

STRATEGIC RESEARCH PLAN
CONTRIBUTING TO THE FUTURE
OF MARINE SCIENCES
IN COLOMBIA



CEMARIN STRATEGIC RESEARCH PLAN

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MARINE SCIENCES IN COLOMBIA

COLOMBIA IS ONE OF THE FIVE “MEGA-DIVERSE COUNTRIES” IN THE WORLD, EXHIBITING EXTRAORDINARILY HIGH LEVELS OF SPECIES DIVERSITY AND ENDEMISM.

In addition to a well-documented terrestrial biodiversity, particularly in the country’s tropical rain forests, Colombia has a vast marine biodiversity across a variety of ecosystems along the Pacific and Caribbean coasts, as well as around oceanic islands and in the open ocean. These ecosystems and their associated species provide essential ecosystem services to hundreds of thousands of people, particularly in coastal communities.

However, most marine ecosystems and species are threatened by local, regional, and global anthropogenic pressures. Therefore, better protection and sustainable use of this natural wealth is becoming a national priority in Colombia. In particular, the loss of marine biodiversity and bioresources, the increasing destruc-

tion of coastal habitats by non-sustainable agriculture, industry and tourism, as well as the adverse influences of climate change, have long been of increasing concern for scientists, politicians, and the public.

These threats, in turn, strengthen the need for a powerful and effective marine science strategy in Colombia and a close collaboration among researchers. However, during the past decades, both the direction and focus of scientific research have changed dramatically for several reasons –globalization, the increasing complexity of scientific problems, the need for robust scientific information for decision-makers, and the increasing competition for funding have all affected science policy. Today, successful and visi-

ble science has to meet distinct criteria. It has to be inter- and transdisciplinary, based on international networking, focused on emerging fields, and linking basic science with the solution of vexing problems (particularly socio-economical and socio-ecological problems). Despite being an “emerging science nation”, Colombia has lagged behind other South American countries (e.g., Brazil, Argentina, and Chile) in collaborative marine research programs due to logistic and financial constraints.

Even though the country is home to excellent and highly productive marine scientists, interinstitutional and interdisciplinary studies focused on global marine problems are mostly lacking, and links between basic and applied sciences are often underdeveloped. This calls for a marine science strategy aimed at solving global problems with regional implications in Colombia, particularly the protection and sustainable use of marine resources, and which further strengthens interdisciplinary research across basic and applied sciences.



CEMARIN

MISSION AND VISION

CEMarin (Corporation Center of Excellence in Marine Sciences) is an international, non-profit organization, founded by Colombian and German universities in 2009: Universidad de Los Andes (Bogotá, Colombia), Universidad Nacional de Colombia (Bogotá, Colombia), Universidad de Antioquia (Medellín, Colombia), Universidad de Bogotá Jorge Tadeo Lozano (Bogotá, Colombia), Universidad del Valle (Cali, Colombia), and Justus Liebig University Giessen (Giessen, Germany). CEMarin is one of the worldwide four “Centers of Excellence” supported by the German Academic Exchange Service (DAAD).

MISSION

CEMarin aims at answering fundamental environmental and socio-economical questions related to marine ecosystems in Latin America. It integrates interdisciplinary marine research with innovative post-graduate training, and international networking across natural and social disciplines.

VISION

In 2027, we envision CEMarin as an international leader for integrative marine research, post-graduate training, and academic networking in Latin America. Drawing from our access to two oceans and the combined expertise of our member institutions, we will facilitate scientific discovery in emerging fields of marine sciences related to environmental change and its impact on ecosystems and society, the sustainable use of marine and coastal ecosystems, as well as technological advances. Post-graduate researchers trained by CEMarin will become recognized members of the international scientific community and engaged ambassadors of marine ecosystems. CEMarin will become a central platform for networking Colombian and international marine scientists in order to promote and coordinate highly visible, externally funded collaborative research projects. Through strategic investments in marine infrastructure as well as research and training programs over the coming years, CEMarin will increase its impact on the researchers, post-graduate students, and communities it serves.

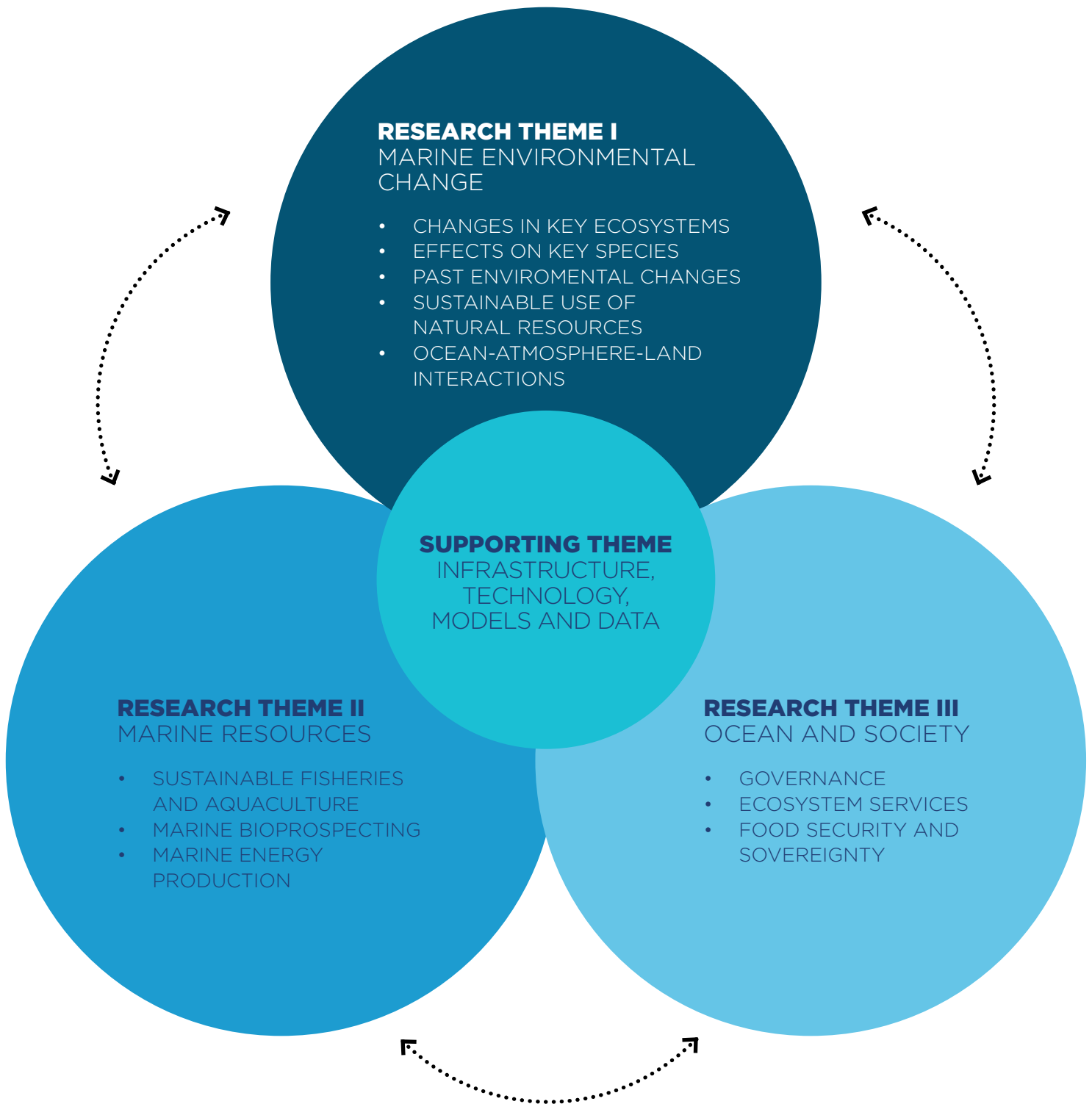


CEMARIN RESEARCH THEMES

In order to integrate Colombian and international marine scientists across disciplines and institutions, as well as to build a strong collaborative research network for solving fundamental questions regarding the protection and sustainable use of marine and coastal resources, CEMarin is focused in several emerging research lines.

These research lines are embedded within three interdisciplinary and interacting research themes (see figure) as well as one supporting theme, which determine the center's strategy regarding research priorities, infrastructure development, teaching programs, capacity building, and policy-making

FIGURE. CEMARIN RESEARCH THEMES AND LINES, AND SUPPORTING THEME.



RESEARCH THEME I: MARINE ENVIRONMENTAL CHANGE

Currently, humankind is facing the so-called “Sixth mass extinction event”. This crisis affects all global ecosystems, but marine and coastal systems are particularly vulnerable because of intensive human activities in and around those areas. Though marine ecosystems, and the species and populations they harbor, are changing in response to both natural and anthropogenic factors, there is growing concern surrounding rapid human-mediated processes such as habitat degradation, pollution, human-caused climate forcing, ocean acidification, fishing pressure, and the introduction of invasive species. Moreover, the adverse effects of anthropogenic stressors are not only evident in near-shore ecosystems but increasingly also in the remotest parts of the oceans.

Understanding the scope of these changes, their underlying processes, the interplay of natural and anthropogenic drivers, as well as the relative contribution of global, regional, and local processes, is of paramount importance for mitigation of environmental change, sustainable use of marine resources, environmental protection, and maintaining a fragile socio-economical balance.

Therefore, research theme I combines earth and biological sciences to study the response of ecosystems and selected model species to drivers of environmental change. The theme is closely linked with Research theme II (Marine resources) and Research theme III (Ocean and society), and comprises a variety of methods and approaches, including long-term field studies, experimental mesocosms, eco-genomics, as well as theoretical and empirical modeling.

RESEARCH LINE IA: ENVIRONMENTAL CHANGE IN KEY ECOSYSTEMS

Colombia harbors a wide variety of marine and estuarine ecosystems. All of them are, to varying extents, affected by natural and anthropogenic environmental changes. However, the precise stressors, or combinations thereof, often remain unknown. Understanding the structure and function, and the vulnerability of these ecosystems to environmental pressures is therefore of great importance for mitigating adverse environmental impacts, and for assuring ecosystem integrity, resilience, and function.

Of particular concern are coral reefs and coral assemblages. Global pressures, such as climate change and ocean acidification, are leading to a worldwide decline, while regional and local threats include destructive fishing practices and overfishing, unplanned coastal and urban development, pollution and sedimentation, and the introduction of invasive species.





Collaborative research is needed to assess the impact of multiple overlapping stressors on coral reef ecosystem resilience under both natural and controlled conditions. Colombia is ideally suited for such studies because it harbors coral reefs both in the Caribbean Sea and the Pacific Ocean, in near-shore and off-shore regions, in photic- and mesophotic systems, and in upwelling and non-upwelling areas.

Mangrove forests also cover extensive stretches of the country's coastline. This ecosystem protects coasts from erosion and storm surge, is highly productive and an important carbon sink. Also, it provides habitats for many marine and terrestrial species, acts as a nursery for marine and estuarine organisms, provides fishery resources and is an important source of livelihood for coastal communities. Mangrove forests are heavily affected by human activities and climate change.

Other marine ecosystems of particular interest for CEMARIN are rocky coasts, seagrass beds, and estuaries, as well as mesophotic and deep-sea benthic habitats (see also Research line Id). The latter may serve as potential refugia for vulnerable species and as study sites for understanding the extent of the human footprint.

PRIORITIZED CEMARIN RESEARCH TOPICS

- 1. INTEGRATED ECOSYSTEM ASSESSMENTS (IEAS) OF KEY ECOSYSTEMS**
- 2. ENVIRONMENTAL MONITORING OF ECOSYSTEMS USING STATE-OF-THE-ART APPROACHES**
- 3. EXPLORATION OF PREVIOUSLY INACCESSIBLE ECOSYSTEMS USING NEW TECHNOLOGIES**
- 4. CONTROLLED ENVIRONMENTAL STUDIES USING MODERN MESOCOSM AND MICROCOSM FACILITIES**

RESEARCH LINE IB: EFFECTS OF ENVIRONMENTAL CHANGES ON KEY MARINE SPECIES

As a mega-diverse country, Colombia harbors numerous marine species, some of them being endemic. However, despite increased systematic research conducted during the past decades, many taxa remain unknown and undescribed, particularly along the country's Pacific coast and in the deeper parts of the oceans. Additionally, even for well-recognized species, comprehensive knowledge about their biology is often lacking.

In order to qualify and quantify the effects of environmental change on key marine organisms it is necessary

to understand their life history, ecology, spatial distribution, and stress responses. Model species of interest comprise taxa of particular importance for understanding environmental change in key ecosystems (see Research line Ia). These taxa include foundation species and ecosystem engineers (e.g., corals and mangroves), keystone species that have a disproportionately large effect on ecosystems (e.g., sea urchins and parrotfishes), taxa that actually or potentially serve as resources for aquaculture, fisheries, and bioprospecting (e.g., various coral, algae and sponge species), and invasive species such as lionfish and white shrimp.

This research line integrates long-term field observations with transplantation experiments, genetic and eco-genomic investigations of species and populations, physiological and behavioral studies under controlled conditions, studies of phenotypic plasticity, as well as predictive modeling and risk assessments at the species and population levels.

PRIORITIZED CEMARIN RESEARCH TOPICS

- 1.** PROCESSES GOVERNING CHANGES IN POPULATION AND RANGE DYNAMICS OF KEY COASTAL AND MARINE SPECIES
- 2.** DRIVERS AND EFFECTS OF BIOLOGICAL INVASIONS
- 3.** LIFE HISTORY OF COMMERCIAL AND ECOLOGICALLY IMPORTANT SPECIES
- 4.** STRESS RESPONSES BOTH AT THE PHYSIOLOGICAL AND GENETIC LEVEL

RESEARCH LINE IC: UNDERSTANDING PAST ENVIRONMENTAL CHANGES TO PREDICT THE FUTURE

Marine areas provide excellent model systems for integrated geo-biological studies of past environmental changes. Knowing the geological, environmental, and climatic history of a particular area allows researchers to investigate, for example, the relationship between turnover (biodiversity change) and the underlying regulatory processes. This approach requires the integration of stratigraphic, sedimentological, geochemical, paleontological, ecological, and molecular data to identify the critical environmental conditions and processes involved. Understanding causes of past ecosystem and biodiversity change and their consequences helps to shed light on current environmental changes, and to disentangle the relative contributions of natural and anthropogenic stressors. Paleocological investigations can thus provide important baseline data for understanding the drivers and consequences of current global change processes. This information will also help researchers assess of the relative severity of the current biodiversity crisis and to make modeled predictions of the fates of marine ecosystems and their associated biota in the future.

This research line integrates paleo-oceanographical studies, such as the recovery of sediment cores from near- and off-shore sites, with paleontological studies of macro- and microfossils, analyses of stable isotopes, deep-biosphere studies (i.e., the microbial life in marine sediments), seismic surveys, molecular-clock analyses, and predictive modeling.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. PALEOENVIRONMENTAL RECONSTRUCTIONS OF KEY ECOSYSTEMS
2. RESPONSE OF MARINE ECOSYSTEMS TO PAST ENVIRONMENTAL CHANGES
3. RESILIENCE OF ECOSYSTEMS AND RESISTANCE OF SPECIES TO PAST CHANGES
4. THRESHOLDS OF ENVIRONMENTAL CHANGES ('CATASTROPHIC EVENTS') LEADING TO REGIME SHIFTS
5. BACKWARD MODELLING TO VALIDATE THE MODELS FOR DRIVERS OF CURRENT ENVIRONMENTAL CHANGES
6. FORWARD MODELLING TO PREDICT FUTURE CHANGES UNDER DIFFERENT GLOBAL CHANGE SCENARIOS

RESEARCH LINE ID: SUSTAINABLE USE AND CONSERVATION OF NATURAL MARINE RESOURCES

Colombia is rich in marine resources that provide a variety of ecosystem services, particularly biotic resources from key ecosystems such as coral reefs, mangrove forests, seagrass beds, rocky shores, and estuaries. In addition, the country has a high diversity of marine animals, plants, and microorganisms, many of which produce substances or materials that are or can potentially be utilized for human purposes (see also Research line IIb). However, various marine resources are directly or indirectly affected by environmental changes, particularly human-mediated changes such as habitat destruction, pollution, overfishing, and the introduction of invasive species. The loss of natural resources, in turn, may result in the loss of ecosystem services, increasing social inequity and potentially even causing social unrest (see also Research theme III).

Researchers are particularly interested in (1) direct links between environmental changes, biodiversity, and sustainable resource management, (2) the contribution of key ecosystems to *in situ* conservation of natural resources, (3) the assessment, management, and conservation of endemic species, (4) marine ecosystems managed by indigenous and local communities, (5) eco-regional networking and collaboration, (6) restoration and rehabilitation of marine ecosystems, (7) climate change adaptation and mitigation, (8) research programs on coral farming, (9) international networking to combat invasive species, and (10) the utilization of emerging technologies to support the sustainable use and conservation of natural marine resources.

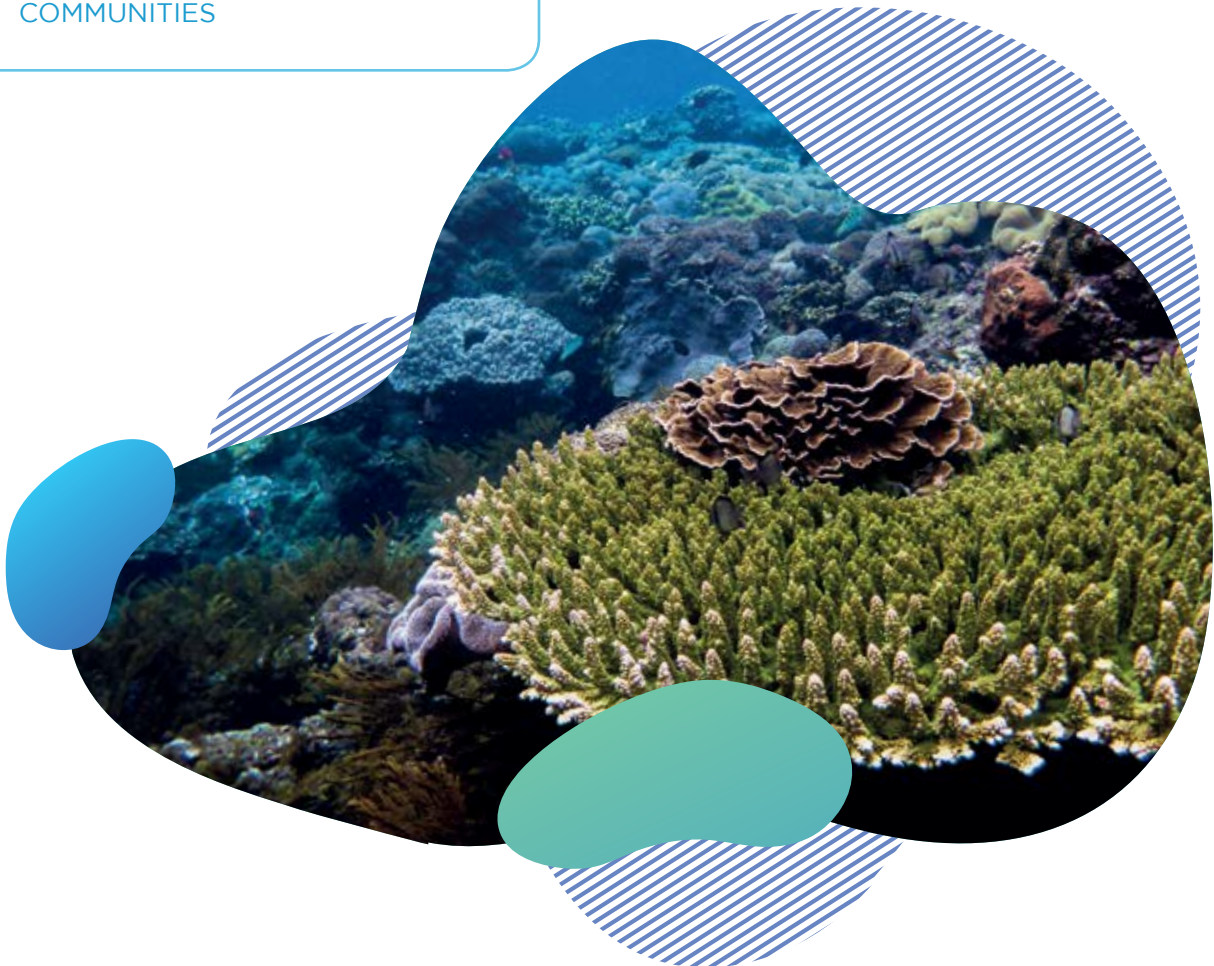
The depletion of natural marine resources in Colombia continues mostly unabated, and innovative approaches are necessary to tackle ecosystem service loss.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. RELATIVE CONTRIBUTION OF DIRECT (E.G., UNSUSTAINABLE FISHERIES, POLLUTION, AND HABITAT DESTRUCTION) AND INDIRECT (E.G., DEMOGRAPHY, ECONOMY, SOCIETY, POLITICS) DRIVERS TO OVERALL CHANGE
2. ECOSYSTEM RESILIENCE AND SPECIES RESISTANCE
3. CONCEPTS FOR THE PROTECTION AND SUSTAINABLE USE OF MARINE NATURAL RESOURCES
4. GOOD PRACTICE APPROACHES FOR THE MANAGEMENT OF NATURAL MARINE RESOURCES THAT ALSO ENGAGE LOCAL COMMUNITIES

RESEARCH LINE IE: OCEAN-ATMOSPHERE-LAND INTERACTIONS

The Earth is a highly complex system formed by inter-linked components. Therefore, understanding coastal and marine systems and their dynamic interactions with other Earth components under global change scenarios remain a key challenge. Unraveling such dynamics typically requires the interaction of diverse disciplines and approaches, in order to address problems occurring across various temporal and spatial scales. Large-scale climate, mesoscale/submesoscale ocean dynamics and sea-level change, upwelling/downwelling, biogeochemical cycles, fluvial runoff, water and energy balances in oceanic basins, coastal geomorphology, and coastal groundwater dynamics are all examples of such processes. Of particular interest are ocean-land and ocean-atmosphere interactions.



PRIORITIZED CEMARIN RESEARCH TOPICS

- 1.** IMPACT OF LAND-USE, LAND COVER, SEA LEVEL, AND CLIMATE CHANGE ON COASTAL SYSTEMS THROUGH CHANGES IN GEOCHEMICAL CYCLES, FRESHWATER DYNAMICS, AND UNDERGROUND WATER
- 2.** MARINE AND COASTAL GEOMORPHOLOGICAL PROCESSES
- 3.** OCEANIC CIRCULATIONS AND THEIR IMPLICATIONS FOR THE EXCHANGES OF HEAT, WATER, SALT, OXYGEN, NITROGEN, AND CARBON DIOXIDE BETWEEN THE OCEAN AND THE ATMOSPHERE
- 4.** BIOGEOCHEMICAL CYCLES ACROSS TIME SCALES
- 5.** MODELING ATMOSPHERE-OCEAN-LAND INTERACTIONS
- 6.** CLIMATE CHANGE AND NATURAL HAZARD ADAPTATION STRATEGIES

RESEARCH THEME II: MARINE RESOURCES

Marine resources include all services and benefits that humanity obtains from the ocean. These include food and feed, chemicals compounds for pharmaceutical and industrial processes, marine energy resources, and recreational values, among other benefits. However, unsustainable use of marine resources has increased worldwide. Therefore, several institutions and organizations are promoting the assessment, sustainable use, proper management, and conservation of these resources.

Some concern include, for example, significant reductions in fish stocks over the last decades as well as environmental concerns associated with current fishing practices and aquaculture approaches. Solving these problems requires innovative research approaches that combine basic and applied science.

This also applies to the search for chemical and genetic resources of commercial value (“bioprospecting”). In the marine context, the latter is also referred to as “Marine” or “Blue Technology”. The vast diversity of marine environments supports life forms that thrive across a wide range of environmental conditions, resulting in the highest genetic diversity on earth. Therefore, the field has received substantial interest not only within the scientific community, but also in the industrial sector.

The sustainable use of marine resources also includes renewable energies derived from salinity and thermal gradients as well as waves and tides. Utilizing such resources requires both a proper understanding of physical and chemical processes in the ocean, and the assessment of their potential effects on sensitive ecosystems (see also Research theme I).



RESEARCH LINE IIA: SCIENTIFIC BASIS FOR SUSTAINABLE FISHERIES AND AQUACULTURE

Unregulated exploitation of marine resources, particularly fish stocks, has contributed to the degradation of marine ecosystems and generated conflicts among local communities that traditionally use such resources. There is an urgent need for obtaining basic information on fish stocks and fisheries in Colombian seas, as well as on their underlying environmental factors. These data could be the basis of a Marine Spatial Framework that provides valuable information for the scientific, economic, and political management of Colombian fishing grounds.

Worldwide, decreasing fish stocks are primarily compensated by marine aquaculture. In Colombia, marine aquaculture has mainly been centered on shrimp species. Moreover, some recent initiatives aim at culturing marine fishes such as cobia, groupers, and snappers, though commercial scale has not been reached yet. Yet, little is known about the biology, population genetics, and life histories of other potential target species, particularly ornamental taxa (see also Research line Ib). Moreover, marine aquaculture is often associated with environmental problems, calling for novel environmentally-friendly technological approaches.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. BIOLOGICAL AND ECONOMIC POTENTIAL OF TARGET SPECIES (ALGAE, FISHES, AND INVERTEBRATES)
2. LIFE HISTORY, DEMOGRAPHY, AND POPULATION GENETICS OF POTENTIAL TARGET SPECIES
3. SUSTAINABLE AQUACULTURE PRODUCTION REQUIREMENTS (NUTRITIONAL DEMANDS AND DIET, REPRODUCTIVE NEEDS) FOR THE SPECIES OF INTEREST
4. INNOVATIVE AQUACULTURE TECHNIQUES THAT ALLOW COST-EFFICIENT AND SUSTAINABLE PRODUCTION BY LOCAL COMMUNITIES
5. NOVEL LINES OF AQUACULTURE FOCUSING ON ORNAMENTAL SPECIES AND SPECIES OF PHARMACEUTICAL AND BIOMEDICAL IMPORTANCE, WHICH ARE IN DEMAND ON THE INTERNATIONAL MARKET
6. OFF-SHORE AQUACULTURE APPROACHES

RESEARCH LINE IIB: MARINE BIOPROSPECTING

In 2011, the “National Strategy for Biotechnology and Sustainable Use of Biodiversity Policy” was implemented by the Colombian government to improve institutional capacities for the sustainable use of biodiversity (biological and genetic resources as well as their derivatives) and the commercial development of biotechnology.

In Colombia, marine bioprospecting has so far mainly involved chemical studies of invertebrates such as sponges and soft corals. However, there has recently been an increased interest in the genetics and chemical ecology of invertebrate-associated bacteria, actinomycetes, and cyanobacteria as well as marine algae (mainly red and brown algae). For example, current reports indicate that the microbial diversity is still grossly underestimated and that many organisms await discovery. Most of this research has been performed in the Colombian Caribbean, especially in the Santa Marta area, followed by the San Andrés Archipelago, and the Gulf of Urabá. Other marine regions of the country have been explored to a far lesser extent.

Even though the Colombian Government, Colciencias (Colombia Bio program), and various organizations are highly interested, several challenges still need to be addressed. There is a strong need to strengthen the country’s scientific and technological capacities of the country, to encourage groups to collaborate in bioprospecting research, and to improve the regulatory framework for patenting. There is also a great need to strengthen and apply scientific training in regard to genomic, proteomic, and metabolomic tools for the exploration of marine biodiversity and consequently of bioprospecting.

PRIORITIZED CEMARIN RESEARCH TOPICS

- 1. SCIENTIFIC AND ECONOMIC POTENTIAL OF ORGANISMS FROM UNEXPLORED MARINE ECOSYSTEMS IN COLOMBIA**
- 2. NOVEL COMPOUNDS FOR INDUSTRIAL APPLICATIONS (E.G., PAINTS, ENZYMES, BIOPOLYMERS, BIOMATERIALS, COSMETICS, AND COSMECEUTICALS)**
- 3. NOVEL FOOD AND FEED PRODUCTS, AND INGREDIENTS WITH IMPROVED NUTRITIONAL PROPERTIES**
- 4. NOVEL DRUGS FOR THE TREATMENT OF HUMAN DISEASES**
- 5. OMICS TECHNIQUES FOR BIOPROSPECTING**
- 6. CULTIVATION METHODS FOR MACRO- AND MICROORGANISMS**
- 7. SUSTAINABLE BIOTECHNOLOGICAL APPROACHES**

RESEARCH LINE IIC: SCIENTIFIC BASIS FOR MARINE ENERGY GENERATION

During the past decades, there has been an increased interest in renewable energy sources, and the Colombian government has recently increased support for research on the use of alternative energy sources. Colombia is particularly interested in marine energy sources such as waves and tides as well as salinity and thermal gradients. Current simulations indicate, for example, a high potential for salinity gradient energy in river mouth systems in the Colombian Caribbean. In addition, a second source of renewable energy, Ocean Thermal Energy Conversion (OTEC), might be of particular interest for small islands. Islands, on the one hand, face challenges in guaranteeing sustainable energy supplies and, on the other hand, have a large ocean thermal potential. However, since generating energy from marine renewable resources is still scientifically challenging and technically demanding, relatively little research has been conducted in Colombia in this emerging field. Moreover, the environmental impact of these technologies on specific ecosystems in Colombia remains poorly understood (see also Research theme I).

PRIORITIZED CEMARIN RESEARCH TOPICS

1. SPATIALLY-EXPLICIT STUDIES OF ENERGY POTENTIALS IN COLOMBIAN COASTAL WATERS
2. DEVELOPING AND IMPLEMENTING RENEWABLE MARINE ENERGY TECHNOLOGIES
3. INTEGRATED SOLUTIONS FOR SUSTAINABLE ENERGY, DRINKING WATER, AND FOOD PRODUCTION ON SMALL ISLANDS, IN ISOLATED COASTAL VILLAGES, AND IN VULNERABLE ECOSYSTEMS
4. ENVIRONMENTAL IMPACT STUDIES ON MARINE ENERGY TECHNOLOGIES
5. ECONOMIC ASSESSMENT OF SUSTAINABLE MARINE ENERGY PRODUCTION



RESEARCH

THEME III: OCEAN AND SOCIETY

The interactions between people and oceans are very complex. On the one hand, humans derive many benefits from oceans and seas, such as food, feed, energy, medicine as well as ecosystem services. On the other hand, the ocean and its associated processes may inflict negative impacts on and risks to society such as severe weather events, coastal disasters, anthropogenic pollutants, harmful algal blooms, invasive species, and diseases caused or transmitted by marine organisms.

Traditionally, social sciences address problems related to the impacts and risks of ocean-human-interactions, while related benefits are typically recognized by marine sciences. However, with more people living in coastal areas and with the ever-increasing effects of global change, interactions between ocean and society become more complex. This, in turn, calls for multi- and interdisciplinary research approaches.

The purpose of this research is to understand how different stakeholders relate to marine ecosystems and each other, in order to improve the quality of life of inhabitants of marine-coastal areas. Stakeholders include the communities that inhabit marine and coastal areas such as artisanal fishermen, community organizations and fishermen's associations, NGOs, the fishing industry, and other actors involved in the use of marine and coastal ecosystems. All these stakeholders are related to, and benefit from marine ecosystems in different ways, and should be responsible for their conservation. Government agencies are also stakeholders, given their role in policy making, monitoring, and law enforcement.

In Colombia, there is an increasing loss of knowledge related to the understanding of how communities in-

teract with the environment they inhabit, and how these interactions influence their social dynamics and quality of life. Moreover, baseline data are required on the performance of social organizations such as fishermen's cooperatives, and their impact on the welfare of coastal communities. Finally, conservation and ecosystem stewardship practices, implemented by different stakeholders, must be identified.

This research theme also aims to understand how governmental policies and rules for ecosystem-based fisheries management are implemented at the national, regional, and local levels and how stakeholders get involved in the formulation and implementation of those policies and rules.

Understanding the social dimensions of marine and coastal ecosystem management is a multidisciplinary effort that encompasses natural, social, and health sciences. The combination of insights and perspectives from different disciplines is essential to understand the relationships of human populations with their surrounding ecosystems and the social dynamics derived from these relationships. This understanding will allow scientists to identify those specific practices that have a positive impact on the sustainability of marine and coastal ecosystems, and the welfare of the coastal communities that rely on them.

RESEARCH LINE IIIA: GOVERNANCE

Governance plays a crucial role in solving current problems in marine sciences, since stakeholders may have different views of the emerging balance among economy, ecology and society. In addition, they may play different roles in the sustainable use of marine resources and ecosystems. Therefore, the purpose of this research line is to understand the perspectives, mechanisms, and levels of participation of stakeholders in the management of ecosystems, to assess the legitimacy of measures for solving conflicts among resource users, and to comprehend norms for ecosystem conservation.

PRIORITIZED CEMARIN RESEARCH TOPICS

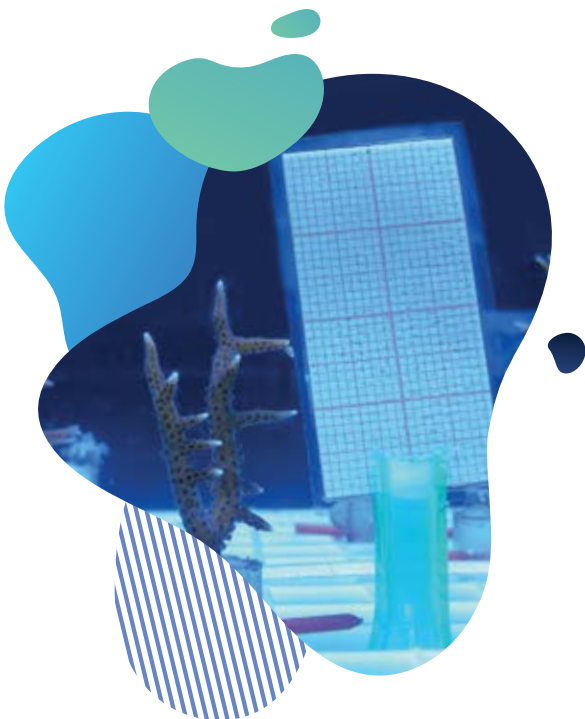
1. SOCIO-ECONOMICAL PROCESSES AFFECTING THE MANAGEMENT OF MARINE RESOURCES
2. IMPACTS ON COASTAL COMMUNITIES BROUGHT BY REGIONAL CONFLICTS AND THE PEACEBUILDING PROCESS IN COLOMBIA
3. KNOWLEDGE SHARING AND INTER-SECTORAL DIALOGUES RELATED TO THE USE OF MARINE RESOURCES
4. POLICIES, STANDARDS, INCENTIVES, AND AGREEMENTS FOR THE SUSTAINABLE USE OF MARINE RESOURCES

**RESEARCH LINE IIIB:
ECOSYSTEM SERVICES**

Humankind receives numerous benefits from oceans and seas (ecosystem services). The recognition, analysis, and quantification of the effects of anthropogenic activities on the flow of ecosystem services is the basis and becomes a tool for the sustainable management of marine resources and ecosystems, as well as for the creation of policies and norms for that purpose. This exercise requires an interdisciplinary approach, as well as the identification, integration, and sharing of traditional knowledge.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. ECOSYSTEM SERVICES IN A REGIONAL AND TERRITORIAL CONTEXT
2. RISK ASSESSMENT OF NATURAL AND ANTHROPOGENIC THREATS
3. PRESERVATION OF THE ETHNOBOTANICAL, ETHNOZOOLOGICAL, AND ETHNOMEDICAL KNOWLEDGE OF LOCAL COMMUNITIES
4. ECONOMIC ASSESSMENT OF ECOSYSTEM SERVICES
5. ECOSYSTEM SERVICES-BASED SUSTAINABLE MANAGEMENT OF MARINE AND COASTAL SYSTEMS



RESEARCH LINE IIIC: FOOD SECURITY AND SOVEREIGNTY

Ocean and seas play a crucial role in food security and food sovereignty. They guarantee a stable and timely access to high-quality, safe food for millions of people. Moreover, oceans and seas safeguard the rights of local communities to nutritious, culturally adequate and accessible food, as well as to choose their own food and production systems. Marine food sovereignty thus also helps to preserve traditional knowledge regarding food diversity and sustainable production techniques.

Food security and sovereignty research aims at understanding food security status of communities that inhabit marine and coastal environments. It also assesses how communities interact with the environment that provides food resources, identifies levels of food sovereignty, and evaluates the empowerment of communities towards a more sustainable use of ecosystem resources. The research line aims to assist policy-makers in their efforts to improve the living conditions of coastal communities, and helps communities recognize the importance of a harmonious and sustainable relationship with marine ecosystems.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. STATUS AND FACTORS CONDITIONING FOOD SECURITY OF MARINE AND COASTAL COMMUNITIES
2. ECOSYSTEM USE AND FOOD SOVEREIGNTY OF MARINE AND COASTAL COMMUNITIES
3. TRADITIONAL KNOWLEDGE AND CULTURAL PRACTICES IN REGARD TO FOOD DIVERSITY AND PRODUCTION



SUPPORTING THEME: INFRASTRUCTURE, TECHNOLOGY, MODELS, AND DATA

Implementing Research themes I–III requires the continuous development, coordination, and active sharing of resources across CEMarin member institutions and scientific disciplines. These resources include infrastructure, technologies as well as scientific models and underlying data.

The member institutions of CEMarin maintain critical infrastructure for marine research both in the Colombian Caribbean and the Colombian Pacific. They include, among others, field stations, marine observatories, and experimental aquaculture facilities. In addition, mainland research facilities in Colombia and Germany comprise hydrological, genetic, and ecological laboratories, controlled microcosm systems as well as computational clusters and cloud facilities.

CEMarin also promotes a wide range of state-of-the-art technologies to advance marine sciences in Colombia. These technologies enable CEMarin researchers to study small, difficult to observe, and cryptic organisms (e.g., next-generation DNA sequencing, underwater robotics), to manipulate environmental conditions for key taxa (e.g., micro- and mesocosm technologies), to discover new bioprospecting compounds (e.g., metabolomics and proteomics technologies), to monitor entire ecosystems and to assess anthropogenic impacts on large scales (e.g., remote sensing technologies), to understand hydrodynamic processes related to environmental change processes (e.g., wave flumes), and to efficiently interact with local communities in socio-economic studies (e.g., crowd technologies). Moreover, CEMarin research groups also actively develop new technologies in the field of renewable energy production for example.

Finally, models based on “big data” are increasingly used by CEMarin to supplement field studies, test alternative scenarios, increase the statistical power of experiments, and infer past and predict future changes in a system. Several types of models are being used or developed at CEMarin. They include empirical, physical, ecological, environmental, pathway, biomedical, and socio-economic models.

The underlying data for these models are derived from public databases or are increasingly generated by CEMarin researchers in a coordinated fashion.

PRIORITIZED CEMARIN RESEARCH TOPICS

1. COLLABORATIVE RESEARCH AT FIELD STATIONS
2. JOINT USE OF STATE-OF-THE-ART TECHNOLOGIES
3. STANDARDIZATION OF MARINE RESEARCH METHODS
4. STANDARDIZATION OF COLLECTION AT KEY FIELD SITES
5. EFFICIENT DATA DIGITIZATION AND PROVISIONING
6. JOINT USE OF DATA (OPEN ACCESS)
7. INCREASING THE TIMELY AVAILABILITY OF DATA (“FROM THE SEA TO THE CLOUD”)
8. SPECIFIC TRAINING PROGRAMS FOR CEMARIN RESEARCHERS







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