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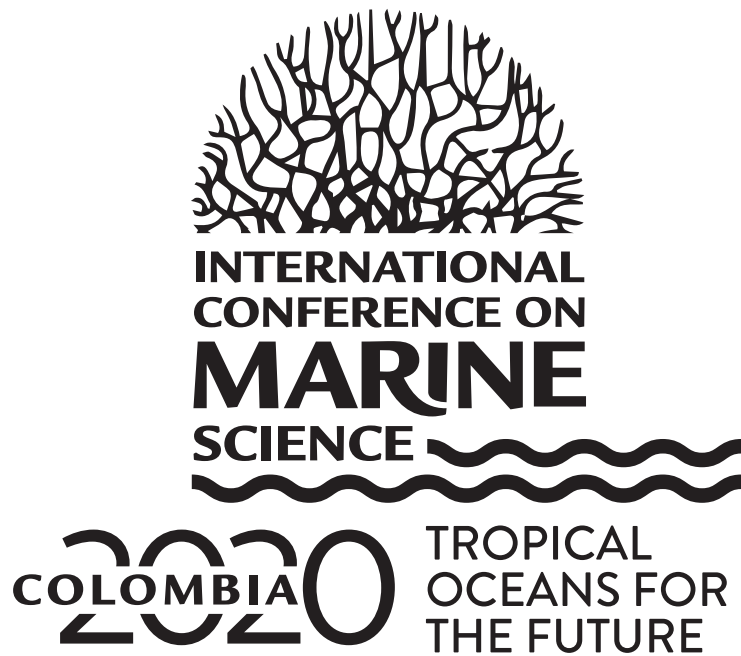
**Book of
Abstracts**

Colombia 2020:

International Conference on Marine Science

Tropical Oceans for the future

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Abstracts**



Colombia 2020:

**International Conference
on Marine Science**

Tropical Oceans for the future

The International Conference on Marine Science 2020, Colombia: Tropical Oceans for the Future is an event organized by the Corporation Center of Excellence in Marine Sciences - CEMarin.

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The International Conference on Marine Sciences 2020: Tropical Oceans for the Future, was the second on a series of international conferences organized by the CEMarin. This new reality we all face has opened new opportunities of interaction, allowing us to gather an extraordinary group of expert scientists, young researchers and decision makers, to discuss the latest scientific research on marine sciences and the emerging issues for the management and understanding of tropical marine ecosystems.

Ocean ecosystems worldwide are on the brink of collapse. Therefore, sustainable use of their resources has become mandatory, even more in the face of global change. In this context, the United Nations proclaimed the Decade of Ocean Science for Sustainable Development (2021-2030), aiming to reverse its degradation, where science-based decisions are crucial to reach a real positive transformation of our oceans and coastal territories. In this context, the ICMS 2020 opened up discussions around (1) the impacts of climate change and other global issues related to the health of oceans, (2) the complexity of interactions among ocean-land and atmospheric systems, (3) the sustainable use of marine resources, (4) the co-production of knowledge between academia and society towards participatory-based conservation strategies, and (4) the challenges we face to collect and systematize big data, in order to make decisions for a more sustainable future.

This edition joined together over a thousand participants from 54 countries, with 93 contributions from scientists, students, and managers from eight different countries. For a full week, we met around cutting-edge ideas in talks, posters and speed-talk presentations, four workshops, and networking sessions all framed by a formidable team of Keynote Speakers and special guests.

We would like to extend our gratitude to all the participants. Also, we acknowledge the work of our predecessors during this 10-year journey, having promoted our Corporation Center of Excellence in Marine Sciences - CEMarin to become a unique example of academic and scientific collaboration between Latin American and European universities, helped by the continuous support of DAAD and the constant dedication of its members. However, we face an enormous challenge for this new phase, starting for us with this event. This new reality of major environmental challenges and societal reconfiguration calls for imperative and urgent action, demanding a united scientific community working for and with society, as it is the only possible way to build a better future for the oceans and for humanity.

Co-chairs, Dr. Andres Fernando Osorio and Dr. Catalina González

Aims and objectives

This book of abstracts summarizes the works presented at the International Conference on Marine Sciences (ICMS 2020): “Tropical oceans for the future” held virtually. It was the second in a series of international conferences organized by the Corporation Center of Excellence in Marine Sciences (CEMarin) and supported by the German Academic Exchange Service (DAAD).

On the occasion of the 10th anniversary of the CEMarin, the conference brought together more than 1000 students, scientists and decision makers from 44 countries. The participants spent six days discussing emerging issues for the protection, management and sustainable use of tropical marine ecosystems in Colombia and across the planet. Integrating the fields of global change research, marine biology, oceanography, socioeconomy and big data science, the major findings of the conference were:

1. The global problems faced by our oceans can only be adequately addressed through interdisciplinary approaches and international collaboration
2. Continuing warming of the tropical oceans is considered the most severe threat to ecosystems, organisms and coastal populations
3. In addition to key environmental factors, socioeconomic drivers such as market gravity significantly affect marine ecosystems
4. However, the effects of climate change on marine organisms and ecosystems are multifaceted, and the consequences for biodiversity and sustainable use of marine resources are often poorly understood
5. Quantification of current and future impacts of environmental change on coastal productivity, biodiversity and fisheries requires the measurement of biotic and abiotic parameters in real time and over the long term
6. The process of valuation of ecosystem services is becoming increasingly important for connecting marine ecosystems and human well-being
7. Big data are essential for measuring and modeling environmental changes in the oceans
8. Environmental data should be collected in a coordinated and standardized fashion, and access to data should be free and timely
9. Solving problems in tropical oceans requires cross-ecosystem approaches that assess the close interplay of marine, freshwater and terrestrial ecosystems
10. Addressing the complex problems in tropical oceans requires coordinated interdisciplinary and international training programs for graduate and post-graduate students
11. The new reality of major environmental changes and societal reconfiguration calls for immediate science-based actions to halt the degradations of the tropical oceans and coastal areas.

Inspired by the great success of ICMS 2020, the next conference will be held in 2022.

Ocean-land-atmosphere interactions



Photo: Miguel Angel Avila on Unsplash

Theme 1

The Role of submerged canopies in releasing wave-induced steady currents shoreward

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Abstract

Aquatic vegetation provides a wide range of benefits and services for ecosystems such as the production of oxygen, improvement of water quality, sheltering of important species, prevention of shoreline erosion by damping waves and storm surges, reduction of the oscillatory velocity inside the canopy, and the increasing of turbulence at stem length scales. Besides, the generation of a shear layer in the velocity profile at the canopy top increases the wave stress term, the mechanism in charge of releasing a mean current shoreward by a balance against the form drag force. However, the effects due to other factors such as the wave decay throughout the canopy, and/or the vertical gradient of the turbulent stress are not yet well understood. In this study, dimensional analysis of the momentum equation is performed at the wavelength (λ) and water depth (h) spatial scales over a long period (t) to develop a depth-dependent wave-induced steady current as a function of the incoming wave characteristics and submerged canopy properties. The analytical model is compared with laboratory data for rigid stems and with numerical data for flexible elements presenting a good agreement, allowing the model to be extended to coastal scale and real-field applications.

Tidal-river interactions in the estuary of the Magdalena River. Redefining the estuary extension

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Abstract

At the mouth of the Magdalena River Estuary (MRE), the tidal range only reaches 0.60 m during spring tides. When comparing the tides with the mean freshwater discharge of 7000 m³/s of the Magdalena River, it is easy to understand why the effect of the tides in the hydrodynamics of the MRE has been systematically neglected in the scientific literature. However, a recent inter-institutional effort to improve the monitoring of the main physical environmental variables of the MRE has allowed revealing the notorious effect of tides in the main physical processes of the estuary. We used data from a set of water level gauges installed along the last 40 km of the Magdalena River and complemented this data with analytical derivations of the N-S equations for describing the celerity and damping of the tide in unconverging river-dominated estuaries such as the MRE. As a result, we were able to revisit fundamental aspects of this estuary such as its extension, frictional effects of the channel, and tidal-river interactions. This is the first step for an analytical and data-based understanding of the circulation patterns, saline interchange, and human-induced effects on the dredging, narrowing, and aligning of these important systems for the freshwater and sediment balance of the Caribbean Sea and the sustainable development of the Colombian Caribbean region.

Differences in Sea Surface Temperature and Sea Level in the Colombian marine coasts by the year 2100 according to MPIOM data

Corinne Daniela Gonzalez Duque, Nancy Liliana Villegas Bolaños
Universidad Nacional de Colombia

Abstract

Anthropogenic forcing generates observable climate changes in sea surface temperature (SST) and sea level (SL) across the planet. Since the Caribbean and Pacific coasts of Colombia are vulnerable to this forcing, in this article we use the results of the Max Planck Institute Ocean Model (MPIOM) to describe the SST and SL in the study areas by the year 2100. The SST and SL, which were run by MPIOM under Representative Pathways of Concentration (RCP) 4.5 and 8.5, allowed to obtain climatologies of 30 years every 10 years during the period 2010-2100. These climatologies were analyzed statistically and graphically to find relationships between the variables and factors that influence the Colombian climate, such as the Caribbean Low-Level Jet (CLLJ), the Chocó Low-Level Jet (ChLLJ), and the Intertropical Convergence Zone (ITCZ). The SST and SL of RCP 4.5 and 8.5 showed different characteristics on the Colombian Caribbean and Pacific coasts, taking into account factors that affect differentially SST and SL in each sector for the year 2100: 1- the SST is higher in the Caribbean Sea, which showed a unimodal SL regime; 2- the SL is higher in the Pacific Ocean with a bimodal regime; 3- the SST showed a positive trend and higher amplitudes of climatological oscillation in RCP 8.5; 4- the SL showed more extreme values and a slight decrease at the end of the century in the RCP 8.5.

Biomechanical ecosystem services in coastal protection along temperate climate coastlines of the North Sea

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Abstract

The research project “Gute Küste Niedersachsen” investigates which factors account for good coastal conditions along temperate climate coastlines, focusing on the symbiosis of human settlements and sustainable coastal protection. A focal point of the project is the strengthening of ecosystems in the vicinity of the coastal protection works outlined here. Specifically, the identification of vegetation-bound effects within salt marshes and coastal dune systems at the North Sea coast of Lower Saxony, Germany is addressed here.

The overarching goal of the transdisciplinary project is to gain knowledge of natural or nature-based systems and their processes within real-world laboratories at the coast to incorporate ecosystem services into coastal protection design guidelines and promote integrated coastal zone management.

Methods include field observations and experiments, hydraulic laboratory experiments, and numerical simulations over the course of 5 years. During the first years,

systematic observation of vegetation regarding the zonal occurrence, growth, density, and biomechanical properties is conducted. Simultaneous measurements of environmental parameters covering waves, currents, and soil properties yield a comprehensive data set for analysis, numerical and analytical modeling purposes. Hydraulic experiments modeling the wave-vegetation-soil interaction will be devised based on field data, developing dynamically and geometrically scaled vegetation surrogates. Besides vegetation properties aboveground, previously overlooked root system effects that are hypothesized to govern erosional processes in salt marshes and dunes will be of particular interest.

At present, two field laboratory sites are selected based on a site assessment matrix for the coastline, thus incorporating expert feedback. The first surrogate model designs are under development and field methods are being evaluated.

Atmospheric water transport between the Caribbean Sea, North of South America, and the Tropical Pacific Ocean: connections with the ocean

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Universidad Nacional de Colombia

Abstract

The salt balance between the Pacific and the Atlantic Oceans is essential for the Global circulation belt. Differences in salinity between the Pacific and the Atlantic are maintained by the humidity transport from the Atlantic to the Pacific through the atmosphere. Most of this transport occurs in the tropical region of the SW Caribbean (Colombian basin), North of South America, Central America, and Panama basin (Pacific), with several low-level jets. As a result, the Eastern Pacific Fresh Water Pool is formed. This work aims to represent the circulation of atmospheric water in this region and its connection with ocean salinity. To achieve this, we quantified the atmospheric water flows on the Caribbean and Pacific catchment areas (including the continent and the ocean) and the balance between their inflows and outflows on different time scales (mean, seasonal, and interannual). Since the excess or insufficient water for each balance is received or lost (respectively) by the ocean, the results were compared with the surface salinity of the Colombian and Panama basins over the different time scales. The atmospheric mean balance is consistent with the ocean's mean salinity, i.e., the net balance of the Caribbean catchment area is negative, while that of the Pacific is positive. This indicates that while the Colombian basin loses water (salinity increases), the Panamanian basin gains ten times more water (salinity decreases). However, seasonal and interannual results showed decoupling. The results reveal interesting information about the flows of water in this relevant corner of the planet.

Turbulent analysis of the effects of the roughness of a coral specimen under steady flow conditions

Juan Pablo Ramírez Monsalve, Andrés Gómez Giraldo, Andrés Fernando Osorio Arias, Juan David Osorio Cano
Universidad Nacional de Colombia

Abstract

This study seeks to determine the influence of the roughness associated with a coral species (*Stylophora pistillata*) on the hydrodynamics of the incident flow by analyzing the turbulent motions generated around the coral structure. The experiment was carried out in a laboratory flume, where the coral was exposed to stationary flow with Reynolds numbers of 5624, 11249, 16863 and 22497. Velocity measurements were taken in two scenarios: coral with and without living tissue. Turbulent motions were studied via quadrant analysis, divided into four types: transport away from the bottom with an increase of upper layers velocity (outward interactions), transport away from the bottom with a decrease of upper layers velocity (ejections), transport towards the bottom with a decrease of lower layers velocity (inward interactions), and transport towards the bottom with an increase of lower layers velocity (sweeps). Results indicate that the predominant motions for both scenarios are ejections and sweeps, increasing its dominance as the Reynolds numbers increase. However, the behavior of each motion varies depending on the coral state. For the coral with living tissue, the motions were dominated by the ejections and a little less by the sweeps, showing that, in this case, the more energetic motions generate a transport away from the coral delaying the upper layers, followed in importance by motions towards the bottom. On the other hand, for the coral without living tissue, the occurrence of these two types of events and how energetic they are was more balanced, especially for the lowest Reynolds numbers.

Estimation of frictional coefficients across a barrier reef. Case study: San Andrés Island, Colombian Caribbean Sea

Juan David Osorio-Cano¹, Paula Andrea Espinosa¹, Julián Prato¹, Margarita López¹, Andrés Osorio¹, Adriana Santos¹, Alejandro Orfila²
Universidad Nacional de Colombia¹, IMEDEA²

Abstract

The transformation of surface gravity waves across a barrier reef at San Andrés Island in the Colombian Caribbean Sea was examined through field measurements. Pressure sensors were located offshore the reef crest, at the northeast side of the barrier reef, and the inner reef lagoon ("Little Reef"). Wave energy fluxes and near-bottom velocities were estimated to characterize the wave energy dissipation process and reef roughness, represented by the short-wave friction coefficients (f_w). The f_w varied from 0.01 to 2.58 at the fore-reef, increased as wave-orbital displacements decreased, and were approximated to a constant value using a least-squares

fit, obtaining $fw = 0.56 \pm 0.021$ ($R^2=0.75$). Using the parameterization proposed by Swart (1974) and the equivalent bottom roughness scale, the KN varied from 0.01 - 1.42 m, which are qualitatively consistent with the scales of variability of the reef observed during the field campaign. The study suggests that healthy reefs with high coral cover may provide greater coastal protection than degraded reefs with low coral cover. It also highlights the importance of obtaining more field data to better correlate the bottom reef surface and coral species distribution with KN values, which is still an open research question.

Seasonal & inter-annual variability of observed mesoscale eddies in the Caribbean Sea

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Alejandro Orfila²

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Abstract

Mesoscale eddies are ubiquitous features in the ocean that typically exhibit different properties regarding their surroundings. They transport passive tracers such as heat, salt, and carbon, and are relevant structures for the redistribution of energy and mass around all the oceans. Eddies also play an important role in supplying nutrients to the shelf-slope and to the upper layers where plankton blooms may result. In this work, the main statistical characteristics of mesoscale eddies in the Caribbean Sea were studied, as well as the seasonal and inter-annual variability in the number of eddy observations. Key descriptors of mesoscale eddies from satellite-based sea level anomalies (SLA) such as their lifetime, size, and amplitude were assessed for the period between 1993 and 2016. Additionally, the spatio-temporal variability in the number of eddy observations was evaluated in relation to the Sea Surface Temperature (SST), the surface wind-curl, and the main climatic index of variability in the area. Eddy-observations were correlated with the wind-curl at the annual cycle, whereas their density was influenced at the inter-annual scale ENSO.

Parametric hurricane wind model and methodology for the construction of wind and wave database for extreme conditions

Mariana Roldán Upegui^{1,2}, Rubén Darío Montoya Ramírez^{1,2},
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Universidad de Medellín¹, Universidad Nacional de Colombia²

Abstract

During every year's hurricane season, the Atlantic and the Caribbean are exposed to the economic, social, and environmental impacts of these phenomena. The analysis of variables such as wind and waves generated by these extreme events is essential to determine their possible impacts, as well as their multiple scientific and engineer-

ing applications. Available information such as satellite data and reanalysis databases present significant problems of low temporal and spatial resolution preventing a good representation of the asymmetry of the maximum winds around the eye, as well as a tendency to underestimate some of these phenomena, respectively. A modified parametric model is proposed to represent the asymmetry of the maximum velocity field more adequately, according to the hurricane category. The proposed methodology uses the information of 13 years of data –available from flying airplanes– of the Hurricane Research Division (HRD), the HURDAT2 database of the National Hurricane Center (NHC), and automatic scripts for the detection of the variability of the maximum wind speeds around the eye. The wind fields obtained are combined with ERA5 wind fields in the periphery of the hurricanes and the final field was used to force the WAVEWATCH III model. The results were compared with wind and wave parameters of buoys of the National Data Buoy Center (NDBC) in the Gulf of Mexico. The validation shows satisfactory results with error rates below 8% in the region of maximum winds for some of the hurricanes analyzed. A 40 years wind database for the Caribbean and the Gulf of Mexico was constructed with this methodology.

In-canopy Velocity Attenuation in a Model of Submerged Vegetation

Johann K. Delgado, Andrés F. Osorio, Francisco M. Toro

Universidad Nacional de Colombia

Abstract

Seagrasses are ecosystems that provide shelter, food, and habitat to many marine and coastal species, but also can be considered as natural-protection coastal structures against wave attacks. Previous laboratory studies have shown that, for seagrasses in-canopy, the velocity (U_w) is attenuated by the flow-vegetation interaction. However, most models assume the in-canopy velocity field is not perturbed. Neglecting a significant velocity decrease within the meadow can produce a wave-energy attenuation four times greater than the value obtained when the flow attenuation is accounted for (Lowe et al., 2007). As a new alternative to predict U_w , we propose to modify the momentum-balance analytical model to investigate the flow structure induced by the wave-driven oscillatory flow inside a moderately flexible seagrass; the model was originally developed by Lowe et al. (2005) assuming rigid vegetation. Introducing the flexibility of seagrass stems, two new terms are added to the momentum-balance model: the relative-velocity-based drag force and the added mass force. The model was validated through the experiment results taken from Abdolahpour et al. (2017). Simulations show an improvement in the calculation of in-canopy velocity. Furthermore, based on these results, we calculated the “new” velocity attenuation coefficients (α) for the non-rigid vegetation. Fitting the experimental data with the model, we found that the drag coefficients (CD) developed a new empirical potential equation. In conclusion, this developed approach provides a better and satisfactory estimation of U_w , α , and CD for moderately flexible vegetation. Additional experiments must be carried out to validate the applicability of the model for other kinds of marine submerged vegetation.

Influence of the ENSO on the nearshore hydrodynamics and morphodynamics of the Punta Soldado Island, Colombia

Ballantyne Puin, Johann K. Delgado, Simón Acevedo, Camilo A. Cabrera, Franklin F. Ayala, Andrés F. Osorio, Ligia E. Urrego, Gladys R. Bernal
Universidad Nacional de Colombia

Abstract

Coastal erosion is a serious concern for the Colombian Pacific coastal communities and their ecosystems. Punta Soldado Island (at Buenaventura Bay) is a key example of climate-caused displacement. In the last four decades, its inhabitants have endured three relocations due to coastline retreat and the anomalous rising of sea levels. Previous studies have shown that the El Niño Southern Oscillation (ENSO) is responsible for interannual changes in waves and sea-level dynamics in the Pacific Ocean. This study aims to understand the impact of ENSO on coastal erosion at Punta Soldado Island. We assessed wave- and tide-driven nearshore currents during the 'very strong' ENSO events in 1982-83, 1997-98, and 2015-16, by using a multi-tool approach: a) numerical models (SWAN, WAPO, and Delft3D), b) remote sensing (aerial and satellite photography, as well as altimetry-recorded wave data), and c) in-situ measurements (ecological survey, bathymetry, topography, ocean currents, waves, and sea level). Imagery showed erosion of up to ~600 m for the southern island area and a loss of 80 ha of mangrove forests since the '80s. During the ENSO events, the velocity of near-shore currents increased by approximately 5-10% in comparison with similar scenarios in normal periods. Meanwhile, significant wave heights increased by 12%. However, variations of wave period and direction were not significant. Also, we observed sea-level rises greater than 40 cm, which is equivalent to ~20 m horizontal water intrusion on the island. We concluded that ENSO is contributing to exacerbating erosion on Punta Soldado Island.

Effect of the ENSO on the interannual sea-level variability in the Colombian Pacific coast

Franklin F. Ayala, Johann K. Delgado, Andrés F. Osorio
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Abstract

On the Colombian Pacific coast (CPC), sea level rises that have caused significant damage to coastal communities and retreated coastline up to 600 m (e.g., Punta Soldado Island) have been registered. Some authors have associated these increases (~30-40 cm) with the occurrence of the warm phase of the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). However, the contributions of these phenomena to sea level anomalies (SLA) have not been characterized yet for the CPC. By using in-situ tide data from the Buenaventura and Tumaco stations (1954-2018) and satellite-altimetry SLA from AVISO (1993-2018), we analyzed

coastal sea-level variability throughout these periods focusing on years with ENSO occurrences. We characterized SLA by considering time- and frequency-domain analysis including harmonic decomposition, spectral analysis, and empirical orthogonal functions. Results show that SLA increased up to 43 cm during El Niño events (warm phase), whereas the contribution of PDO reaches 10 cm. The event durations were classified into two types: < 1 year and > 1 year. The longer events showed higher SLA amplitudes and stronger periodic variations than the short ones. Moreover, the ENSO explains about 40% of the variance in the spatio-temporal pattern of interannual sea-level oscillations. The maximum correlation between the 3-month filtered SLA and Oceanic Niño Index (ONI) was ~0.7 when SLA lagged by one month. In the CPC, the ENSO effects may be greater according to the PDO phase. These results provide insight for disaster protection during extreme ENSO events.

Coral reef benefits at insular territories: wave attenuation and habitat provision for fish at North, Center, and South Islands at Seaflower Biosphere Reserve, Colombian Caribbean

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Abstract

Coral reefs provide multiple ecosystem services (ES) for biodiversity and human wellbeing. Despite this, they have been jeopardized worldwide by several anthropic pressures. At the Caribbean Sea, up to 80% of the coral cover has been lost since the 1970s and 90% of the remaining reefs are at risk. At insular territories such as the San Andrés, Providence, and Santa Catalina Archipelago (Seaflower Biosphere Reserve), marine ES such as coastal protection and food provision become vital, and a healthy reef is crucial for wellbeing and safety, especially nowadays under pandemic and/or climate change scenarios. To better understand the important role of coral reefs for people, we have evaluated since 2017 coastal protection by wave attenuation provided by the barrier reefs at different islands on the Archipelago: I.C. Albuquerque, San Andrés, and I.C. Serranilla (North, Central, and South Seaflower). Through field measurements, we found wave height attenuation from 40% to 91% under different sea conditions and locations. Additionally, we measured heavy waves outside the reef shelter up to 5 m height (Hs), reduced to a safer 50 cm thanks to the barrier reefs. This is especially important for low-lying island's cays on Serranilla and Albuquerque with an average terrain height of about 2 m and relevant beaches for the economy, such as Spratt Bight at San Andrés Island. Aside from the potential contribution of reef rugosity to wave attenuation, it is also important for food provision and fish biodiversity, as we uncovered through fish census at those islands; we found higher biomass and biodiversity correlated with higher rugosity. With these results, we aim to encourage policymakers to increase investment in better reef management for sustainability purposes.

Ocean and atmosphere changes in the Caribbean Sea during the 21st century using CMIP5 models

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Abstract

This study identifies possible changes in the Caribbean Sea during the 21st century using three climate models provided by the Coupled Model Intercomparison Project Phase 5 (CMIP5) under the HISTORICAL scenario and using two representative emission scenarios (RCP4.5, RCP8.5). The assessment includes ambient air surface temperature, atmospheric pressure, and wind, as well as surface ocean temperature, surface salinity, and mean sea level changes in 2050 and 2100, referenced to 2005. Results indicate that, regardless of the RCP used, there will be a considerable increase in air and sea surface temperature, which have the potential to broaden the hurricane season and increase their frequency of occurrence in the region. Besides, the ocean temperature rise will probably enhance the coral bleaching in the Caribbean Sea. Mean sea level trends show a notable increase in the period 2005-2100 compared to the periods 1960-2005 and 1850-2005. Although expected sea level trends in the Caribbean are below the median of global projections due to the regional microtidal environment, such trends have the potential to enhance flooding and erosion, putting low-level islands such as those in the San Andrés and Providencia Archipelago at risk.

Dating recent submarine landslides in the Pacific Margin of NW South America

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Abstract

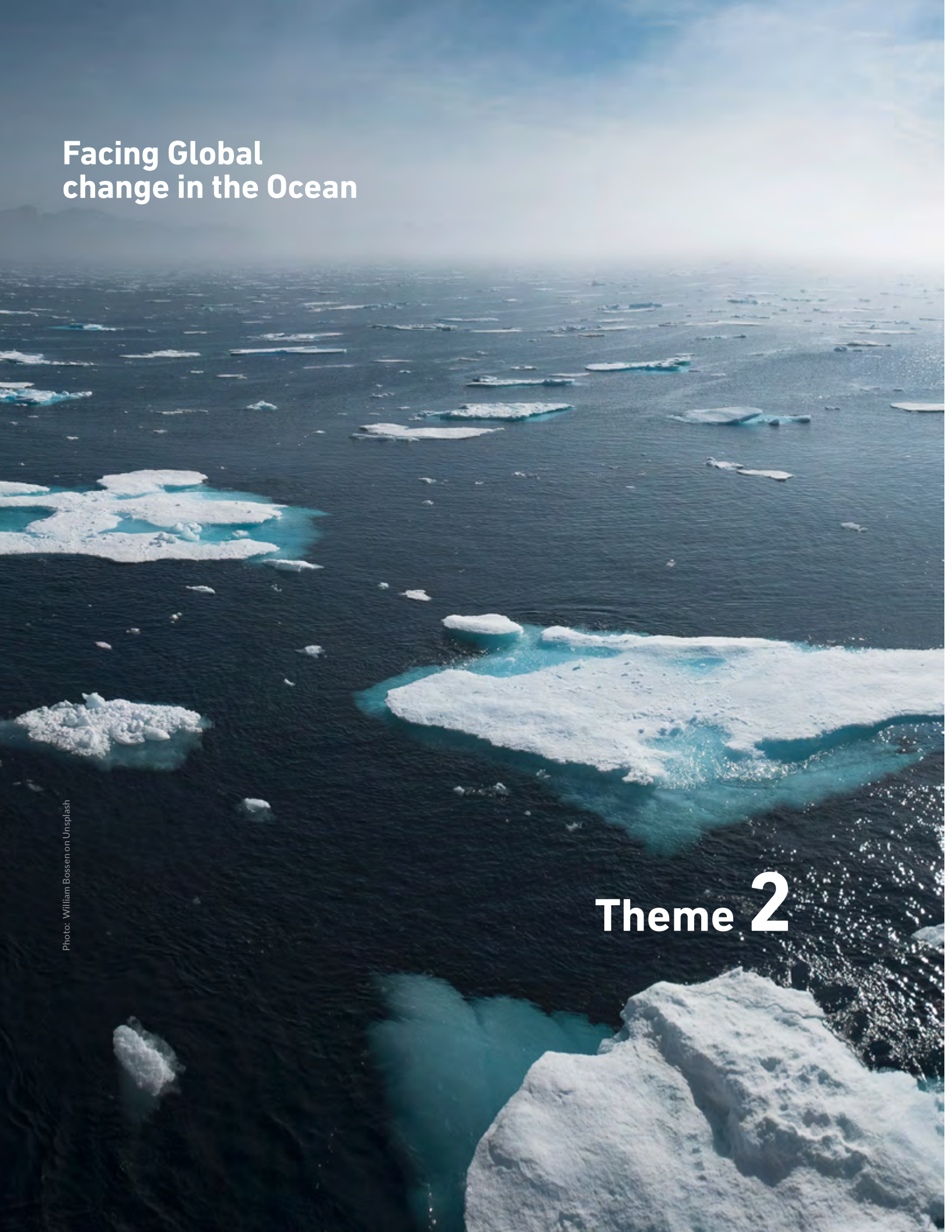
On the eastern margin of the Panama Basin, the Nazca oceanic plate converges towards the continental plate of South America at approximately 53 mm/a. Subduction processes are accompanied by the presence of anomalous bathymetric elements including the Sandra Ridge. This east-west-orientated ridge is cataloged as an aborted rift derived from a magmatic spreading axis that was active between 12 and 9 Ma. Seismic activity within this structure is considered evidence of fault reactivation and tectonism. Once the structure reached the subduction trench, several submarine landslides were triggered. Run-out lengths of these submarine landslides are perpendicular to the convergence of the structure, with some units spreading and forming a wide fan that reaches tens of kilometers to the north and south of the trench. The area affected by the three main landslides varies between 130 and 300 km² approximately, with relatively superficial earthquakes (.33 km) and with magnitudes

that reach up to Mw 7.2. The morphology of the landslides suggests a retrogressive nature with younger events proximal to shore. This work presents estimates of the age of these landslides and discusses sources of uncertainty regarding these times of occurrence.

Facing Global change in the Ocean

Theme 2

Photo: William Bossen on Unsplash



Impacts of ocean acidification and warming on tropical marine suspension-feeders

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Abstract

The resilience of marine filter-feeders under environmental disturbances caused by climate change and the impact of those changes on their biology and ecosystem functions represent a real concern for coastal management and conservation strategies. Using a short-term study, we evaluated the biological responses of the tropical ascidian *Polycarpa captiosa* to ocean acidification and warming (OAW). Treatments included (0) control: ambient pCO₂ (±400 ppm) at 25°C, (1) ambient pCO₂ (±400 ppm) and high temperature 30°C, (2) elevated pCO₂ (±1,000 ppm) at 25°C, and (3) elevated pCO₂ (±1,000 ppm) at 30°C. The responses of ascidians were assessed by analyzing their resilience (survival, coping) and clearance, absorption, and ingestion rates. We found that these levels of disturbance significantly affect the resilience and performance of ascidians at the individual level. Animals reacted by skin shedding and gut ejection after every high temperature and elevated pCO₂ treatment, and 20% mortality was observed on ascidians that could not recover from environmental stress. We conclude that ascidians increased their metabolic rates under warm temperature treatments as clearance and ingestion rates increased by 50%, whereas absorption efficiency was not significantly affected. In contrast, under higher pCO₂ conditions, a significant reduction of the ingestion and clearance rates was registered. Our results could be considered crucial for the future of the coastal management and conservation strategies of those important ecosystem improvers.

Diversity of drift macroalgae in Aruba, Netherland Antilles, Caribbean Sea

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Abstract

The detachment of natural populations may originate drifting and wrack seaweeds that are transported by currents until reaching the coast. When this is part of the natural renewal process of the seaweed beds, the drift is normally multispecific. Monospecific drifting biomass is, on the contrary, originating from the excessive blooming of ephemeral and opportunistic species, and it is a consequence of anthropogenic impact.

Drift and wrack algae were collected at four sites at Aruba for a taxonomic survey of the floating flora in the area. A total of 73 species were identified: 7 of Cyanophyta, 38 of Rhodophyta, 13 of Phaeophyceae, 13 of Chlorophyta, and two angiosperms, for a total of 73 taxa. Of these, 62 of these species are new records for Aruba.

Due to the absence of floristic studies on the island, the present work increases its macroalgal diversity by 205%. *Dasya puertoricensis* is reported for the first time outside its type locality. At Eagle beach, the drift was dominated by deep-water species.

**Latitudinal patterns of offspring size in reef coral species
Presence of microplastics and mesoplastics in coral reef and mangrove
fishes, Isla Grande, Colombian Caribbean**

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Abstract

Understanding changes in offspring size along environmental gradients and how these changes affect offspring fitness helps to comprehend species adaptation to climate change. Corals provide their offspring with energy resources that support survival and settlement after dispersal in ocean currents. Egg size is frequently used as a proxy for energy supply, which may be linked to a species ability to withstand environmental pressures. Rasse's rule predicts that the temperature at which reproduction occurs is inversely related to egg size, which also tends to vary predictably along latitudinal gradients. Most aquatic and terrestrial animals follow this rule when using latitude or temperature. Here, we tested for a latitudinal gradient in egg size in scleractinian reef corals, correcting for phylogeny by compiling a global dataset of egg sizes. We found significant positive covariation of coral egg size with absolute latitude at the intraspecific level for two subsets of the data. Hermaphrodites with horizontal symbiont transmission displayed a 1.7% increase in egg size with each unit increase in latitude while gonochores with vertical symbiont transmission showed a much higher increase of 9.1% in egg size with each unit increase in latitude. Thus, we confirm corals conform to Rasse's rule, indicating that positive selection towards larger offspring size occurs with increasing latitude as larger eggs favor offspring fitness. Given that egg size varies with latitude within individual species, it is likely that this plastic trait will play an important role in modulating the adaptive potential of corals under changing thermal conditions following climate change.

**Presence of microplastics and mesoplastics in coral reef and mangrove
fishes, Isla Grande, Colombian Caribbean**

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Abstract

Pollution by plastics has grown rapidly, impacting marine ecosystems and wildlife. Although the dynamics of the currents and proximity to the coast are different between coral and mangrove ecosystems, comparative studies on the accumulation of plastics in these ecosystems have not been carried out. This study aims to determine if there are differences between the presence of microplastics and mesoplastics in fishes of coral reef ecosystems and those of mangroves in Isla Grande, Colombian Caribbean. To this end, the collection of three species –with an abundance of 10 individuals for each one– from each ecosystem was carried out; in the coral reef: Common snook (*Centropomus*

undecimalis), Crevalle jack (*Caranx hippos*), and Lane snapper (*Lutjanus synagris*); in the mangrove: Striped mojarra (*Eugerres plumieri*), Common snook (*Centropomus undecimalis*), and Western Atlantic sea bream (*Archosargus rhomboidalis*). All species were found to have ingested microplastics and mesoplastics, with a significantly higher average abundance in the mangrove species than in the coral reef species (1.9 vs 1.6 items/individual). Additionally, the average abundance and weight of microplastics and mesoplastics were significantly higher in females than in males ($p < 0.05$), and the abundance of microplastics and mesoplastics in the intestines was significantly higher than in the stomach ($p < 0.05$). Based on the results of this study, it would be beneficial to perform rigorous monitoring of the presence of plastics in organisms and ecosystems of the Colombian Caribbean.

From papers to parameters: applying meta-analyses to provide ecosystem models with quantitative sensitivity of tropical marine organisms to ocean acidification and warming

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Abstract

Atlantis models are an 'end-to-end' approach spanning biogeophysical and socio-economic processes and can be used to simulate changes stemming from ocean acidification and warming across these levels. An Atlantis model is in development in the southeastern Hawaiian Islands to support decision-making in the context of ecosystem-based fisheries management. We produced sensitivity parameters that link changes in pH and temperature to changes in organismal biomass by applying a meta-analytic framework for 29 functional groups of organisms in tropical coastal waters, including bacteria, algae, and fauna. From an initial screening of over 1,500 full papers, we gathered and analyzed data from 334 papers of controlled experiments that exposed organisms from Tropical Pacific and Indo-Pacific regions to changes in pH or temperature. The responses of interest were broad and encompassed basic metrics such as survival and behavioral responses like avoidance of predator cue. We fit mixed-effects models that related effect size to changes in temperature or $[H^+]$ and, using these model parameters, we developed sensitivity curves and values that were successfully incorporated into the Hawaiian Atlantis model. This meta-analytical approach can be used to provide quantitative estimates of sensitivity to climate change for Atlantis ecosystem models and, as such, to produce more realistic biomass trajectories of functional groups in the changing oceans. Besides, we identified functional groups and geographical regions where studies of ocean acidification and/or warming responses are either absent or limited, highlighting areas where additional research is needed.

Quantitative assessment of inter and intrapopulation isotopic niche patterns between invasive lionfish and native mesopredators

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Abstract

The invasive lionfish (*Pterois volitans*) can significantly reduce the abundance and richness of their prey fishes, altering community structure, food webs, and functioning of coral reef ecosystems, threatening the conservation of these iconic ecosystems. However, within their potential negative effects on native fishes, there is a paucity of knowledge on lionfish impacts over native mesopredators with similar biological and ecological traits, especially in the Southern Caribbean. Using stable isotope analysis ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), Bayesian analytical tools, and residual permutation procedures on basic isotopic niche metrics, this study aims to provide an in-depth comparative assessment of inter- and intra-specific trophic patterns between lionfish and two economically and ecologically important species (*Cephalopholis cruentata* and *Lutjanus mahogoni*) in the Colombian Caribbean. Therefore, it contributes useful information to predict the extent to which lionfish may affect local mesopredator populations. An increase in $\delta^{15}\text{N}$ values with body length in graysby and lionfish populations suggest ontogenetic dietary and/or habitat shifts. Stable isotope results confirmed that smaller lionfish individuals present niche segregation from larger individuals, differentially affecting native mesopredators. Lionfish isotopic niche width was significantly greater (i.e. > 4 times) than that of native mesopredators, whose niche was substantially overlapped (< 60%) by the large lionfish niche. This was consistent with isotopic niche metrics since individual lionfish presented considerably higher trophic diversity within the population relative to native mesopredator populations. In conclusion, depending on its body size, the lionfish population has distinctive trophic patterns that are advantageous in case of competition for food resources with native mesopredators, perhaps leading to detriment of mesopredator populations.

Wind speed reduction and habitat provision by mangroves at Colombian Caribbean oceanic islands: the first line of defense to protect infrastructure and provide habitat for fish communities

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Abstract

The San Andrés, Providence, and Santa Catalina Archipelago located in the South-western Caribbean, includes nine islands and 180,000 km² of Colombian oceanic waters. The influence of tropical storms and hurricanes at this location exposes the islands and their infrastructure to high-speed winds which can cause structural damage to buildings. Although mangroves are recognized for their capacity to protect coasts against waves and winds, this has not usually been considered by policymakers and society, leading to mangrove forest decline for the sake of urban and touristic “development”. To highlight the importance of mangroves for reducing wind-speed, we conducted field measurements (including a high-speed winds season during 2020) at three locations on San Andrés Island, Colombia. After several measurements, we found that one mangrove tree can reduce 70% of wind-speed on average, starting from 59% speed reduction by *Rhizophora* mangle roots and up to 88.9% reduction by *R. mangle* and *Conocarpus erectus* canopy; projections suggest that mangroves can reduce wind speed maintaining non-damaging conditions even under a category 2 hurricane. At the same time, the mangrove provides a habitat for ecologically important fish species, such as parrotfishes (Scarinae). We conducted a fish census on nearby areas of fringing mangrove forests and “tierradentro” inland mangroves. Results showed a higher abundance of parrotfishes, especially juveniles, nearby the fringing mangroves (between 426 and 444 ind.), highlighting the importance of these ecosystems as fish nurseries. These results encourage stakeholders to protect the remaining mangroves at the Archipelago and consider mangroves as a suitable multipurpose coastal solution.

Diverging populations of the mangrove periwinkle *Littoraria angulifera*: finding ways in an urbanizing coast

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Abstract

Periwinkles (genus *Littoraria*) are one of the very few molluscan clades showing adaptive radiation closely associated with the mangrove habitat. However, pervasive urban expansion and land-use changes are prompting mangrove loss or degradation

with unknown consequences for mangrove-associated fauna. We studied the relative abundance, position in the intertidal zone, and size structure of *L. angulifera* in the remaining mangrove patches and quasi-natural (woody debris) and anthropogenic (boulder seawalls and built structures) substrates in the Urabá Gulf, a human-transformed region of the Southern Caribbean coast of Colombia. The abundance of *L. angulifera* was up to two orders of magnitude higher in anthropogenic than in quasi-natural and natural substrates. Snails, however, displayed a significant preference for wave-protected positions in boulder seawalls and built structures exposed to wave action, which was not observed in mangrove patches. Moreover, snail populations in the anthropogenic substrate were consistently dominated by small sizes in comparison with mangroves or driftwood. We argue that the long-term expansion of the Turbo city and agriculture, departing from a mangrove-dominated coastline, is resulting in both challenges and opportunities for *L. angulifera*. Challenges might be epitomized by an increased mechanic and thermal stress in hard, wave-exposed urban structures, which snails seemingly confront through behavioral adjustments. In turn, the dense populations of small snails developed in urban intertidal structures suggest either increased recruitment or a phenotypic shift resulting from a directional selection in human-dominated seascapes.

The reef-building coral *Galaxea fascicularis*: a suitable species for long-term bleached maintenance and experimental manipulation

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Abstract

Coral bleaching events and the breakdown of the obligate coral-algal symbiosis with dinoflagellates of the family Symbiodiniaceae are becoming alarmingly frequent and pose a serious threat to the survival of coral reefs. Despite significant efforts to unravel the functioning of this symbiosis, the mechanisms leading to its breakdown are still not fully understood. One of the main obstacles is the short survival time of bleached corals in the absence of their algal partner, which limits the timeframe available for experimental manipulations. Indeed, most studies on the symbiotic partnership are conducted on other cnidarian model organisms, and their results may not be fully translated to tropical reef-building corals. Therefore, we have identified the stony coral species *Galaxea fascicularis* as a candidate for a new coral model. Individual polyps of this species can be separated and mounted on plates, enabling highly replicable genotype studies. Furthermore, we bleached individual polyps and maintained them in the aposymbiotic state for up to eight weeks. As a proof-of-concept, we studied these bleached and symbiotic polyps in two experiments looking at the role of light in calcification and coral physiological performance at different temperatures. We also confirmed the ability of bleached individuals to be fully re-colonized by homologous symbionts. These preliminary results highlight the great potential of the tropical coral species *G. fascicularis* for investigations of symbiosis functioning and manipulation.

***Pelliciera rhizophorae*: some anatomical traits in the Caribbean coast**

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Abstract

Pelliciera rhizophorae Triana & Planch is nowadays a common species in mangrove forests along the Pacific and Caribbean coasts of Colombia. It is a particular species due to its restricted distribution on neotropical coasts and for being considered the oldest neotropical mangrove species (dated to the Eocene, according to biogeographic and population studies). Nonetheless, its anatomical properties are still poorly studied. We performed a histological characterization of vegetative organs in young plants at Playa de los Muertos (Cartagena, Colombia). We established a 60 m transect perpendicular to the coastline where we measured salinity points and chose two control points (salinity values: 38,70 and 47,00 ppt) to take root, stem, petiole, and leaf samples. All tissues were fixed in alcohol 70% and colored with Astra Blue Fuchsin to observe histological structures. Cuticular impressions of the upper and lower leaf surfaces were prepared. Our results present comparative anatomy of the roots, leaf organs, and stomatal density for the first time in this species across different salinity interstitial water. We found a decrease in the diameter of xylem vessels and a reduction in stomatal density at high salinity conditions. Our study contributes to knowledge about the functional responses of *P. rhizophorae* to salinity changes in interstitial water on coastal ecosystems, which are key for humanity's wellbeing thanks to the ecosystem services that they provide.

The effects of water flow on photosynthetic responses of reef-building corals to ocean acidification

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Abstract

Coral reefs are among the most productive ecosystems in the world and provide important ecosystem services for coastal communities. They are largely supported by the primary productivity of reef-building corals, which is known to increase with ambient water flow. However, ocean acidification (OA) poses serious challenges to the physiology of reef-building corals. While coral growth generally decreases under OA, effects on coral photosynthesis remain unclear. Additionally, whether certain flow regimes may still enhance this physiological process under OA conditions is yet unknown. Therefore, we performed a controlled microcosm experiment to investigate the combined effects of OA and water flow on the photosynthesis of the reef-building coral species *Porites cylindrica* and *Acropora cytherea*. We expected moderate flows, common in reef environments, to induce higher photosynthetic rates than slow flows, and tested whether such differences were maintained under

OA conditions. Specifically, coral fragments were exposed to two pCO² conditions (~400 µatm and ~1000 µatm) for three months, and photosynthetic rates were assessed in two flow regimes (~2 cm/s and ~6 cm/s). Preliminary results indicate that moderate flow (~6 cm/s) had a positive effect on *P. cylindrica* and a negative effect on *A. cytherea*, compared to low flow (~2 cm/s). Under OA conditions, flow-enhancing effects disappeared, while negative effects were further reinforced. Nonetheless, coral photosynthesis was generally reduced with OA regardless of the flow. These findings may help to better predict future coral reef productivity and suggest that higher water flow may not mitigate OA effects on reef-building corals.

The absorption of microdebris in reef-building corals

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Abstract

The pollution of the oceans is increasing, and microplastics have been especially detected in nearly every marine environment and may also accumulate in food chains due to its small size (0.1–5 mm). For example, it has been shown that reef-building corals may overgrow microplastic particles or embed them in their skeletons after ingestion. Most studies experimentally investigating the effects of microplastics are focusing on a single type of plastic (e.g., polyethylene), but little is known about the effects of naturally occurring mixtures called “marine microdebris”. Thus, we plan to conduct a study to assess the absorption of different mixtures of marine microdebris of major anthropogenic pollutants in two scleractinian coral species (*Stylophora pistillata* and *Pocillopora verrucosa*), which are known to frequently ingest microplastics. Therefore, we exposed corals in an 8-week laboratory experiment to 1) a mixture of secondary marine microdebris composed of fragmented plastic, 2) a combination of residues from the automobile sector consisting of tire wear, brake abrasion, and varnish, 3) an assortment of artificial fibers from clothes, 4) polyethylene as single polymer and 5) a plastic-free control treatment. To study the quantity of absorption in correlation with the type of microdebris, particles incorporated in the coral tissue and the skeleton will be extracted by dissolving tissue and skeleton separately. We aimed to find which microdebris types might be most prone to be absorbed by corals and get a better understanding of underlying processes and the impact on coral reef ecosystems under environmentally realistic scenarios.

Reef-building corals do not acquire avoidance mechanisms against microplastic uptake

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Abstract

Microplastics (MP) pose an increasing threat to marine species and ecosystems. Suspension feeders such as corals can be particularly affected by contact or ingestion. Recently, it has been shown that actively feeding corals may prefer MP to natural food. However, little is known about the MP feeding behavior of tropical reef-building corals, almost all of which are additionally supplied with nutrients by their symbiotic algae. These corals depend highly on energy provided by the photosynthetically active symbionts (the so-called zooxanthellae). Moreover, it is unknown whether corals can develop mechanisms that prevent the uptake of MP in the long-term. Therefore, this study aimed to experimentally determine the potential for long-term acclimatization of reef-building, zooxanthellate corals to MP. Four coral species (*Acropora muricata*, *Porites lutea*, *Pocillopora verrucosa*, and *Heliopora coerulea*) were exposed to MP for 15 months, and MP feeding rates were compared to those of natural food (brine shrimp cysts). It can be shown that the feeding behavior of the corals did not change even after long-term exposure to MP. This suggests that, although reef-building corals may differentiate between natural food and MP, likely due to chemical stimulants leaking from food particles, they do not develop mechanisms to avoid the uptake of MP entirely even after long-term exposure. The affected corals may, therefore, suffer sustained energy losses, amongst others, which may partly explain the adverse effects of MP pollution on coral health.

Assessment of deep demersal fish fauna diversity of the Colombian Caribbean Sea

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Abstract

Deep-sea biota, and, particularly, fish, are threatened by extending fishing frontiers and oil and natural gas exploration. Thus, knowledge of deep-sea fish biota diversity is necessary to inform management and protection plans.

Objective(s)/Hypothesis(es): We aim to assess the level of survey coverage, the completeness of species inventories, and the geographic distribution of depth (>200 m depth) demersal fish diversity (species richness) at a scale of 15 minutes by 15 minutes cells inside the current Colombian Caribbean Economic Exclusive Zone (EEZ).
Methods: We compiled georeferenced records of deep demersal fishes (> 200 m depth) from the Colombian Caribbean Sea from the Global Biodiversity Information Facility GBIF and other local sources. Georeferenced records were cleaned (elimination of duplicates, records with the geographic coordinates 0° longitude and 0° latitude, records outside the Colombian Caribbean EEZ and/or above 200 m depth)

and processed with the application ModestR with produces files directly usable for the module KnowBR of the application RWizard, which in turn contains functions designed to conduct a search of both well and poorly surveyed spatial units in geographical space.

Results: We identified a rich demersal fish fauna with a minimum of 356 species registered. Areas with comparatively elevated observed and predicted species richness were identified (the Gulf of Salamanca, Guajira, Palomino, and mixed coralline bottoms) as well as areas in need of extensive surveys (the rest of the study area). Survey coverage and the completeness of geographic richness resulted in being deficient with no cell reaching the status of the well-sampled spatial unit and 83% of the Colombian Caribbean Exclusive Economic Zone depth bottoms remaining unexplored, in particular regarding depths beyond 1000 m.

Implications/Conclusions: This research is one of the first steps towards studying the diversity of deep-sea demersal fish species beyond the compilation of species' names. Much work remains to be done both for scientific and practical purposes focusing on protecting Colombian Caribbean deep-sea biodiversity. Areas identified here as showing comparatively high numbers of depth demersal fish species might be candidates for erecting deep-sea marine protected areas in the Colombian Caribbean where currently only one National Park with a focus on the conservation of deep-sea biota ("Corales de Profundidad") exists.

Microplastics in Buenaventura Bay sediments: an increasing problem

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Abstract

The production increase, consumption, and inadequate disposition of plastics has generated an accumulation of these elements in the marine ecosystems, which is recognized as an important microplastics sink (< 5 mm). The objective of this investigation was to determine the time differences of the density and type of microplastics in sediments of Buenaventura Bay. To address this question, samples of the sediment were obtained in the dry and rainy season for the years 2015 and 2019. Microplastics were extracted following the density separation method, where each particle was classified and measured by optical microscopy. The abundance of microplastics varied from 11 to 1354 particles/kg. On the other hand, significant differences were observed in the density of microplastics between years ($p(\text{PERM}) < 0.05$), being lower in 2015 (194.9 51.3 particles/kg) and higher in 2019 (359.6 88.0 particles/kg); there was an increase of 84.4% in the accumulation of microplastics in the study period. Significant differences were observed between sampling times ($p(\text{PERM}) < 0.05$). The largest amount of microplastics was presented in the rainy season (274.2 63.3 particles/kg) and the smallest in the dry season (132.0 30.3 particles/kg). Besides, the fibers constituted the most common form of microplastic particles, with 63.7 and 56.03% dominance for the years 2015 and 2019, respectively. The presence and increasing accumulation of this type of pollutant can generate risks and adverse effects for the marine communities and compromise food safety.

Abundance and assemblage assessment of native reef fish along with the invasive lionfish *Pterois volitans* in the Colombian Caribbean

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Universidad de Bogotá Jorge Tadeo Lozano¹, Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona (UB)², Universidad Nacional de Colombia sede Caribe. Instituto de Estudios en Ciencias del Mar-CECIMAR³, CEMarin - Corporation Center of Excellence in Marine Sciences⁴, Makarela S.A.S.⁵

Abstract

The composition and abundance of the native fish assemblage and the abundance of the invasive lionfish *Pterois volitans* were evaluated through visual censuses carried out in two climatic periods (dry and rainy) and two regions of the Colombian Caribbean from 2016 to 2020. Permanent transects of 25 × 10 m were delimited at depths between 10 and 24 m. A total of 135 species grouped in 40 families was recorded, 112 species in Bolívar, and 104 in Magdalena. Lionfish abundance varied between 1 and 20 ind./250 m², Magdalena being the region with the highest density (3.28 ± 3.35 ind./250 m²). The species with the highest count was *Clepticus parrae* (20.36%) for Bolívar and *Canthigaster rostrata* (14.13%) for Magdalena. The highest species richness (83 species) was recorded in Bolívar in the dry period of 2019.

The structure of the fish assemblage varies significantly spatially between regions (PERMANOVA, Pseudo-F_{1,211} = 38.39; P = 0.001) and temporally between periods (PERMANOVA, Pseudo-F_{1,211} = 3.01; P = 0.001) and years (PERMANOVA, Pseudo-F_{4,211} = 4.44; P = 0.001), except between 2017 and 2018, and 2019 and 2020. In Bolívar, the species richness (r₁₃ = -0.62; P = 0.017) was significantly negatively influenced by lionfish presence, whereas the abundance was not significantly influenced (r₁₃ = -0.10; P = 0.720). In Magdalena, the relationships between lionfish presence and species richness and lionfish presence and abundance were positive but not significant (r₁₂ = 0.47; P = 0.101 and r₁₂ = 0.48; P = 0.09 respectively).

Mangrove migration due to changes in sea-level and elevation rates: A methodology to identify potential colonization areas and description of cases in Colombian ecosystems

Maria-Angélica Aguirre-López, Gladys Bernal
Universidad Nacional de Colombia

Abstract

Despite being an important ecosystem services provider, mangroves are facing impacts driven by climate change effects and anthropic pressures. Forecasts foresee area losses worldwide due to sea-level rise and changes in temperature and precipitation. Mangroves can keep pace with the sea-level rise in function of their elevation rates, resulting in movements or migration across the coastline. This migration is conditioned by zonal characteristics that provide sustainable areas for new occupa-

tions. In this study we make a review of the conditions influencing mangrove migration and, as a tool for conservation, we propose a methodology to identify which places could be colonized by mangroves migrating locally. We also tried to apply the methodology in 4 deltaic associated mangroves in the Colombian Caribbean and Pacific regions, but lack of data led to a simplification and resulted in a qualitative description of the cases. The proposed methodology can give information related to changes in mangrove distribution at a local scale. However, more research efforts in Colombia are needed to adequately represent the future and face the impacts of global change.

Presence of microplastics and the influence of the environmental conditions on the trophic ecology of the brown sole *Achirus klunzingeri* in Buenaventura Bay, Colombian Pacific

Daniella Tafurt Villarraga¹, Andrés Molina², Guillermo Duque¹

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Abstract

The dynamics of the environmental conditions influence the availability of the food resources for the estuarine organisms, affecting the food consumption of the benthic organisms such as flounders, essential for establishing and monitoring the environmental quality of estuarine ecosystems. The objective of this study was to determine the trophic habits and presence of microplastics in the *Achirus klunzingeri* species in Buenaventura Bay, Colombian Pacific. A total of 98 fish were collected using artisanal trawling. Then, the diet of this species was determined, and different trophic indexes were calculated. The diet of *A. klunzingeri* presented a dynamic pattern based mainly on crustaceans and fish, presenting also the ingestion of microplastics. These microplastics were mainly elongated and colorless fibers which were present in individuals with a size range of 17 to 29.5 cm (TL). The trophic habits of *A. klunzingeri* were related to the environmental variables such as the temperature, transparency, and dissolved oxygen, presenting negative correlations with the fish consumption, and positive for the crustacean ingestion. It was registered that *A. klunzingeri* is a generalist species presenting microplastic intake related to the environmental dynamics. In particular, the fiber intake was greater in the rainy season than in the dry season, according to the greater presence of this microplastic in sediments registered by other studies in Buenaventura Bay. These results contribute to the understanding of trophic ecological processes and the environmental impact generated by the presence of microplastics in estuarine organisms..

Study of the wave damping, wave velocity, and turbulence in an Artificial *Rhizophora mangle* Population (ARmP) including secondary roots

María Alejandra Piedrahita Ospina, Andrés Fernando Osorio Arias,
Ligia Estela Urrego Giraldo.
Universidad Nacional de Colombia

Abstract

Sea-level rise and extreme events are the product of current human-caused climate change, among many other problems. The loss of some ecosystems, such as mangrove forests, causes a rapid increase in the effects of climate change. Innovative studies on new uses for these forests can guarantee mechanisms for their conservation and protection. The objective of this research is to propose these forests as sediment retention and erosion control structures through the study of wave velocity and turbulence between the roots of mangroves. These variables are related to sedimentation and erosion processes. A 1:10 scale physical model of an artificial *Rhizophora mangle* population (ARmP) exposed to oscillatory flow in the wave channel of the Universidad Nacional de Colombia - Medellín was made. The (ARmP) were parameterized in stainless steel considering the trunk and the primary and secondary roots. Eight wave gauges were implemented along the flume to record the free surface elevation and a 3-D Acoustic Doppler Velocimeter (ADV, Nortek Vectrino) was used to measure velocity profiles inside the model. A fixed wave height and depth of $H = 0.07$ m and $h = 0.28$ m were considered, systematically varying the wave period ($T = 1 - 2$ s). During the experiments, a 30% reduction in the stationary component of velocity was observed within the (ARmP), regardless of the period, increase in velocities in high periods, negative Reynolds efforts, and wave damping of 14 %. Thus, it can be inferred that this structure could help retain sediment and reduce erosional processes.

Microplastics in queen conch (*Lobatus gigas*) in the Archipelago of San Andrés, Providencia and Santa Catalina - Seaflower Biosphere Reserve

Alicia C. Rodríguez Alcárcel¹, Ernesto Mancera¹, Jairo Medina¹, Ruben Azcarate²
Universidad Nacional de Colombia¹, Archipelago of San Andrés, Providencia and Santa Catalina Governance²

Abstract

Microplastics (MP) are one of the most abundant pollutants in marine environments. One of the primary environmental risks of MP is their ingestion and bioaccumulation in the food web. The queen conch is among the most important fishery resources in the Caribbean because its meat has traditionally been an important part of the diet in many islands. In the present study, we investigated microplastic pollution present in queen conch (*Lobatus gigas*) feces from four sites (San Andrés, Providencia, Albuquerque, and Roncador) along the Archipelago of San Andrés, Providencia, and Santa Catalina in 2019. We found microplastics in all the sites. Our results suggested that the number of MP was closely related to human presence and activities. The most common microplastics were fibers, followed by fragments. The proportion of micro-

plastics of less than 1 mm in size was 62% of the total microplastics. We propose that the queen conch could be used as a potential bioindicator of microplastic pollution in the islands of the San Andrés, Providencia, and Santa Catalina Archipelago.

Cryptic diversity in the gooseneck barnacle *Pollicipes elegans* as result of recent vicariance in the tropical eastern pacific

Sergio Marchant¹, Amy Moran², Peter Marko²
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Abstract

Species are the most basic units of classification and diversity measurements in biology. However, the delimitation of species is often difficult because recently separated biological species may not yet have accumulated many distinguishing phenotypic differences. Species delimitation based on analyses of multilocus datasets has transitioned from the identification of species based on reciprocally monophyletic groups (no shared diversity among cryptic species) to the recognition of species before lineages completely sort at neutral loci (species delimitation in the presence of incomplete lineage sorting), allowing the detection of speciation early in the speciation process. *Pollicipes elegans* is a species of gooseneck barnacle with a disjunct distribution that spans multiple biogeographic provinces and different sea surface temperature regimes in the Tropical Eastern Pacific. To test the existence of cryptic diversity in *P. elegans*, we surveyed nucleotide variation and analyzed sequence data from six nuclear loci and one mitochondrial gene. Results from a combination of phylogenetic and phylogeographic species delimitation methods provide strong evidence that *P. elegans* contains two cryptic species. We, therefore, recommend separation into two species of the populations in the California/Mexican transition zone and the Mexican zoogeographic province, as well as of the populations south of the Central American Gap.

Assessment of the lionfish (*Pterois volitans*) invasion on the prey of reef fish assemblage in the Colombian Caribbean

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Abstract

Prey fish assemblage composition and abundance and the abundance of *Pterois volitans* were evaluated through visual censuses from 2015 to 2017. They were carried out in two climatic periods (dry and rainy) and two regions of the Colombian Caribbean.

bean (Bolívar and Magdalena). Permanent transects of 25×2 m (50 m^2) were established in nine sites in every region at depths between 10 and 24 m. A total of 117 species, grouped in 43 families, were recorded (98 species in Bolívar and 84 species in Magdalena). The abundance of lionfish varied between 0.2 and 2.0 ind./ 50 m^2 , Magdalena being the region with the highest abundance (0.51 ± 0.08 ind./ 50 m^2). The species with the highest abundances were *Coryphopterus personatus* (41.9 %), *Stegastes partitus* (6.8 %), and *Clepticus parrae* (5.5 %). The highest density was found during the rainy season of 2016 in Magdalena (0.83 ind./ 50 m^2) and the lowest during the rainy season of 2015 in Bolívar (0.2 ind./ 50 m^2). The structure of the fish assemblage varies significantly spatially between regions (PERMANOVA, Pseudo-F = 13.91; DF = 1, 78; P = 0.001), temporally between periods (PERMANOVA, Pseudo-F = 7.99; DF = 1, 78; P = 0.001), and all years (PERMANOVA, Pseudo-F = 2.78; DF = 2, 78; P = 0.001). Non-significant negative correlations between lionfish abundance and prey richness were found in Magdalena ($r = -0.30$; DF = 7; P = 0.51) and Bolívar ($r = -0.61$; DF = 10; P = 0.06).

Submerged solid waste: restoring the animal life

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Universidad de Antioquia¹, Dive dreams Medellín²

Abstract

The solid waste found in the seafloor could present lots of marine life associated with living inside or attached to every available surface. Once a program on the extraction of solid waste is carried on, the management of this life is very important to restore the integrity of the ecosystem, as well as to improve its conditions with a lesser impact. We are proposing a methodology that avoids the impact on the reef ecosystem. The steps include the selection of one particular diver who will take the information. The first step is to evaluate if it is possible to extract the waste associated with an animal; this will depend on the cover proportion and the type of animal. Second, once the waste is selected, it must be revised to return any animal associated with it to the site. Third, keeping the waste on the shore, all the surface and cavities must be checked to collect the remaining animals. All the rescued biota must be kept in jars on water and air pumps while they are returned to the sea. Since the methodology establishes the adequate state of the animals, the diver must come back to the sea and release every animal at the same depth they were captured with the waste. This will avoid the predation and death of animals in comparison with procedures consisting of just releasing them on the shore. Although this seems simple, the least impact on biota must be ensured during waste extractions.

A man with a beard and short hair is shown in a close-up, looking intently at a piece of coral he is holding with both hands. The coral is dark and has a complex, branching structure. The background is a laboratory or aquarium setting with bright, horizontal light fixtures. The entire image is tinted with a blue color.

**Participatory
Science**

Photo: JLU aquarium facilities

Theme 3

Conservation of the hawksbill turtle (*Eretmochelys imbricata*) in Rincón del Mar, Sucre, Colombia

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Tortugas del Mar - FTM³, Wider Caribbean Sea Turtle Conservation Network - WIDECAST⁴

Abstract

The conservation and nesting ecology processes of the hawksbill turtle (*Eretmochelys imbricata*) are described as a result of participatory monitoring carried out by an NGO, a local community, and a government entity between 2018 and 2019 in Rincón del Mar, Sucre, Colombia. Between July and September of both years, day and night patrols were performed with the help of local experts on a 7 km stretch of beach. Six turtle nests were recorded in situ, one of which had been looted by humans. Females spawned a total of 761 eggs in five clutches (mean \pm SD: 152.2 \pm 15.5 eggs per clutch). Hatching success was (mean \pm SD: 78.2 \pm 12.4%) and emergence success was (mean \pm SD: 74.7 \pm 14.1%) (n = 5). The incubation period was (mean \pm SD: 54 \pm 7.8 days; n = 4). 591 hatchlings were released into the sea, 22 of which (3.72%) were rescued by community monitoring personnel. Besides, physical measurements of the nests (width, depth, and distance to the beach), description of associated vegetation, and morphometric measurements of the hatchlings (SCW, SCL, and weight) were carried out. As part of environmental education activities, beach cleanups, workshops, and training and awareness lectures were held with more than 120 people. These results demonstrate the potential for nesting in the area and the need to continue monitoring and prioritizing the protection of nesting areas for the conservation of hawksbill turtles with interinstitutional work and the participation of the native community.

Scientific Tourism on remote beaches, a divergent bet for tourists from a new world

Bianca Suárez-Puerta, Camilo M. Botero
Remonautas Playascorp

Abstract

In the world we formerly lived in, there were no beach tourism alternatives in Colombia that did not degrade the environment with unsustainable commercial processes. That being so, we developed a network of scientific tourism in remote beaches, an applied marine research project that executes a knowledge management model in remote marine-coastal areas with high socio-natural value. We aim to understand, protect, restore, and promote the sustainable use of these fragile ecosystems. Each of the members of the network has the mission of preserving, protecting, promoting, and developing sustainability while motivating universities to undertake their fieldwork at those areas and school children to engage in scientific learning about

mangroves, flamingos, sloths, birds, fish, turtles, and corals. We use science, communication technologies, and social innovation with an educational approach so that the knowledge of the sea and the culture of the inhabitants of the coast are closely linked to development processes. This scientific tourism network has had a great social impact since some of these remote beaches are inhabited by indigenous communities with ancestral knowledge and others are led by people of African descent. Not only those families, or those of the tour operators, benefit from this type of marine conservation tourism; the exchange of information can have alternative effects leading to, for instance, the preservation of marine wealth by tourists.

Coastal community inclusion in an offshore marine protected area: Prospects and challenges for management and investigation

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Parque Nacional Natural Corales de Profundidad, International cooperant with
Cuso International

Abstract

Colombia is directing its interests to the sea through policies of economic openness, generating conflicts between the environmental offer of marine space and their multiple uses, which include artisanal or small-scale fishing, economic development, and conservation. This prompted coastal communities to explore fishing areas beyond 3 nm to guarantee the availability of fishing resources. In the Colombian Caribbean, the discovery of deep areas with high biodiversity led to the creation of the Corales de Profundidad National Natural Park in 2013, located 18 mn from the coast, to preserve deep-sea ecosystems and the goods and services they provide. Its creation generated a wide social impact because it was subject to legal fishing restrictions. The unawareness of the coastal population's potential use of hydrobiological resources led to establishing a dialogue between the institution and the coastal communities as part of conservation strategies. Using SIPEIN methodology, surveys were conducted with fishermen within the protected area, allowing them to identify the main communities, fishing gear, and the types of boats they use. Through dynamic workshops and the participatory action research methodology, we enabled the sharing of empirical knowledge and evaluated the interest to unite conservation efforts. Aside from data about catch by species, harvested areas, historical context, and fishing expeditions, preliminary results confirm community interest to conserve marine resources cooperating with different actors and their willingness to participate in this effort. The main challenges identified were the need for a personalized approach to each community and the need to build a sustainable collaboration grounded in trust.

Biocultural innovation: An option for the well-being of coastal communities?

Juan David Reina-Rozo

Instituto de Estudios Ambientales, Universidad Nacional de Colombia

Abstract

Biocultural heritage has been consolidated as a hybrid area of both academic study and social movement advocacy. Within this framework, biocultural innovation emerges as "a new way of doing things" based on diverse modes of knowledge, biodiversity, landscapes, cultural and spiritual values, and customary laws. These processes are translated into new knowledge, resources, skills, and practices concerning a territory. This work in progress aims to explore the possibilities of biocultural innovation for coastal community environments. Thus, a literature review is being conducted to determine how this concept has been used by its practitioners and the scientific community. It has been found so far that its development has been limited at the scientific level, while at the professional one it has developed more smoothly in conjunction with communities located in the Global South. Although it is a term related to biocultural heritage, its use has been mostly limited to agriculture. These conclusions are preliminary compared to the emerging performance of the concept in the academic world, but it has been accepted by the communities as a process for safeguarding their knowledge and culture, both intrinsically related to biodiversity. Although several case studies in marine territories are not included, these new ways of doing things have the potential to improve the visibility of the cultural and productive processes related to the traditional knowledge of coastal communities, as well as their landscapes, values, and norms.

Information system for the coastal wetland Ciénaga Grande de Santa Marta, Colombia - Call for cooperation

Dr. Horst Salzwedel

Abstract

The Ciénaga Grande de Santa Marta Ecoregion (CGSM) is the largest coastal wetland in Colombia. Since the 1960s, its water balance had been so disturbed that the original 512 km² of mangrove-covered area decreased to only 226 km² in 1995, having serious consequences for the artisanal fishery and the socio-economic situation of the local population. The Colombian-German project Pro-Ciénaga (1992-2001) largely restored the water balance of the CGSM. Moreover, CGSM was declared the first Ramsar area in Colombia in 1998, a biosphere reserve in 2000, and an important bird and biodiversity area in 2001. Today, however, no management plan for the ecoregion is being implemented, and the experience of the former Pro-Ciénaga project and other ventures cannot be used because the once established documentation center with hundreds of documents was not maintained.

Since 2015, more than 1000 references of edited and unedited scientific work about the CGSM ecoregion have been collected and classified in a Zotero database. These

will be used to build up an information system for the CGSM, which will provide policymakers with sound and up-to-date information, e.g., for adequate management plans. The available information is presented to the interested scientific society on the Sí-CGSM platform sicgsm.co, which can be used not only for the social acquisition of knowledge but also to promote community participation in resource management.

The present document is a call for cooperation.

Large Scale Coral Reef Restoration in the Seaflower Biosphere Reserve - San Andrés, Providence, and Santa Catalina Archipelago, Colombian Caribbean

Ruben Azcarate¹, Diana Lucía Gómez², Erick Castro Gonzalez, Maria Fernanda Maya, Anthony Rojas-Archbold³, Juan Pablo Caldas⁴, Maria Claudia Diazgranados⁴, Phanor Montoya-Maya⁵

CORALINA¹, Universidad Javeriana de Bogotá², Secretary of Agriculture and Fisheries of the Government of the San Andrés, Providencia, and Santa Catalina Archipelago³, Conservation International Colombia⁴, CEO Corales de Paz⁵

Abstract

October 2017 saw the start of Colombia's largest coral rehabilitation project via the two-step process of coral gardening. The project objective is to upscale coral reef restoration actions in the San Andrés, Providencia, and Santa Catalina Archipelago to accelerate the natural recovery of intervened reefs, promote adaptation to climate change, anticipate the direct effects of anthropogenic origin, and reach a great social impact. In its initial phase, eight underwater rope nurseries were built with the capacity to grow at least 20,000 fragments of coral reef species. The initial stock was 5,302 fragments of four hard corals, three soft corals, and two sponge species. Six months after stocking (final stock of 13,468 fragments), the average fragment survival ($89\% \pm 7$ SE) and the increase in ecological volume recorded ($365\% \pm 99$ SE of their initial size) were within the reference values for reef restoration projects in the Caribbean. To develop the local capacity in coral gardens and the monitoring of coral reefs in the archipelago, artisanal fishermen were involved until now. In 2020, we have added > 6,000 nursery-grown coral colonies in 14 hectares, leading to an increase in the live coral cover of 8%, which will allow us to assess changes in fish biomass, aesthetic value and structural complexity, and overall health at intervened coral reefs within the Seaflower MPA.

A photograph showing two men on a boat, likely a research vessel, working with a piece of scientific equipment. The man in the foreground is wearing a blue t-shirt, a light-colored bucket hat, and yellow gloves. The man behind him is wearing a white t-shirt, a dark baseball cap, and yellow gloves. They are both looking down at the equipment, which consists of a metal frame with a large orange container and various pipes and sensors. The background shows the ocean and a clear blue sky.

**Big and open
data in the
ocean**

Photo: Santiago Estrada

Theme 4

Fish Aggregating Devices as potential oceanographic monitoring platforms in the Eastern Tropical Pacific

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Abstract

Background: Marine environmental characterization is often developed from traditional tools of ocean sciences such as multiparametric sounders, fixed monitoring stations, and, recently, remote sensing. However, the technological advance in oceanographic instrumentation and the approach of multidisciplinary studies invites to consider non-traditional but complementary sources of information. Aims: To analyze the spatial-temporal distribution of Fish Aggregating Devices - FADs as a justification for their possible use as alternative platforms for the monitoring of oceanographic conditions in the eastern region of the Eastern Tropical Pacific. Methods: The spatial coverage and temporal distribution of oceanographic data obtained from the ERFEN program, the World Ocean Data Base, the World Ocean Atlas, and satellite images from the MODIS-Aqua sensor were reviewed. The result of this review was compared with the spatial-temporal coverage of sets made on FADs, information reported by the Inter-American Tropical Tuna Commission, and the Colombian Fisheries Observer Program. The 39,988 sets made on FADs between 2009 and 2015 had an almost uniform distribution in the study area, regardless of the year analyzed. The oceanographic information included 1048 stations of the ERFEN Program and 176,271 data belonging to the World Ocean Database. Despite the amount of oceanographic information available, its temporal distribution and spatial coverage showed information gaps in the et-POT. Conclusion: The information gaps identified in the spatial and temporal distribution of oceanographic data measured by different programs and instruments, compared to a more uniform coverage of WDDs in the et-POT, could justify the development of alternative oceanographic monitoring systems based on the use of these devices.

Harnessing big and open datasets for mangrove mapping, species conservation, and decision-making for blue carbon investments in Colombia

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Ana M. De Los Ríos, Yéssica
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Abstract

Scientists and natural resource managers currently face three challenges regarding the study, conservation, and sustainable use of mangroves in Colombia: updating distribution maps, designating new marine protected areas, and identifying potential areas for investing in blue carbon projects. A growing number of satellite imagery

archiving and online-processing services now facilitate mangrove mapping tasks, while global datasets of the attributes of mangrove ecosystems now allow to estimate areas and to determine the dynamics of different variables such as ecosystem biomass, tree and canopy height, and fragmentation, among others. Besides, the implementation of cross-agency open geographic data repositories in Colombia provides a unique opportunity to combine mangrove data with environmental, social, and economic variables at scales ranging from landscapes to municipalities and departments for identifying conservation gaps and threats to vulnerable species, and guiding decision-making on blue carbon investments. Here, we present three examples of the application of open and big data to face the above challenges. Firstly, we show the usefulness of the Google Earth Engine platform and Sentinel imagery for mapping multiyear mangrove cover in the Urabá region. Secondly, we identify threats for the vulnerable Tea Mangrove Tree *Pelliciera rhizophorae* combining published field surveys with landscape attributes and nighttime lights imagery along the Caribbean coast. Thirdly, we identified areas for potential investments on blue carbon projects combining estimated mangrove carbon with socio-economic variables, concluding that they are critical for long-term potential success. In conclusion, it is important to incorporate multiple sources of big data for studying, preserving, and managing mangroves in Colombia.

Comparison between in situ and satellite sea surface temperature in whale shark distribution areas at the northeast of Yucatán Peninsula, Mexico (2005 – 2020)

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Abstract

Ecological research focusing on marine species with ecologic and socioeconomic importance, like whale sharks, are crucial for their management and sustainable use. Previous research on whale shark habitat determined that sea surface temperature (SST) is a key environmental factor for their distribution and abundance. The aim was to compare the average status and the variation of the in situ and satellite SSTs in whale shark aggregation areas (May to September from 2005 – 2020) at the northeast of the Yucatán Peninsula, Mexico. Whale sharks were recorded in marine (93) and aerial (26) censuses. In situ SSTs were measured during marine censuses while satellite SSTs were obtained from weekly climatologies from MODIS-Aqua with a 1 km spatial resolution. We assessed the correlation between whale shark abundance and the in situ and satellite SSTs. We identified *in situ* SSTs between 23.3 - 29.7°C (mean = 27.8°C, S.D. +1.6) and satellite SSTs between 26.6 - 29.8°C (mean = 28.6°C, S.D. +0.7) in 165 sightings where 4,235 whale sharks were recorded. No statistical differences between in situ and satellite SSTs (Kruskal-Wallis = 80.81, $p = 0.48$)

were observed, and the correlation analysis exhibit a direct relationship statistically significant (Spearman = 0.75). The *in situ* (Kruskal-Wallis = 61.92, $p = 0.13$) and satellite-derived (Kruskal-Wallis = 130.30, $p = 0.33$) SSTs where whale shark presence was consistent were not statistically different to thermal conditions in adjacent areas. Due to changes in thermal conditions of whale shark habitats that can modify their abundance and spatial distribution, the long-term monitoring of this environmental factor is relevant, particularly in the context of changing climatic conditions.

Forty years of global wave hindcasts using the observation-based source terms: validation and geophysical applications

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Abstract

Forty years (1979-2019) of global wave hindcasts are developed with the third-generation spectral wave model WAVEWATCH III® using the state-of-the-art observation-based source term parameterizations (i.e., ST6) and the advanced irregular-regular-irregular (IRI) 1/4° grid system. The wave model has been forced with two distinct wind databases sourced from the latest NCEP Climate Forecast System (CFS) and the fifth generation of the ECMWF climate reanalyses (ERA5), together with the ice concentration available from the EUMETSAT OSI SAF (version 2). The hindcasts not only include traditional integral wave parameters (e.g., wave height, period) but also provide various novel parameters such as the dominant wave breaking probability, wave-induced mixed layer depth, and whitecap coverage that are derived from wave spectrum based on previous theoretical and empirical studies. Wave parameters are extensively validated against observations from *in situ* buoys and satellite altimeters on a global scale. Possible applications of these hindcasts in the fields of freak waves, sea spray, and the air-sea gas transfer will also be discussed.

A quality control measure for wave buoy observations

Joey Voermans, Alexander Babanin, Cagil Kirezci, Jonas Carvalho,
Marcelo Santini, Bruna Pavani, Luciano Pezzi
University of Melbourne

Abstract

Wave buoys are an important data source for met-ocean model validation and calibration. To guarantee the accuracy of wave buoy observations, sophisticated quality control measures are required. It is a common practice to detect anomalies or outliers in surface wave measurements by applying a standard deviation threshold. While perfectly able to flag spikes in a wave record, the standard deviation thresh-

old method cannot distinguish between a rare but natural event and an instrument problem. In particular, extreme waves will be flagged erroneously. Here, we present a semi-physical wave anomaly identification method using a phase-space threshold. We show that surface displacement time-series are well described by a predictable ellipse in phase-space, the axes of which are defined by the spectral properties of the wave field.

DDW3: A useful tool for download and analyzing wave and wind data

Román Alejandro Canul Turriza¹, Violeta Zetzangari Fernández Díaz², Gregorio Posada Vanegas¹, Ángel Gabriel Kuc Castilla³

Universidad Autónoma de Campeche¹, Universidad Autónoma de Baja California², Universidad Nacional Autónoma de México³

Abstract

For the accurate development of projects in the coastal zone, it is necessary to have extensive and reliable information on maritime climate (wave and wind data). For this purpose, several institutions have made available to the scientific community information that can be freely downloaded; however, knowledge in both advanced programming and statistics are required for its downloading and processing.

This paper presents a tool developed in MATLAB®, which allows the fast and automated download and analysis of waves and winds records from the NCEP – NOAA (WaveWatchIII) database for the 1979 to 2018 period. This tool allows the downloading of information from one or several points of interest within the same domain and performs a statistical analysis, which characterizes the medium and extreme regimes through the annual maximum method and generates useful graphs that facilitate the interpretation and subsequent management of the information such as wave and wind roses, joint probability, exceedance probability, among others. This tool allows obtaining and analyzing information from a free database in a simple, fast, and automated way, saving processing time, and obtaining robust and reliable information.

Species distribution modeling for *Pelliciera* (Tr & Pl) spp. in Colombia: an endemic and vulnerable Neotropical mangrove

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Abstract

Pelliciera rhizophorae (Triana & Planchon) (Ericales: Tetrameristaceae) is an endemic Neotropical mangrove tree which until recently was believed to comprise a single species, but a new species, the *P. benthamii* (Cornejo & Bonifaz, 2020; Duke, 2020), has recently been proposed. *P. rhizophorae* was classified as Vulnerable B2ab (iii) according to IUCN criteria due to its narrow geographic range and isolated populations. Such conditions could be even more serious if the two species are considered separately. Currently, *Pelliciera* has a discontinuous distribution along the Western

Caribbean (found only in small patches in Nicaragua, Panama, and Colombia), but a wider and more continuous distribution along the Eastern Tropical Pacific (from Costa Rica to Ecuador). *Pelliciera* is believed to have high mortality and slow individual growth under medium-high salinity conditions. Knowing the climatic factors that affect this mangrove genus will allow the formulation of a plan for its conservation and guide ecoregional coastal planning in a time of global change. Therefore, we compiled a database of the presence and absence of this mangrove tree for the Colombian continental coast based on the national inventory of mangroves (HELIO.SP.CO v1), the GBIF, and the scientific literature. Subsequently, we built a logistic model to test for the climatic, oceanographic, and geomorphological factors that best explain the occurrence of the genus. We found that mean sea surface salinity (SSS) explained 30% better the occurrence compared to a null model. Thereby, changes in SSS due to climate changes and anthropogenic disturbances pose a risk to *Pelliciera* in the fore-coming years.

Understanding Coastal Biodiversity in the Americas Through the Pole-to-Pole Marine Biodiversity Observation Network (MBON)

Luis Lizcano-Sandoval, Enrique Montes, Frank Muller-Karger
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Abstract

Understanding biodiversity over continental scales is a challenge but is required to plan for its management, including conservation and sustainable development. The Marine Biodiversity Observation Network (MBON), a thematic component of The Group on Earth Observations Biodiversity Observation Network (GEO BON), is collaborating with the Global Ocean Observing System (GOOS), the Ocean Biogeographic Information System (OBIS), and other global partners to make available observations needed to ensure living marine resources are sustainably conserved and managed and can support essential human needs. This open community of technical experts helps international cooperation regarding the best practices for observing and data management and services, combined with capacity development. In this context, a regional MBON provides benefits such as (1) expanding our knowledge of biodiversity and its services; (2) coordinating disaggregated biodiversity monitoring and science programs to share data, knowledge, and protocols; (3) increasing understanding of physical and biological connectivity, including distributions and movements of migratory species across jurisdictions; (4) minimizing the high costs of data management and of improving access to information; and (5) developing a framework for a country to establish biodiversity baseline indices needed for future assessments and science-based decisions. The Pole-to-Pole MBON effort is a pilot demonstration with a network of collaborators across the region and from many different countries. The collaboration seeks to address common problems related to observing life, as well as its diversity and abundance, to sustain ecosystem services. The collaboration uses common methodologies, capacity building, and shares best practices to conduct joint science programs.



**Fair and
Sustainable
use of Marine
Resources**

Photo: Elena Quintanillas

Theme 5

Abundance and body size of parrotfishes (*scarus and sparisoma*) at the seaflower biosphere reserve: a characterization

Natalia Rivas Escobar,
Instituto de Estudios en Ciencias del Mar (Cecimar)

Abstract

Five parrotfish species are currently included in the Colombian Red Book of Marine Fishes. Fish population traits such as abundance and individual body size are among the most popular features used to identify potential effects of fishing pressure. In this study, a diver-operated stereo-video technique was used to characterize parrotfish populations (*Scarus* and *Sparisoma*) in terms of abundance and body size, differentiating between color phases. Data were collected between September and November 2018 in parrotfish populations of four nearby locations at the Seaflower Biosphere Reserve. *Sparisoma viride* was less abundant in San Andrés island, as well as the fraction of its population in the terminal phase. Concerning body sizes, *Sparisoma viride* and *Scarus vetula* presented smaller values in San Andrés, while *Scarus taeniopterus* and *Scarus iseri* had larger sizes at the same locality. We discuss how our findings can be related to fishing exploitation. The results obtained are presented as a baseline to continue and expand the study of these relationships.

Marine recreational fishing as an alternative for the development of ecological tourism in the Magdalena region, Colombian Caribbean

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Abstract

Marine recreational fishing is an activity that encourages the development of the blue economy. However, the seasonal migration of pelagic fish and its relationship with oceanographic conditions should be considered to promote this economic activity in sustainable and responsible fishing. Therefore, the objective of this study is to present the spatio-temporal distribution of pelagic fish that are objects of recreational fishing and its relationship with environmental variables such as temperature, salinity, and winds in the marine area of the department of Magdalena, Colombian Caribbean. The catches were obtained through the trolling method and the fishing rod gear that is generally used in recreational fishing. Two to three monthly samplings were carried out between March 2018 and April 2019. 120 individuals of billfish species such as *Thunnus alalunga*, *Euthynnus alletteratus*, *Sphyraena barracuda*, *Scomberomorus cavalla*, *Coryphaena hippurus*, *Caranx ruber*, *Caranx hippos*, *Caranx crysos*, *Auxis thazard*, *Acanthocybium solandri*, *Sarda*, *Seriola rivoliana*, and *Elagatis bipinnulata* were captured. The highest catches were observed between the months of March-April and August-October, related to oceanographic conditions. This recreational fishing activity can be carried out as ecological tourism, contributing to the development of the blue economy since it encourages responsible fishing and income.

Understanding the livelihoods of artisanal fishing communities: An approach based on a household production model

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Universidad de los Andes

Abstract

In developing countries, artisanal fishing households are like peasant households. Their livelihood strategies are defined by the fact that production can be sold or consumed within the household itself. They engage in a range of productive activities, mainly based on the use of family labor. However, in contrast to peasant households, fishing involves hunting, and the production factor associated with natural capital is a non-excludable resource. As far as we know, there is no microeconomic model intended to help understand the economics of artisanal fishing households by incorporating these details. In this paper, we propose a theoretical model based on the household production model by Singh et al. (1986) to understand the livelihoods of artisanal fishing communities. Our contribution consists of: i) we include the stock of the resource within the model, given that fishers exploit a common pool resource, and ii) based on the optimization, we determine the stock of the resource that leads to the tragedy of the commons. The theoretical model can be used to estimate the supply of fish for sale, the demand for fish for self-consumption, the supply of labor for the fishing activity and other activities, and the demand for consumer goods other than captured fish. We also estimate the elasticities for all relevant parameters. The results of the model are useful for the design of policy tools intended to ensure the sustainability of resources extracted in a manner that is compatible with the economic development of fishing communities.

Risk assessment of potential tourist-vessel collision with cetaceans in the Colombian EEZ: a tool for whale-watching management

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Abstract

The rapid expansion of tourist vessel-based activities constitutes a potential threat for cetaceans due to vessel collision. Here, we evaluated the potential tourist-vessel collision risk within the Colombian Exclusive Economic Zone for the most common cetacean species that are a target for whale-watching activities, which include the bottlenose dolphin, the pantropical spotted dolphin, and the spinner dolphin for both the Caribbean and Pacific Oceans, the Atlantic spotted dolphin and the humpback whale for the Caribbean and the Pacific Ocean, respectively. Tourist vessel

types used for analysis included touristic (e.g. cruise) and pleasure boats (e.g. motor yacht, sailboat) from 2016 and 2017. We used the algorithms of maximum entropy method (Maxent), Maslike, and Support Vector Machine-SVM for modeling species geographic distributions with presence-only data. Environmental information was gathered from MARSPEC in raster format at 1 km resolution, including bathymetry, bathymetric slope, distance-to-shore, Sea-Surface-Temperature, and Sea-Surface-Salinity, and we produced information for currents and waves. We used the species habitat models to build a geographic information system using ArcGIS to visualize the overlapping between the most traveled touristic routes and the most suitable areas for cetacean species. Afterward, we used a multicriteria analysis with experts and we defined the areas with the highest risk of collision (critical areas). Results showed that coastal zones were the areas with the highest collision risk for all species and both types of vessel analyzed. Therefore, it is paramount that boat-based touristic operators maintain a vessel speed below 10 knots to mitigate vessel collision risk, mainly in coastal areas.

Microbial composition and diversity in deep-sea sediments in the Southern Colombian Caribbean Sea

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Abstract

Deep-sea sediments are considered an extreme environment due to high atmospheric pressure and low temperatures. The microorganisms inhabiting marine sediments are poorly studied since most are non-culturable and there are challenges associated with deep-sea sampling. This study used 16S rRNA sequencing to estimate the microbial composition and diversity of six samples collected at different depths in two localities of the Southern Colombian Caribbean Sea. We found 1851 OTUs assigned to Domains Bacteria (1842) and Archaea (9). For the latter, we identified the phyla Crenarchaeota and Parvarchaeota. In the bacteria domain, the most abundant phylum was Proteobacteria (54.74%), followed by Bacteroidetes (24.36%) and Firmicutes (9.48%). At the class-level, Alphaproteobacteria was most abundant (28.4%), followed by Gammaproteobacteria (24.44%) and Flavobacteria (16.97%). Particularly, we observed a higher abundance of Flavobacteria in samples collected at greater depths. On the other hand, for Bacteria, the dominant species was *Erythrobacter citreus*, followed by *Gramella* sp. Overall, we found that in deeper marine sediments (e.g., locality CSC_B), the microbial alpha diversity decreased while the dominance of several genera increased; moreover, for locality CSC_A, we found that the microbial diversity was associated with total organic carbon content.

Genetic status and connectivity of *Sparisoma aurofrenatum* the South Caribbean

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Abstract

Sparisoma aurofrenatum, the redband parrotfish, plays an important ecological role: maintaining the balance between corals and macroalgae, facilitating recruitment and coral growth. Since the populations of commercial fish species such as groupers and snappers are currently declining, there is an increasing trend towards catching mid-sized herbivorous fish, and *S. aurofrenatum* is not the exception. Therefore, it is necessary to explore the genetic status of this species, given its gradual appearance as a fishery target, either legally or illegally. This fish is an important herbivore reef fish since it plays an important ecological role in helping to maintain the balance of the benthic reef communities. A population with good genetic health should have enough genetic diversity to potentially allow it to cope with present or future environmental challenges. Therefore, we studied the genetic status of this species in the Southern Caribbean and the effects of some biogeographic barriers on its genetic connectivity, which may have important implications in management and species conservation. A mitochondrial gene (control region) was used in 88 individuals sampled throughout four localities across the South Caribbean. Our results point to a panmictic population with high genetic connectivity and a high and effective population size that has experienced a recent population expansion during the last glacial period.

Deep-Sea Queen Conch Monitoring Using ROV Technologies in the Seaflower Biosphere Reserve, Colombian Caribbean

Omar Abril-Howard¹, Ruben Azcarate¹, Alfredo Abril-Howard¹, Anthony Rojas³,
Jairo Medina⁴

SEPIAROV¹, Secretary of Agriculture and Fisheries, Provincial Government of the Archipelago of San Andrés, Providencia, and Santa Catalina², Universidad Nacional de Colombia³

Abstract

In the Seaflower Biosphere Reserve (BR), marine ecosystems deeper than 40 meters have been little studied, this generates information gaps that affect the processes of conservation and recognition of the population dynamics of marine species. For more than two decades, the Departmental Government, the Universidad Nacional de Colombia, and the CORALINA Corporation have monitored strategic ecosystems for the conservation of marine biodiversity in the Seaflower BR, rarely more than 40 meters deep due to the technical, physical, and operational limitations. Remotely Operated Underwater Vehicles (ROVs) have become a viable alternative to monitor these ecosystems. The local company SEPIAROV developed ROV technologies that solve the monitoring of deep ecosystems at low cost, optimizing data collection, and simplifying logistics using a Class-1 ROV. In 2019, for the first time at the BR, the assessment of the queen conch *Aliger gigas* (formerly known as *Strombus gigas*) was

carried out with results that indicate the good state of conservation of its populations at greater depths. ROV characteristics such as focal length, camera systems, navigation, speed, and others were adapted to estimate the abundance and distribution of the queen conch that inhabits up to 100 meters deep. The methodology was developed and validated with the Universidad Nacional, which allowed obtaining data comparable with the shallow monitoring carried out before. With the development of this project, stakeholders have understood the potential and need to monitor deep populations of the queen conch, as well as other species of importance to the BR, to improve conservation efforts.

Genes associated with resistance and antimicrobial compounds synthesis in a mangrove subjected to contrasting salinities

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Angie Vanessa Sandoval³

Universidad Nacional de Colombia¹, Universidad Javeriana², Universidad Antonio Nariño³

Abstract

Mangroves are subject to biotic, abiotic (e.g., variable salinity), and anthropogenic stresses, notable pollution from urban waste. In this context, salinity and wastewater pollution in mangrove ecosystems could affect populations of microorganisms and the relative abundance of genes involved in the biological response to these stressors. This research aimed to identify genes associated with resistance and biosynthesis of antimicrobial compounds in mangrove soils subjected to contrasting salinities. Rhizospheric soil samples were taken from three areas with different salinities in a mangrove contaminated with wastewater at the Ranchería River's mouth in La Guajira, Colombia. Genomic DNA was extracted for sequencing using Illumina HiSeq 2500, and taxonomic and functional diversity analyses revealed a dominance of 56 families and 193 genera of Actinobacteria. The most common biosynthesis routes were for streptomycin and monobactams. Forty-three genes were associated with the synthesis of antimicrobial compounds, and the expression of 24 of them was significantly influenced by salinity. Increased salt concentration influenced the metabolic pathways and differential expression of genes associated with the synthesis of antimicrobial compounds (i.e., *rfbB*, *INO1*, *rfbA*, *sat*, *asd*, and *lysC*). Also, of 29 genes involved in intrinsic antibiotic resistance, 16 were significantly influenced by salinity (i.e., *acrB*, *cusR*, *bpeF*, *mexF*, *vgb*, and *cmeB*). We conclude that the mechanisms of tolerance and adaptability to saline stress conditions could favor the synthesis of antimicrobial compounds in mangroves subjected to contamination by wastewater.

Spatial structure of biomass and size of demersal fishes in the Colombian Caribbean

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Universidad del Magdalena, Universidad del Magdalena, Tropical Fisheries Science and

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Abstract

Fish play an important role in the flow of matter and energy in marine communities. When anthropogenic and natural alterations appear, they produce structure modifications in terms of composition, abundance, and distribution of the assemblages. The present work aims to establish spatial distribution patterns of density for the 10 most recurrent demersal species in the Colombian Caribbean. Data were obtained by 64 sample stations located from Punta Gallinas (7114'0) to Golfo de Urabá (7653'0). From the standardized information of the number of individuals and biomass (CPUA) of each species, the length-weight, sex-ratio, size-structure by depth strata, and sex-zone relationships were evaluated. Also, the spatial distribution of density analysis was obtained, as well as the possible relationship of the highest densities with environmental conditions like depth and geographical position. Size structure was evaluated using frequency histograms, spatial distribution was achieved using geostatistical modeling, and the relationship between density and environmental conditions was analyzed using generalized additive models. The largest species aggregations were associated with Punta Gallinas, Cabo de la Vela (upwelling zone), Bocas de Ceniza, Cartagena, Golfo de Morrosquillo, and Golfo de Urabá. Also, species showed a high correlation with latitude and depths between 30 – 50 m. This work emphasizes the importance of increasing knowledge of basic biology and the ecology of these species, key to the fish assemblages of shallow waters, which are highly frequent and abundant in the by-catch of shrimp trawl developed in the Colombian Caribbean.

Bioerosion produced by porcelain crabs (Crustacea: Anomura: Porcellanidae) from the Caribbean coast of Colombia

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The University of Bremen Faculty for Biology and Chemistry

Abstract

To research the bioerosion activity of porcelain crabs in dead coral skeleton blocks, built aquariums with aeration and constant seawater flow were used to sustain living organisms. One preliminary test and three other different ones were performed, providing evidence of bioerosion activity by this specific group of crustaceans. Each aquarium had a different set up concerning the number of crabs, coral blocks, and other general outlines (caved or not caved blocks, temperature, and water flow). The crabs were taxonomically identified, sexed, and properly fed for their maintenance

throughout the test. The calcium carbonate detached from each coral block was daily stored in plastic tagged flasks. Behavioral reports, history of survivorship, and general environmental noise factors were reported. The weight of calcium carbonate detached from each coral block was measured and statistically analyzed, finding no differences between the aquarium treatments and the production of CaCO_3 measure in weight over several individuals during a specific lapse of time. The state of weariness of different crab claws was measured together with their percentages of mass composition (Ca, Mg, and O), finding a statistically positive relationship between these two conditions. This research is important to obtain a good comprehension of the cryptic species that habit rocky shore ecosystems, to evidence activity facts from them, and to bring new scientific questions and discoveries that can lead to a big source of new research related to these issues.

Responsible markets as a strategy for fish stock conservation and implementing blue economy

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MarViva Foundation Colombia

Abstract

The concept of the blue economy has permeated the rhetoric of public, private, and multilateral actors that conceive it as a strategic path towards economic growth. The literature highlights the importance of stakeholder engagement for social innovation to contribute to achieving ocean sustainability and social and economic development for almost 60 million people whose livelihoods depend on the oceans. In light of the Standard for Environmental Responsibility in the Commercialization of Marine Fish developed and implemented by the MarViva Foundation, this paper discusses the relevance of civil society organizations and their efforts in promoting sustainability through certification schemes for sustainable fishing. This private certification is aimed at companies that commercialize marine and farmed fish and seek to promote better commercial practices. These practices are governed by principles and criteria that promote the future availability of species so that they can continue to be available to future generations. So far, 541 artisanal fishers have been trained in responsible fishing, food safety, business administration basics, and interpersonal skills in Costa Rica, Panama, and Colombia; 9 responsible fishing value chains, encompassing 22 productive groups in 16 coastal communities in the three countries, have been strengthened thus far. Artisanal fishers achieve an average of 30% higher price/kg for responsible, certified (versus non-validated) products. This case study contributes to the understanding of responsible markets and certification schemes as viable market-driven strategies to operationalize the concept of the blue economy while promoting the sustainability of fisheries resources, as well as the economic and social development of coastal communities.

Income diversification strategies and their impact on coastal households' well-being: evidence from Latin America and The Caribbean region

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Universidad de los Andes¹, Justus Liebig Universität²,
Corporation Center of Excellence in Marine Sciences³

Abstract

Income diversification refers to the increase in income sources or the balance shared among the different sources. It has been promoted to reduce vulnerability, provide a pathway out of poverty, improve the well-being of the rural communities, and, in the context of fisheries, for reducing dependence on the resources. This research analyzes income diversification by identifying the drivers and impacts of this strategy on marine fishing households' well-being in the LAC region. To this end, an empirical model is estimated in which the degree of income diversification is regressed over a set of exogenous predictors available in the monthly data panel of a Colombian coastal community. The causal relationship between diversification and households' well-being is estimated using the instrumental variable approach. The results of this study have two implications for fisheries development policy. On one hand, they allow understanding whether fishing is a “last resort activity”, and, therefore, if the creation of alternative livelihoods as a response to overfishing or restriction on marine resources is acceptable and beneficial. On the other hand, the results will allow us to understand whether income diversification can improve household well-being, even when sources of income rely on the same ecosystem.

Phylogenomics of the Caribbean candelabrum corals

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Abstract

Octocorals with around 3500 valid species are one of the most diverse groups in marine benthic communities, which includes gorgonians, soft corals, and sea pens. In the Caribbean reefs, the diversity and biomass of octocorals can be greater than those of scleractinian corals in some habitats. The genus *Eunicea* is the most abundant and diverse group of Octocorals in Caribbean reefs. However, its diversity is still unresolved, mainly because of the high morphological variability among and within species and the lack of powerful genetic markers. In this study, we provided a complete *Eunicea* phylogeny using a phylogenomic approach based on new molecular techniques from genome-scale data, including all described species and all the possible undescribed morphotypes. Our results support the monophyletic status of the group and at least one new species.

Biology and Ecology of *Pterois volitans* in the Corales de Profundidad Natural National Park, Colombian Caribbean

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Abstract

The vast majority of the Lionfish invasion investigations have been carried out in the shallow environment, so knowledge of the deep sea is limited. The abundance, feeding habits, and reproduction of *Pterois volitans* were studied in the mesophotic environment of the Corales de Profundidad National Natural Park (35-160 m). Observations and captures of Lionfish were made by remote operation vehicles, drift cameras, closed-circuit technical diving -rebreather-, and artisanal fishing traps. 237 specimens were observed, most of them in the upper mesophotic zone. The mean length was 30.5 ± 3.5 cm ($n = 75$), the males being larger than the females. Sixteen preys were identified, the most important being the teleosts Acanthuridae and Monacanthidae, and the crustacean Penaeidae. A stable isotope analysis using a Bayesian model indicates that *P. volitans* occupies a less extensive isotopic niche in the Park than in shallow sectors and that there is an isotopic niche overlap between the sexes. All the specimens were mature; in females, the regression phase predominated ($n = 15$) and only five females were in late development. The condition factor (FC), the gonadosomatic index (IGS), and the hepatosomatic index (IHS) increased with gonadal development, reaching the peak in the active spawning phase and decreasing in the regression. The results of this first study of lionfish in the mesophotic environment of the PNNCPR highlights the need to continue monitoring and observation efforts throughout the depth range of the Park and the implementation of novel strategies for the control and management of lionfish.

Deep-sea megainvertebrates in the Colombian Caribbean: biological and ecological approach

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Universidad del Magdalena², Universität Bremen³,
Pontificia Universidad Católica de Chile⁴

Abstract

In the Colombian Caribbean, high abundance and distribution of deep-water species with potential commercial value have been reported. However, information about these local species is limited. Therefore, the objective of the present study was to determine the composition, distribution, and some biological and ecological aspects (diversity index, size structure, abundance biomass comparison curves) of deep-sea megainvertebrates in the Colombian Caribbean. The samples were taken in August and December 2009 and March and May 2010 at depths between 100 and 600 m in a shrimp trawler vessel in the Colombian Caribbean. We found a total of 36 species corresponding to 19 families. The species with higher biomass, abundance, and occurrence were *Pleoticus robustus*, *Aristaeomorpha foliacea*, *Metanephrops binghami*, *Penaeopsis serrata*, *Plesionika longipes*, *Agononida longipes*, and *Glyphocrangon neglecta*. Since the commercial species, such as *A. foliacea* and *P. robustus*, have been depleted in ecosystems like the Mediterranean Sea and were found in higher abundances in the Colombian Caribbean Sea, this information is highly important globally. However, information about the biology and ecology of these megainvertebrates should be expanded under an ecosystem approach to develop adequate strategies for their management and conservation.

Distribution, abundance, and threat status of large pelagic sharks in the Colombian Caribbean Sea

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Diana Rubio-Lancheros, Jose Luis Correa

Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andrés (INVEMAR)

Abstract

Many species of sharks share the oceanic habitat along with other large important commercial pelagic fish and, therefore, they have high interaction with the industrial fishery. In Colombia, longline industrial tuna fleet evaluation shows that sharks are an important bycatch component. Although pelagic sharks are highly migratory and widely distributed, there are few specific studies of this group in our country. Therefore, information about large pelagic resources available from prospecting cruises carried out between 2013 and 2018 in the Colombian Caribbean was integrated to determine the distribution and abundance of sharks, as well as its association with oceanographic variables. Six species of the families Lamnidae, Carcharhinidae, and

Sphyrnidae were catches and all fall into some threat category (Endangered, Vulnerable, or Near-threatened), the most abundant being the silky shark (*Carcharhinus falciformis*) and the blue shark (*Prionace glauca*). The pelagic shark occurrence was significantly associated with cold water temperatures (24-26.5 °C) and higher chlorophyll-a concentrations (> 0.20 mg/m³) present in the North-Central Colombian Caribbean Sea. The information provided about the pelagic shark threat status and spatial distribution patterns is essential for marine resources management and the development of conservation strategies in Colombia.

The Queen Conch (*Aliger gigas*) (Linnaeus, 1758) populations and sustainable Management Implications in the San Andrés, Providencia, and Santa Catalina Archipelago, Colombian Caribbean

Ruben Azcarate¹, Diana Lucía Gómez², Gilberto Myles¹, Erick Castro Gonzalez, Anthony Rojas³

CORALINA¹, Javeriana University of Bogota², Secretary of Agriculture and Fisheries of the Government of the San Andrés, Providencia, and Santa Catalina Archipelago³

Abstract

The queen conch *Aliger gigas* (formerly *Strombus gigas*) is an important fishery resource in the Wider Caribbean region. The Departmental Government and the CORALINA Corporation have been monitoring the population of this species in the San Andrés, Providencia, and Santa Catalina Archipelago for almost two decades. The Archipelago, with more than 18 million hectares, is divided into three marine protected areas (MPAs): Northern, Central, and Southern. The total average density (TAD) in the Southern MPA in 2019 was only 2.4 ± 1.4 SE adults/ha, and 12.18 ± 7.05 SE adults/ha in the Central MPA, while in 2018 in the Northern MPA TAD was 68.40 ± 26.68 SE adults/ha. Next, Serrana Bank is the only place where queen conch fisheries are allowed, with annual calculated adult biomass of > 100 tons. The queen conch populations are different between these areas, mainly because of the fishing practices and location due to coastal human settlements, both national and international. We concluded that the populations of the queen conch in the Southern MPA, the closest to the human settlements, have densities similar to those of overexploited areas in the Caribbean, and it is necessary to implement relevant conservation measures that allow the recovery and sustainable use of this resource by the communities inhabiting the Archipelago.

Sustainable insect feed for a closed shrimp aquaculture

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Abstract

Food from the sea accounts for > 30% of the protein supply for human consumption. Aside from the traditional fishing industry, aquaculture is constantly rising to cover an increasing protein demand. However, many aquaculture facilities suffer from high disease susceptibilities, comparably low growth rates, and the use of unsustainable feed. The latter frequently originates from unsustainable sources such as fish meal, further depleting the oceans' protein resources. This also affects shrimp aquacultures. Moreover, the non-optimal nutrient content is often compensated with supplementary growth hormones, and feed-borne pathogens are regularly treated with antibiotics and fungicides – all substances that may accumulate in the food species. To address these issues, we are currently establishing sustainable closed aquaculture with the white leg shrimp (*Litopenaeus vannamei*) based on a custom-tailored insect feed as a high-quality protein source with a low pathogen load. The cosmopolitan black soldier fly (*Hermetia illucens*) – an emerging and generalist taxon for feed-food-coupling- is a useful insect species. In particular, we plan to 1) further enhance the immune system of the *H. illucens* with AMPs (antimicrobial peptides), 2) improve the nutritional profile of the feed with HUFA (Highly Unsaturated Fatty Acids), and 3) optimize the husbandry conditions for *L. vannamei*. Anticipated outcomes of the project are an applicable system of biogenic material flows for feed-food-coupling, custom-tailored, hormone- and antibiotic-free insect-based feed, and precise knowledge of species-appropriate husbandry conditions for *L. vannamei*. The innovative approach could provide a new perspective for sustainable and resource-efficient urban agriculture with safe and nutritionally valuable food.

Contrasting economic vulnerability and poverty between fishing and non-fishing households in marine coastal communities

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Abstract

Small-scale fisherfolks are frequently characterized as “the poorest of the poor”. However, it has been recently pointed out that they are not necessarily the poorest of the poor in monetary terms, but may, instead, be amongst the most vulnerable socio-economic groups due to the sensitivity of their livelihood system to risks and their (lack of) ability to cope with external shocks. To explore these statements, this study analyzes and compares the monetary poverty and the economic vulnerability of fishing and non-fishing households of a coastal community in the LAC region based on the Foster-Greer-Thorbecke (FGT) poverty measure and the vulnerability

index proposed by Bené (2009). Furthermore, the study delves into the community's income diversity, using monthly data collected over one year to show how income from fishing activity might lead to poverty reduction while contributing to the economic vulnerability of households. The results seek to draw attention to poverty alleviation strategies which must consider two types of groups, namely, the poor and the vulnerable, and to recognize the relative importance of fishing income source in deriving inter-household poverty.

Epiphytic flora associated with *Hypnea spp.* culture in Old Providence island, Caribbean Colombia

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Abstract

Colombia is the only South American country with a coast on both the Pacific and the Atlantic oceans, and it is one of the twelve megadiverse countries in the world. However, its marine biodiversity is not well known, but it harbors several species of macroalgae that are suitable for culture. Due to this potential, the Government, the Universidad Nacional de Colombia, CORALINA, and Natural Parks started a pilot project to cultivate promising species of algae, among which *Hypnea spp.* were selected for carrageenan production. It is known that one of the main problems in seaweed culture is the growth of epiphytic algae on the target species, which may hamper biomass production. The objective of this research was to identify the epiphytic flora growing on *Hypnea spp.* in the culture system offshore Old Providence island. Epiphyte samples were collected between July 2018 and August 2019 at More Reef, where the culture structures are located. Samples were collected by hand on *Hypnea* and preserved in a solution of 5% formalin in seawater. In the lab, algae were separated and identified using a stereoscope and optical microscope. When necessary, cross- or longitudinal-sections were made by hand. A total of 47 species of epiphytic algae were identified. The dominant phylum was Rhodophyta, followed by Phaeophyceae, Chlorophyta, and Cyanophyta. The most representative genera were *Chondria*, *Polysiphonia*, and *Dictyota*. Additionally, an unidentified species of the genus *Penicillium* (Fungi) was observed in the samples.

The epiphytic flora associated with *Hypnea* on the culture structure is highly diverse. The phylum Rhodophyta is dominant, as it normally is in tropical waters. Some genera identified in the present research, such as *Polysiphonia*, *Lyngbya*, *Acanthophora*, *Ulva*, and *Jania*, may be noxious to the culture, as demonstrated in other works. Finally, seven species identified are a new record for Colombia.

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

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Abstract

Isostichopus sp. is a morphotype of *Isostichopus badionotus*, which has been intensely fished in the Colombian Caribbean due to its value (up to 300 US \$/kg), arousing interest for its aquaculture. However, a limitation for their seed production is the high larval mortality. This study evaluated through three trials the effect of two culture densities (1-3 larvae/mL), 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 (621.8±12.7 µm (+SE)). Density significantly affected larval growth and survival (F = 32.01, p = 0.004; F = 10.88, p = 0.03, respectively) and the temperature influenced the growth (F = 44.43, p = 0.002). The highest growth rates, survival, and percentage of doliolaria larvae were obtained with 1 larva/mL (29.2 µm/day and 31.5% doliolaria larvae) and 26°C (28.4 µm/day and 10% doliolaria larvae). The 64-day culture of juveniles with an average size of 5.1 ± 0.1 mm was recorded. In the two diets evaluated, the larvae did not complete their development, and they showed a low growth rate (between 1.3 and 8.5 µm/day) and high mortality. This work reports, for the first time, the production of sea cucumber juveniles in Colombia, indicating that it is feasible to cultivate larvae of *Isostichopus sp.* to juveniles, using 1 larva/mL and 26 °C.

Metagenome analysis of tolerance and resistance to heavy metals in soils of mangrove in La Guajira, Colombia

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Abstract

Mangroves are tidal swamps found in tropical and sub-tropical regions. These ecosystems are subject to heavy metals of anthropogenic and natural origin that are recalcitrant and accumulate in the trophic chain generating toxicity to mangroves and changes of microbial diversity. However, knowledge of the mechanisms that mangrove microorganisms must tolerate and with which they resist heavy metals is limited. The objective of this study was to determine the abundance of genes associated with resistance and tolerance to heavy metals in a mangrove in La Guajira-Colombia. Rhizospheric soil of *Avicennia germinans* was collected from the mangrove swamp in the Riíto arm of the Ranchería river. By shotgun sequencing, 77 genes for tolerance

and resistance were detected with the following relative abundance: for tolerance: five genes associated with nickel with a relative abundance of 34 % of the tolerance and resistance genes, one gene associated with copper (15%), seven genes associated with zinc (2%). The other genes were associated with Cr, Co, Cd, Mo, and Mn ($\leq 1\%$). For resistance: six genes associated with copper with a relative abundance of 16%, 10 genes were associated with cobalt (7%), two genes associated with Co, Zn, and Cd (7%), nine genes associated with zinc (3%), and the other genes were associated with Hg, Ni, Mo, Mn and As ($\leq 4\%$). The *cusA* and *copA* genes were the most abundant for copper tolerance and resistance, respectively. In conclusion, nickel was the metal with the highest relative abundance of genes associated with tolerance and copper for resistance genes.

Influence of the water quality on the fish community of Tumaco Bay, Colombian Pacific: preliminary results

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Abstract

Tumaco Bay has been reported as an estuary with complex environmental and anthropic interactions affecting water quality, which could determine the dynamics of the organisms that support artisanal fisheries. The objective of this research was to determine the influence of variations in water quality on the fish community. The organisms were captured using artisanal trawl nets at four sampling sites in February 2020. Additionally, some physicochemical variables and the concentration of nitrites, nitrates, phosphates, and alkalinity were determined at the fishing sites. A total of 42 species from 19 families were captured, with Sciaenidae and Ariidae being the most diverse. The highest species richness occurred in areas of higher salinity and a lower concentration of nitrates and phosphates, which has been reported in other studies in Buenaventura Bay. On the other hand, the highest abundance and fish weight occurred in waters of intermediate salinities and dissolved oxygen lower than 5.4 mg/L, which may be related to the dominance of the species (21%) more tolerant to conditions of low water quality. A total of 75% of the water samples exceeded the reference value of nitrite concentration for eutrophic estuaries (0.03 mg/L) and 83.33% exceeded the reference value for phosphates (0.015 mg/L). These results suggest that artisanal fisheries in Tumaco Bay could be vulnerable to deterioration of water quality due to anthropogenic impacts.

Environmental drivers of mercury accumulation processes and consumption risk of the catfish *Cathorops multiradiatus* in Buenaventura Bay, a species of cultural significance

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Abstract

The population of Buenaventura Bay relies on artisanal fisheries for their survival. The catfish *Cathorops multiradiatus* is highly consumed and represents a species of cultural significance. Paradoxically, this estuary is highly exposed to different pollutants such as mercury, among many others. To determine the dynamics of mercury accumulation and the consumption risk of *C. multiradiatus* in Buenaventura Bay, 103 individuals were caught using artisanal trawling in different seasons and representative areas of the estuary. The content of total mercury dry weight (THg) in muscle was determined for each fish, registering that the average of THg content in *C. multiradiatus* was 0.312 ± 0.149 $\mu\text{g/g}$. The highest THg content in this species was recorded in the rainy season and the external zone of the estuary. In general, higher concentrations of THg in muscle were associated with salinities between 22 and 27 PSU and THg in sediments less than 0.06 $\mu\text{g/g}$. Furthermore, 75% of the fish captured had mercury contents greater than 0.2 $\mu\text{g/g}$, representing a risk of consumption for the vulnerable population. In other words, it only takes a daily consumption of over 25 g of *C. multiradiatus* to represent a risk to human health over time. These results confirm the importance of monitoring the mercury content in estuarine organisms such as *C. multiradiatus*, an essential species for the local population food safety.

Determination of the presence of the nemertean *Carcinonemertes conanobrieni* in the eggs of the Caribbean Spiny Lobster (*Panulirus argus*) in the Archipelago of San Andrés, Providencia, and Santa Catalina

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Abstract

Carcinonemertes conanobrieni was reported for the first time in Florida, US, as a predator of the eggs of the Caribbean Spiny Lobster (*Panulirus argus*), a species with high commercial importance in the region, despite its declining population. Later, it was reported in Magdalena, Colombia, South Caribbean. The objective of this study was to determine the presence of *C. conanobrieni* in the eggs of *P. argus* in the Archipelago of San Andrés, Providencia, and Santa Catalina, and evaluate the effect of its presence on the mortality of embryos.

In September 2019, 25 gravid female lobsters were collected from Providencia and Roncador. Embryos were separated in Petri dishes and inspected for the presence

and number of nemertean present in the egg mass (> 10 high, < 10 low incidences). To measure how the parasite affected the mortality of the eggs, the number of empty capsules and dead eggs was counted. Furthermore, significant differences were assessed between both sites.

Thus, 88% of the lobsters presented *C. conanobrieni* and 68% had a low incidence of nemertean. The incidence of the parasite was 7 times higher in Providencia than in Roncador ($p = 0.00078 < 0.05$). There is a relationship between the presence of the nemertean and the mortality of the embryos when the degree of incidence of the parasite is high; in a low incidence, mortality may also be caused by other natural factors that do not depend exclusively on nemertean.

Antioxidant and hemolytic activity of Melanin from *Octopus maya* ink

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Abstract

Marine products are a source of non-toxic natural antioxidants that fight free radicals. Melanin is one of the compounds of the ink of cephalopods lost during evisceration. Therefore, the objective of this work is to determine whether the melanin from *Octopus maya* could work as an antioxidant.

Methods: Melanin was extracted with the modification of previously reported methodologies, combining water, solvents, and acid washes. Once extracted, its antioxidant activity was tested against DPPH, ABTS, and APPH radicals, and the cytotoxicity test was determined by hemolytic activity using human erythrocytes. The physicochemical characteristics were obtained by the DSC, TGA, SEM, EDS, DRX, and FTIR methods.

Results: The results show that the extraction method employed allows the obtention of pure melanin, free of mineral salts content, with a homogeneous spherical morphology and an average size of 170 ± 50 nm. FTIR spectra showed the typical absorption bands of melanin; the -COOH band is shifted to a lower wavenumber while antioxidant activity for ABTS and DPPH radicals was 92% and 71% inhibition, IC₅₀ of 237 $\mu\text{g}/\text{mL}$ and 202 $\mu\text{g}/\text{mL}$, respectively. For the APPH radical, an activity of 483 μM Trolox (TE)/g per sample and 43% hemolysis at 1.4 mg/mL were found.

Conclusion: This work presents, for the first time, the relationship between the biological activity of salt-free melanin from *Octopus maya* and its physical properties. The melanin has a good antioxidant activity which can be considered as a possible food additive or as a nutraceutical.

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