatm), governed mainly by temperature and, to a lesser extent, mixing and air-sea exchanges. The highest values are observed in the western Mediterranean basin, with a range of variation of [314; 529 µatm] where the mean pCO_2 of the Algerian and the Tyrrhenian sub-basins exceeds 400 µatm, vs [240; 525 µatm] in the eastern basin, with minimum pCO_2 values in the Adriatic sub-basin (~360 µatm). In 2011, the Mediterranean Sea was a CO_2 sink in winter and spring and became a source of CO_2 to the atmosphere in summer and autumn. The western basin played, on average, the role of a source of CO_2 to the atmosphere (+19.36 GmolC/year), while the eastern Mediterranean was a CO_2 sink by absorbing 208.41 GmolC/year. This sequestered carbon plays a relevant role in global warming mitigation and understanding of water acidification, and thus climate change.

This study is highly important because it allows the estimation of pCO_2 values using three easily-measured oceanographic parameters (T, S, and UAO), with results in the same error range as currently used models (e.g., CMEMS).

The role of ecosystem services and benefits associated to marine artisanal fisheries in human communities: current threats and drivers of change in the Golfo de Salamanca, Colombia

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Marine-coastal ecosystems provide fundamental benefits and ecosystem services to human communities, such as food, materials, and protection from natural phenomena. However, their use also generates ecological distribution conflicts among several actors, including artisanal fishers. This research assessed the state of ecosystem benefits and services associated with marine artisanal fisheries based on fishers' local ecological knowledge to identify historical changes in their provision and also the drivers of change that have threatened the ecosystems, biodiversity and fishing activity in the Golfo de Salamanca. 44 interviews were conducted with experienced fishers (they employ traditional methods like *boliche*, *chinchorro*, *linea de mano*, *palangre*, *and trasmallo*) who identified 11 benefits and ecosystem services associated with fisheries, dependant on the ecosystem's health and conservation. Fishers highlighted the contribution of fisheries to their quality of life, access to work, and good nutrition, but mentioned that these have declined during the last fifteen years because of several threats, mainly related to marine pollution, traditional fishing zones displacements and resources decrease. The participants firmly believe that if actions are not taken immediately, this trend will continue, at least, during the next 15 years, risking their livelihood and future generations. Meanwhile, contributions of fisheries to the community's quality of life, access to work, and good nutrition were the most recognized benefits and services. Also, fishers acknowledged the role of ecosystems in the maintenance of artisanal fishing and the importance of protecting coral reefs and mangroves. The results suggest differences in the average fish consumption per capita at local, regional, and national levels, although fish is one of the most important sources of animal protein in the study zone, and it's preferred over other animal protein sources like beef or chicken. Participants identified 24 threats and drivers of change that affect their surrounding ecosystems and fishing activities. For instance, the loss of their traditional fishing zones (46%) and coal contamination (46%) negatively affect the quality and presence of the fishing resources and their work conditions as well. Participants pointed out the need to improve regulations, especially when it comes to destructive fishing practices and increasing the support to the fishing sector, they proposed and showed interest in the adoption of better fishing practices and the use of their traditional knowledge, as possible contributions to the study and conservation of fisheries. This study contributes to the understanding of the socio-ecological system in the Golfo de Salamanca and becomes a clear example of the relevance of fishing for coastal communities in Colombia, likewise, this research makes visible the vulnerability that this activity faces in the present and future, risking the viability of fishers and fisheries.

Giant isopods (*Bathynomus giganteus*) as key organisms in the carbon cycle in deep waters of the Colombian Caribbean

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The concept of Blue Carbon has been used to describe the great contribution of coastal and oceanic marine ecosystems to the carbon sequestration from the atmosphere, and its interest has increased due to the need to reduce and mitigate global climate change. It is known that deep-sea systems are important sinks for carbon, but little is known about the organisms involved in the cycle and the mechanisms that lead to carbon storage in deep-sea sediments. Marine macroalgae help to retain carbon at rates similar to or even higher than those of angiosperms in coastal areas. These detach from their substrate, stay at the mercy of the currents for some time, and sink to great depths. Once they reach the ocean floor, different organisms contribute to its decomposition, finally depositing the carbon in the marine sediment where it will remain isolated from the external environment for thousands to millions of years. This is why macroalgae play a key role as carbon donors to deep-sea sink-reservoirs. It has been suggested that the giant isopods of the genus *Acellota*, which inhabit the western tropical Pacific, may be one of these organisms that contribute to the consumption of macroalgal sources that come from surface waters, so it is expected that other species of giant isopods fulfill this same role.

This project seeks to determine the presence of macroalgae or photosynthetic organisms in the stomach content of 118 giant isopod specimens *Bathynomus giganteus*, inhabitants of deep waters (300-1800 m deep) of the Colombian Caribbean. For this purpose we sampled specimens of *B. giganteus* previously collected and deposited in the invertebrate collection of the Makuriwa Museum, of the INVEMAR Marine and Coastal Research Institute. Stomach content samples were obtained by making ventral incisions from the seventh segment of the cephalothorax to the third segment, in order to extract the entire stomach of each individual. DNA extraction from stomach content and molecular analysis were performed through two sequencing methods. The first corresponded to the amplification of mitochondrial and chloroplast genes for the identification of red, brown and green algae. For the second method, samples from which high molecular weight DNA-extractions were obtained, were sent for metagenomic sequencing.

During the extraction of the stomach contents, 3 agglomerations of macrocolonies of cyanobacteria of the genus *Lyngbya* were found. Being a photosynthetic organism, it is likely carried by currents from shallow water to deep water where it was consumed by the isopod. Although this is an ongoing project and we are close to having the molecular results that allow us to confirm the presence of algae, with the identification of *Lyngbya*, we could early consider that *B. giganteus* does consume photosynthetic organisms and thus contributes to the final deposition of carbon in deep waters of the Colombian Caribbean.

Structure and successional dynamics of microbial epilithic biofilm communities across the tidal gradient in the rocky shore

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The structure and dynamics of assemblages of marine microorganism communities that form epilithic biofilms in rocky shores are molded by various physical and biological processes that have been scarcely studied. Whether microbial ecological succession follows 'ordered' patterns of composition and richness across the strong environmental gradients encountered on rocky shores or whether more stochastic organization dominates these communities are open questions addressed through experimental manipulations, microscopy, and molecular techniques. To study the effects of the successional stage and the vertical intertidal environmental gradient on the structure of the microbial community, biofilms were collected from experimentally installed rock surfaces on day 7 and 30 at high, middle, and low intertidal zones of Quintay rocky shore. Biofilms were qualitatively analyzed with scanning electron microscopy and quantified through 16S and 18S rRNA gene sequencing by MiSeq Illumina. Biofilms more densely populated by microorganisms were observed at 30 days at all tide levels. Therefore, clear stages of ecological succession along the environmental stress gradient were found. The bacterial component was dominated by Proteobacteria and secondarily by Bacteroidetes, being richer, more diverse, and more equitable in the low intertidal zone. Also, the eukaryotic component at 7 days is dominated by representatives of the Opisthokonta supergroup (e.g., Fungi and Metazoa). However, after 30 days, there are mainly photosynthetic microorganisms such as Stramenopiles, Archaeplastida and Alveolata. Therefore, strong ecological successional processes appear to occur in rather deterministic ways in these microbial communities, and the stress gradient modifies composition and diversity. Still, it does not seem to override successional interactions within these assemblages, at least over the 30 days of the study. Based on this, it is concluded that microbial community structure and dynamics of the assemblage of epilithic biofilms on the intertidal rocky shore are determined by the successional stage and intertidal zone they inhabit.

Chronic exposure to microplastics does not affect physiology of reef-building corals

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The marine environment gets increasingly polluted with plastic waste on a global scale. Plastic particles < 1 mm, so-called microplastics, are increasingly reported to affect marine biota. Especially suspension feeders like reef-building corals are prone to contact and accidental ingestion. However, previous studies have not provided a consistent picture regarding the negative effects of microplastics on corals: From no impairment to disruption of symbiosis, reduced feeding, growth, necrosis, and even mortality. Differences may be explained by a combination of species-specificity, the type of microplastics used, exposure duration, and concentration. As the knowledge about the physiological effects of chronic microplastic exposure on corals remains limited, we investigated the long-term effects of environmentally relevant concentrations of microplastics on coral physiology. Specifically, we explored the effects on (I) energy reserves and metabolite (i.e., amino acid) profiles of the coral hosts, (II) coral growth, and (III) associated photosymbionts. For this, we conducted a fifteen-month controlled aquarium experiment in which four coral species (*Acropora muricata*, *Pocillopora verrucosa*, *Porites lutea*, and *Heliopora coerulea*) were exposed to polyethylene microplastics at a moderate concentration (200 particles L^{-1}). A microplastic-free control group served as a comparison. We analyzed lipid-, protein-, and carbohydrate content, assessed the levels of selected amino acids, analyzed coral growth (i.e., change in surface area, volume, and weight), and the state of symbiosis (i.e., chlorophyll content and symbiont density). The corals from the long-term microplastic exposure showed no significant changes in the parameters tested compared to the control group. The results indicate that moderate concentrations of microplastics might not affect otherwise healthy corals, possibly due to mitigating effects resulting from symbiosis (e.g., stable energy supply via photosynthesis).

Contamination in sediments by heavy metals (As, Cd, Cr, Cu, Hg, Ni and Pb) in the Colombian Caribbean

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Heavy metals have become relevant pollutants that are released into the environment by anthropogenic and natural sources. These can reach marine and coastal ecosystems through river discharge and other atmospheric processes. In the Colombian Caribbean, the Magdalena River and the Sinú River contribute large

amounts of sediments that contain multiple pollutants like heavy metals. When comparing the sediments present in the areas of influence of both rivers, the Sinú River presented significantly higher concentrations of heavy metals, in contrast to those reported in the Magdalena sector. The metals Cr, Cu and Ni were the ones that presented the highest concentrations, even exceeding the reference values proposed by some international environmental authorities. These concentrations are due to the fact that in the Sinú sector, which has a wide use of pesticides and fertilizers for agricultural and livestock activities, there are sediments with a greater amount of small particles, mainly very fine sand, fine sand and silt. Therefore, it is important to maintain continuous monitoring to generate early warnings in the event of heavy metal contamination in marine and coastal ecosystems in these sectors.

CEMarin

ICMS 2023

Panels

Challenges and Opportunities in International Cooperation

Moderator:
Dr. Paula Zapata, Pontificia Universidad Bolivariana

Panelists:
Dr. Sergio Cristancho, Vice Minister of Knowledge, Innovation and Productivity of Colombia

Catherine Fonseca, Coordinator of International Cooperation Projects, Universidad Tecnológica de Bolívar

Dr. Gordon Wilmsmeier, Kühne Professorial Chair in Logistics, Universidad de los Andes

Dr. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research, Kiel University

This panel focused on the importance of international cooperation and scientific diplomacy for the marine sciences in Colombia and worldwide. From their diverse perspectives and sectors, the panelists shared their experiences of international cooperation -including both the difficulties and benefits- to achieve high impact projects. The panelists discussed key national and international allies and funds for the development and execution of projects, the role of public and private institutions in facilitating these processes, and

Oceanographic Expeditions

Moderator:
Dr. Andrés Osorio, CEMarin Executive Director and Universidad Nacional de Colombia

Panelists:
Dr Oscar Álvarez Silva, Universidad del Norte and Co-Principal Investigator of the María S. Merian Expedition on the Magdalena River Delta

Cristina Cedeño, Scientific Researcher, Invemar, Instituto de Investigaciones Marinas y Costeras "José Benito Vives de Andreis"

Captain Juan Camilo Forero Hauzeur, General Secretary, Colombian Ocean Commission

Dr Luisa F. Dueñas, Universidad Nacional de Colombia and Researcher in the Pristine Seas expedition in the Colombian Pacific

Juan Mayorga, Marine Data Scientist, Environmental Market Solutions Lab (emLab), University of California Santa Barbara and Pristine Seas, National Geographic Society

As a bi-oceanic country, Colombia has huge potential in terms of oceanographic expeditions in both the Caribbean and the Pacific. In this panel, the participants

discussed their experiences of both national and international expeditions, the contributions of these expeditions to issues like the declaration of Marine Protected Areas, the collection and use of the data gathered, and the need for access to different technologies to ensure successful expeditions.

Presentation of the book "Climate Change Mitigation and Adaptation in the Seaflower Biosphere Reserve: From Local Thinking to Global Actions"

Moderator:
Louise Lowe, CEMarin Communications and Project Support Professional

Panelists:

Dr. Juan Felipe Blanco-Libreros, Universidad de Antioquia (author)

Dr. Ernesto Mancera Pineda, Universidad Nacional de Colombia (editor and author)

Dr. Andrés Osorio, CEMarin Executive Director and Universidad Nacional de Colombia (editor and author)

Julián Prato, Universidad Nacional de Colombia (author)

Dr. Carolina Velásquez, Universidad Nacional de Colombia (editor and author)

In 2023, CEMarin publishes its first book "Climate Change Mitigation and Adaptation in the Seaflower Biosphere Reserve: From Local Thinking to Global Actions". This interdisciplinary work, published by Springer Nature as part of its Disaster Risk Reduction series, includes diverse themes like marine and coastal biodiversity, ecosystem services, fisheries, indigenous Raizal culture, research and education, and the impact of hurricanes on tropical ecosystems, and offers tools like maps, models, methodologies for ecosystem restoration, and local knowledge on fishing and agriculture, among many others, to contribute to reconstruction efforts following Hurricane Iota in November 2022 and in a panorama in which hurricanes are expected to increase in frequency and strength in the near future due to climate change. The editors and authors of the book who participated as panelists discussed issues like their hopes and expectations for the publication, the challenges they have faced in the editorial process, and the contents of their chapters.

Sponsors

Performance evaluation of a combined ADCP-scientific echosounder system

David W. Velasco[1], Briony Hutton[2], Dominique Lefevre[3], Bruno Zakardjian[3], Carl Gojak[4], Karim Mahiouz[4], Celine Heyndrickx[4], Sven Nylund[1], Antoine Bezile[1], Cristobal Molina[1]
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The continual global increase in human population is prompting governments to assess protein sources with greater detail. Oceanic fish stocks are one such source which are receiving considerable attention due to their potentially vast contribution to solving the growing global protein requirements, in addition to being a key component of the marine ecosystem. Acoustic technology is widely used in quantifying fish stock biomass and fish behavior. Acoustic technology (in the form of ADCPs, or Acoustic Doppler Current Profilers) has also been used to accurately measure currents in all of the world's major water bodies over the last 30 years. The present work evaluates the performance of the Nortek Signature100 ADCP, with primary focus on data from its high-resolution acoustic backscatter transducer.

The system belongs to the Signature Series family of ADCPs launched in 2013 by Norwegian scientific instrumentation company Nortek. It is powered by the AD2CP electronics platform, described in United States Patent 7.911.880. The four slanted beams operate at a center frequency of 100 kHz and can profile currents over a range of up to 400 m with 4 m spatial resolution and sampling rate up to 1 Hz. The center vertical beam has a wider frequency band, from 70 to 120 kHz with a high dynamic range of approximately 130 dB operating in up to three discrete pulse characteristics: 1) 70 kHz monochromatic, 2) 120 kHz monochromatic, and 3) 91 kHz chirp with 50% bandwidth and pulse compression. This latter pulse type offers a spatial resolution of 37.5 cm and the pulse compression technique allows for this increased range resolution with limited increase of maximum transmit power required to maintain a suitable Signal-to-Noise Ratio (SNR).

Due to its combined current profiling and scientific echosounding capabilities, the system is seeing increased usage in biomass flux applications, particularly in Antarctic krill research. However, capabilities of the system are still being studied and the present work aims to expand characterization of its performance. To that effect, a four month deployment was carried out by the French National Centre for Scientific Research (CNRS) on the Mediterranean Sea with an up-looking Signature100 mounted near the bottom in about 400 m water depth. Initial data visualization showed significant variations in scattering conditions between daytime and nighttime due to diel plankton migration, often unrelated to velocity fluctuations, highlighting not only the dual bandwidth capabilities of the system but also the strength of the combined echosounder and current profiling functions.
Echoview, a commercial software package for hydroacoustic data processing, was then used to further explore the spatial and temporal patterns of the organisms

observed in the echosounder data. A semi- automated technique was implemented to efficiently and objectively clean (e.g. remove interference generated by passing ship traffic), classify (e.g. based on relative frequency response or morphology), and characterize the narrowband and pulse compressed Nortek Signature100 echosounder data by generating outputs that can contribute to the management and monitoring of aquatic resources.

The instrument presented in this work greatly expands collaboration possibilities between fisheries biologists and physical oceanographers, by offering a combined high performance current profiler and scientific echosounder in a single instrument. The work presented here will provide further examples of this.

Speaker Index

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