1.2.6 The State of International Science in the GOM: Cuban National Perspectives

P. González-Díaz

Center for Marine Research, University of Havana

1.2.6.1 Abstract

Cuba, a long and narrow island, is almost entirely a coastal zone and conflicts for the use of the space are inevitable. This overview briefly describes the three primary marine ecosystems in Cuba, mangroves, seagrasses, and coral reefs, and effects of some of the important natural and anthropogenic stressors such as hurricanes, pollution, and overfishing. To avoid user conflicts and organize activities, a variety of regulations have been promulgated with decision making guided by the advice of scientific researchers. Research and educational programs are closely related to the main problems that face marine environments and coastal zones in Cuba, but also to the greater Caribbean region including the GOM.

1.2.6.2 Introduction

As a part of the Caribbean Sea, Cuba is the largest archipelago (ca. 110,000 km^2) in the region (Wilkinson 2008). One of its most prominent characteristics is that it is long (1,250 km) and narrow (191 km across its widest point and 31 km across its narrowest point), and thus, almost the entirety of Cuba can be considered as a large coastal zone. These characteristics imply that many different users, activities and conflicts coexist in the same space. To avoid conflicts and organize activities, the state has enacted a variety of different legislation and regulations with the decision-making process guided by the advice of scientific researchers. The majority of research centers that are focused on studies related to the marine environment are in the city of Havana, Cuba's capital. Research and educational programs are closely related to the main problems that face marine environments and coastal zones in Cuba, but also to the greater Caribbean region including the GOM. Because of this, the goal of this contribution is to offer a general overview about the main Cuban marine ecosystems, the natural and anthropogenic stress that they receive, and the main lines of research that different Cuban marine institutions deliver through national and international collaboration. Briefly, I'll mention the role of women as heads of marine or environmental institutions, and in particular, "Ocean Mother of Cuba," Dr. María Elena Ibarra Martín, who was the director of the Center for Marine Research at the University of Havana (CIM-UH) for almost 25 years.

1.2.6.3 Physical and Climatological Setting

Because of its long and narrow form, the island of Cuba is very dependent on the climatic conditions of the area. The island has a tropical climate, with an average annual precipitation of 137.5 cm, and a daily tidal range of around 20 cm. The main two seasons that produce climatic differences are: 1) the dry season from November to April, and 2) the rainy season from May to October (INSMET 2017). During the rainy season, we receive around 80% of the total annual rainfall related to the passage of cold fronts and hurricanes. Changes in the patterns of rainfall leave the island very susceptible to drought. For example, during a recent three-month period (May–July 2017), there was a severe dry period in the central and eastern Cuban provinces, and this has been very damaging to agriculture, soil health, and human populations. In fact, during the first six months of 2017, the government implemented several special actions to conserve water and increase public awareness about the extreme dryness in some areas of the country. Some provinces (Villa Clara, Sancti Spíritus, Santiago de Cuba, and Guantánamo) have suffered more than others (Figure 10) and have been the focus of the special actions mentioned above. Of course, this situation has also caused many rivers to go dry, and therefore, freshwater discharge into the coastal zone has been reduced. The consequences of this situation on coastal marine ecosystems have been severe—mangroves have started to become affected, many estuaries have dried up, and many fish and other marine organisms have died. At the same time, the natural flow of nutrients to seagrasses and coral reefs from river discharge has been interrupted.

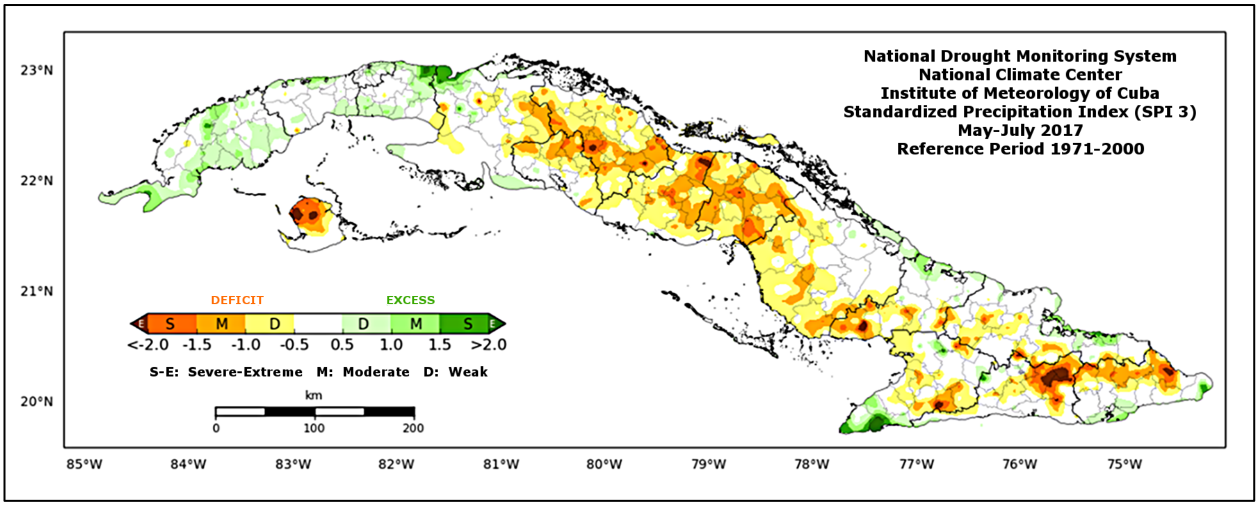

Figure 10. Cumulative rainfall during May–July 2017, expressed as Standard Precipitation Index values.
Modified from INSMET (2017).

Another important component of the Cuban climate system is extreme meteorological events. Hurricane season runs from June 1 to November 30. However, between 2010 and 2016, no significant hurricane passed through the western Cuban provinces and only one big hurricane (Sandy) affected the eastern Cuban provinces (Figure 11). This period of reduced hurricane activity has also had a negative impact on marine communities by contributing to increased temperatures in coastal waters.

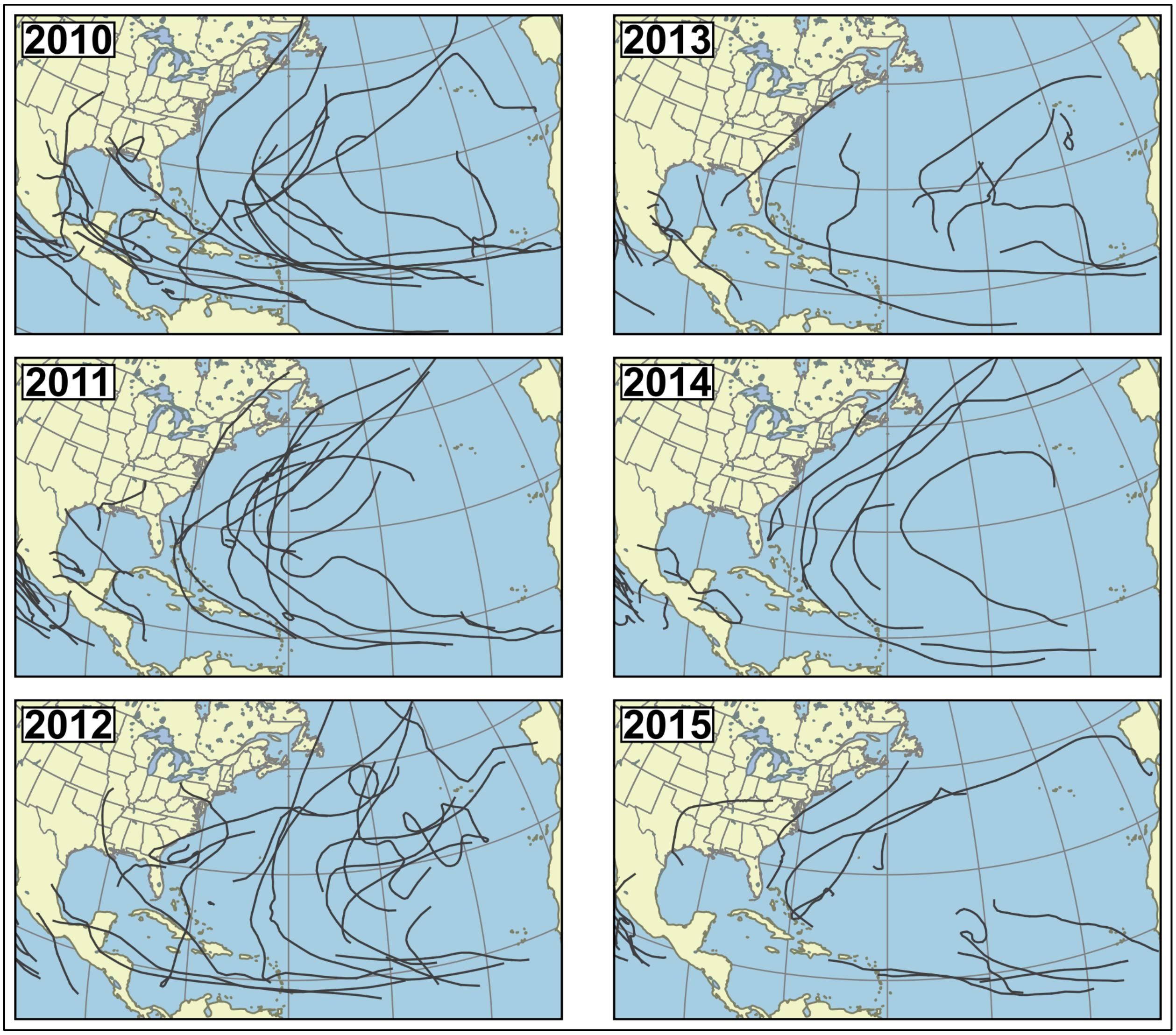

Figure 11. Route of extreme meteorological events for different storm categories during 2010-2015.
Source: Basemap shapefiles courtesy of Natural Earth. Historical hurricane tracks courtesy of NOAA National Hurricane Center. Figure prepared by M. Besonen.

One of the most important oceanographic factors is related to the currents present in the Caribbean Sea and adjacent regions (Figure 12). In general, system currents that involve Cuba and pass through the Caribbean and GOM are associated with strong physical, genetic, and ecological connectivity (González 2000). This characteristic is the basis for much scientific research, from oceanography to ecology, to understand the function and structure of our marine ecosystems, and the migration patterns of our target, protected, and charismatic marine species. Local currents also play a role, for example, with self-recruitment. In some cases, these local currents create upwelling and increase nutrient concentrations in our typically oligotrophic waters.

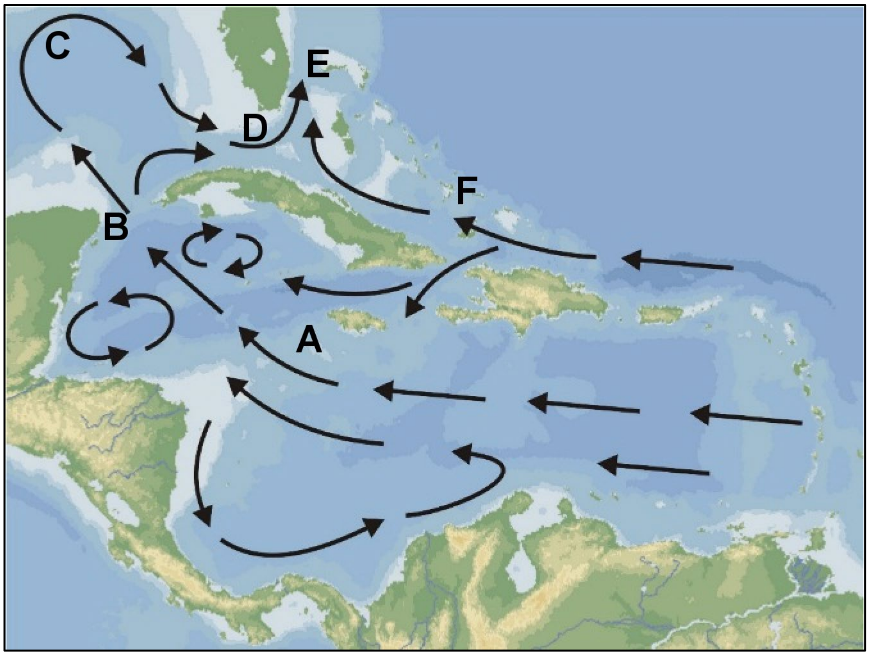

Figure 12. Surface currents in the Caribbean Sea and adjacent waters.
The main currents are: A-Caribbean, B-Yucatan, C-Loop Current, D-Florida; E-Gulf Stream, and F-Antilles. From González (2000).

1.2.6.4 Dominant Marine Ecosystems

It is difficult to discuss Cuba's main marine ecosystems separately from one another (González-Díaz et al. 2015). As mentioned before, from an oceanographic to ecological perspective, strong horizontal connectivity exists throughout the complex (from land to sea) involving mangroves and estuaries, seagrasses, and coral reefs (Figure 13).

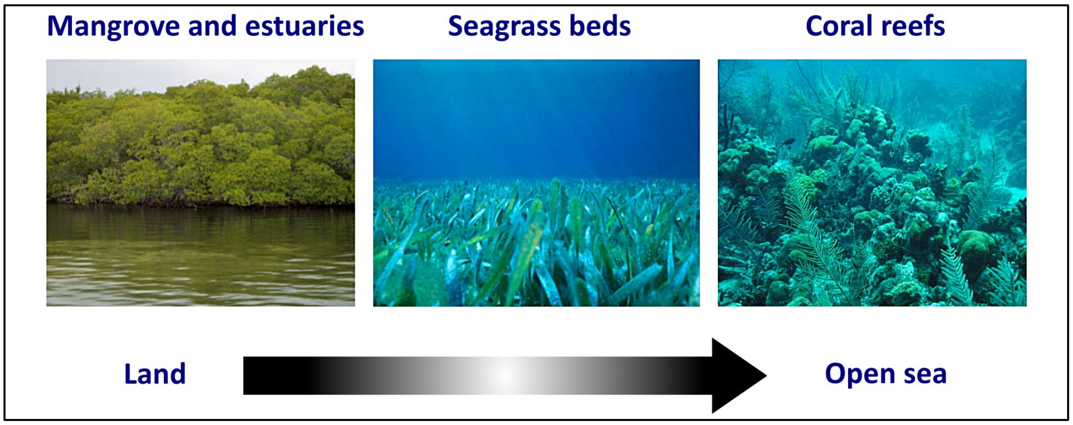

Figure 13. Typical zonation of the complex of primary Cuban marine ecosystems.
From land to sea this includes mangroves and estuaries, seagrasses, and coral reefs.

In the case of mangroves, they occupy 5.1% of the Cuban archipelago surface, which represents approximately 26% of the forest cover in the country. This implies that mangroves occupy between approximately 60–70% of our coastline. The four species of mangroves that we have are: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*) and button mangrove or buttonwood (*Conocarpus erectus*). This ecosystem has a high ecological significance in our research given that it represents the transition between land and sea (Menéndez and Guzmán 2006) as well as nursery area for juveniles of many commercial, target, and endangered species of the Cuban platform. This last ecological function, in addition to the role of mangroves as natural protection for the coastline and a natural filter for sediments and contaminants, increases the economic value of this ecosystem and justifies the protection measures that have been established.

Seagrasses dominate the ecosystem that can be found just adjacent to the mangroves (Martínez-Daranas 2006). Vertical distribution of seagrasses starts in the intertidal zone and reaches to approximately 6–7 m depth. This ecosystem is highly influenced by environmental factors, especially by light penetration and water transparency. Following Suárez et al. (2015), six species of marine phanerogams can be found in Cuba: turtle grass (*Thalassia testudinum* Banks ex König, 1805) which is the most abundant species in Cuban waters; manatee grass (*Syringodium filiforme* Kützing in Hohenacker, 1852); shoalgrass (*Halodule wrightii* Ascherson, 1868); widgeongrass (*Ruppia maritima* Linnaeus, 1753); and the clover grasses (*Halophila decipiens* Ostenfeld, 1902) and (*H. engelmanni* Ascherson, 1875). Shoot density varies greatly (20–4000 shoots/m^2) as does biomass (0.05–2 kg/m^2). Seagrasses play an important role in stabilizing sediments in addition to providing reproduction and feeding area for many species of ecologic and economic significance.

In the case of coral reefs, Cuba has ~3,966 km of coral reef tracts along 98% of the long shelf edge (Wilkinson 2008). Cuban coral reefs can be found along almost the entire border of the Cuban shelf and many of the gulfs. More than 50% of these reefs are separated from the mainland by keys and/or broad shallow lagoons that contain many patch reefs. The main coral reef systems in the south of Cuba, namely "Los Canarreos" and "Jardines de la Reina" (Gardens of the Queen) are considered among the least damaged reefs of the Caribbean Sea (Wilkinson and Souter 2008). Ecologists are interested in coral reefs for many reasons: 1) reefs exhibit the highest biodiversity of species among marine ecosystems, 2) many species of economic significance live in coral reefs as adults (e.g., grouper, snapper, spiny lobster), and, 3) reefs protect coastal zones because the hard skeleton of the corals and three-dimensional structure of the reef is physically strong (González-Díaz et al. 2015).

1.2.6.5 Main Threats to Cuba´s Marine Ecosystems

Cuban marine ecosystems suffer from the same common natural and anthropogenic impacts that affect all ecosystems in the Caribbean and GOM. Because of this, the essence of those processes and impacts will not be described here. Instead, this section focuses on the general situation in Cuba regarding these impacts.

In terms of anthropogenic impacts, one of our major concerns is related to subsistence overfishing, particularly on the reef directly offshore from the city of Havana (González-Díaz et al. 2015). Fishing this reef is illegal, so it is difficult to quantify or obtain precise statistics about how many fishermen work this reef, with what frequency they fish, and exactly which route they use. This kind of fishery usually uses spear guns and takes any kind of commercial fishes and invertebrates (e.g., octopus), no matter the size and legal protection level of the species. Usually, these fishermen do not use boats because Havana's coastal margin reefs are easily accessible from shore. Other fishermen set nets perpendicular to the coast, which is also illegal (Figure 14). All of these activities result in overfishing of our marine resources and cause substantial damage, not just to the species that are fished, but the entire ecosystem as well.

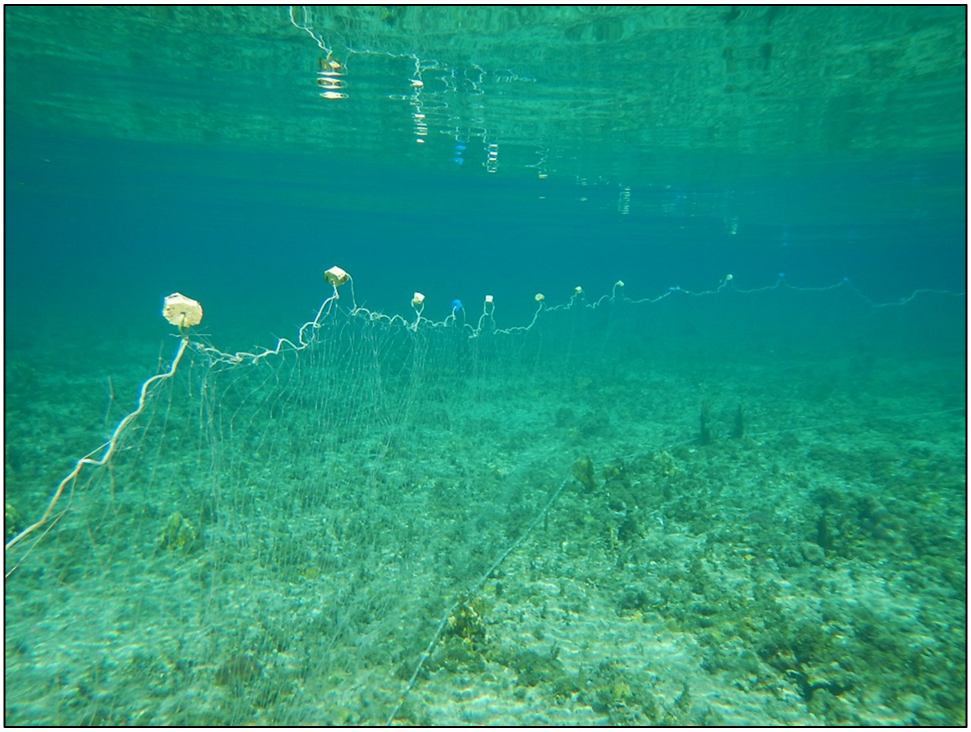

Figure 14. Net established at 1.50 m, perpendicular to coast line of Baracoa Beach by illegal fishermen.
The photo was taken on 28 June 2017 by P. González-Díaz.

Cuba has a strong legal framework and different kinds of regulation to avoid this fisheries situation. Among others, relatively recently the Office of Fisheries Regulations within the Ministry of Food Industry (MINAL), established a new regulation prohibiting the catch of parrotfish. In general, we have laws related to the management of fisheries, the coastal zone, and MPAs (Ripoll et al. 2015). These regulations and laws are continuously reviewed and improved. However, good enforcement is always difficult to establish and maintain. This is generally because the stressed economic situation makes it a true challenge to develop and support a proper enforcement infrastructure (e.g., appropriate number of inspectors, boats for patrolling the areas, and ongoing maintenance and fuel expenses for the boats).

Unfortunately, the situation described above is also very common in the other countries of our region, even in the countries with better economic situations. Fortunately, Cuba does not suffer from some fishing methods that are relatively common in the Caribbean region, for example, dynamiting in the reefs. For the legal framework, we also focus on increasing knowledge and capacity building in the areas related to fisheries. Different kinds of courses and workshops are delivered by different institutions, for example, the Center for Fisheries Research (CIP-MINAL) and CIM-UH. These courses focus on stakeholders, fishing communities, the general public, children and young people, and even researchers.

Another one of our important concerns is related to the impact caused by sedimentation and land-based pollution. This impact is directly related to the fact that the main Cuban cities were constructed along the coast in the sixteenth century. Seven coastal cities were originally founded at that time, but just two big cities with high human population densities exist today: Havana (total population: 2,117,343; density: 2907.4 inhabitants/km^2) and Santiago de Cuba (total population: 1,053,914; density: 169.2 inhabitants/km^2) (Anuario Estadístico de Cuba 2014). Both cities have a main bay where important economic and industrial activities have been developed. In the case of Havana Bay, its being one of the most polluted in the region, motivated the Cuban government to establish a special recovery plan for the bay (Álvarez 2016). The plan includes moving all industrial facilities to Mariel Bay where environmentally-friendly facilities using new technologies will be constructed. At the same time, the margin of Havana Bay will become a tourist route that includes museums, art houses, visitor centers, and other similar attractions (Álvarez 2016). Other local sources of land-based pollution are related to the margins of rivers and the coastal zone in front of cities. In these cases, strong work by the government and different environmental agencies is needed to avoid pollution problems. In general, they work under the umbrella of the laws and decrees related to integrated coastal zone management and land-use planning in each province and municipality (Ripoll et al. 2015).

Direct physical damage is one of the minor types of damage that face our marine ecosystems. The magnitude of the impacts from direct damage is much less than either overfishing or pollution. In some places, boats have caused anchor damage to reefs. However, tourist places have very strict rules, and even more if they are in any type of MPA. In the case of the Gardens of the Queen coral reef system, for example, park authorities are in the process of buying and establishing the proper buoys for different kinds of tourist vessels. In the meantime, tourist boats are not allowed to enter the area except for the boats of the tourist business that manages the area in collaboration with the park authorities. All of these rules are in the management plans for protected areas. A similar situation takes place in Maria la Gorda, where the dive shop and tourist enterprise are constantly advised by researchers from Guanahacabibes National Park.

The effects of climate change that we face are the same that affect all islands in the Caribbean region and GOM. In general, sea-level rise, coastal erosion, and acidification of the ocean are three major concerns for most people, from different levels of the government down to human communities that live in the coastal zone. These themes serve as the focus for many research projects from different perspectives that are delivered by Cuban scientific institutions. We study from the very basic ecology and biology of species to management and conservation strategies. At the same time, the Cuban government has implemented different kinds of studies related to prevention and vulnerability risks. And for quite some time, different actions have been undertaken to solve or at least mitigate the effects of sea-level rise on coastal communities. One action, for example, is that villages are constructed farther from the coast for communities in very vulnerable coastal areas. Thanks to modeling studies of sea-level rise under different future scenarios, all territorial management plans include analyses of these aspects, and the development of each municipality and province is carefully planned. Now, there is clear recognition that construction and building on the dunes must be avoided, and similarly, changing the natural dynamics of coastal areas must also be avoided. Furthermore, the extraction of sand from beaches for construction or other purposes is completely prohibited (Ripoll et al. 2015).

Few studies about the coral communities in Cuba exist before 1998 (Alcolado et al. 2000; Guardia 2000). But following the first big coral bleaching event that year in the Caribbean, Cuban scientists started to track the health status of our corals and benthic community in general. Many research efforts at the Institute of Oceanology and CIM-UH occured during these years. Later, other institutions, such as the National Aquarium of Cuba, Guanahacabibes National Park, and the Center for Coastal Ecosystems Research, among others, began working on these same themes. Now in Cuba, we have good general information about the health status of corals. It is not yet enough, but at least it provides a general overview of the situation at the moment, and we have identified the main knowledge gaps related to coral bleaching and diseases. With regard to bleaching, in general, we have some very broad remarks:

1. The sensitivity of corals to bleaching is not the same for all Cuban reefs (González-Díaz 2010). The specific situation with respect to the natural and anthropogenic stress on any individual reef is crucially important to the health status of its corals. Corals in a relatively "pristine" reef are more vulnerable to bleaching. We explain this based on water transparency and high irradiance in places with significant land-based pollution and eutrophication processes (e.g., the margins of

Havana Bay and the Almendares River). Both impacts produce a dark layer that reduces water transparency, and thus, helps to protect against strong irradiance. We observe the prevalence of bioerosive organisms affecting the corals at these locations.

2. The sensitivities of species are unequal. In Cuban reefs, *Siderastrea siderea* is the first coral species that starts to bleach, but at the same time, it is the most resistant to bleaching and usually recovers (González-Díaz 2010).
3. There is little evidence of diseases observed in Cuban reefs. Probably, the most common one is black band and dark spots. Black band mainly affects species of massive genera such as *Pseudodiploria* and *Orbicella.* Dark spots are frequently found in *S. siderea* (González 2004).
4. The passage of hurricanes seems to bring positive results to corals if you compare bleaching results in years with and without hurricanes. The comparison between 2008 (three hurricanes) and 2009 (no hurricanes), shows clear differences for *S. siderea* regarding the percent of colonies bleached (Figure 15) in different coral reef sites offshore of Havana Province. Since 2010, no strong hurricanes have affected the western Cuban provinces and water temperatures have remained high (Figure 16), resulting in increased sensitivity of corals to bleaching. During very important bleaching events in the Caribbean in 2005 and 2008, the western Cuban provinces were impacted by several severe hurricanes in each year (2005: Katrina, Rita, and Wilma: 2008: Gustav, Ike, and Paloma). These caused the water temperature to decrease and corals recovered very quickly and did not sustain major damage. Since 2010, no hurricanes have passed the western side of the country and the situation for corals has started to change for the worse (Figure 17).

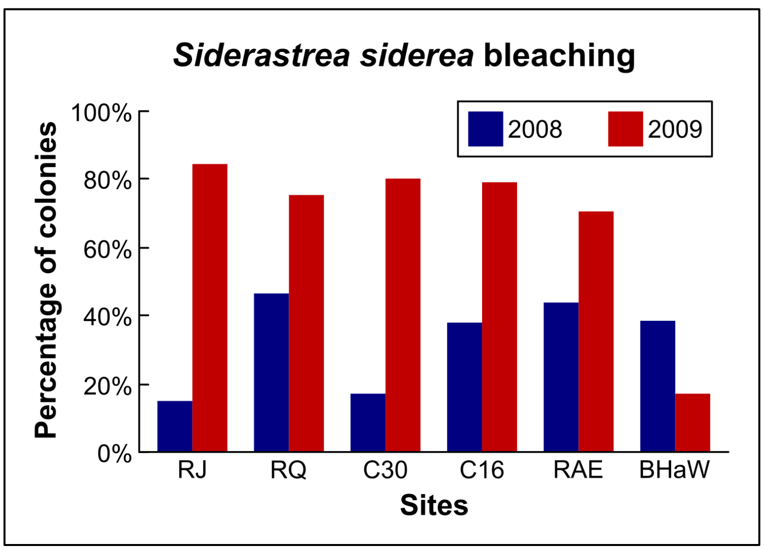

Figure 15. Percentage of bleached colonies of *S. siderea* during a year without a hurricane (2009) and with four severe hurricanes (2008).
The sites include: RJ-Jaimanitas River, RQ-Quibú River, C30-Calle 30, C16-Calle 16, RAE-east of Almendares River, and BHaW-west of Havana Bay.

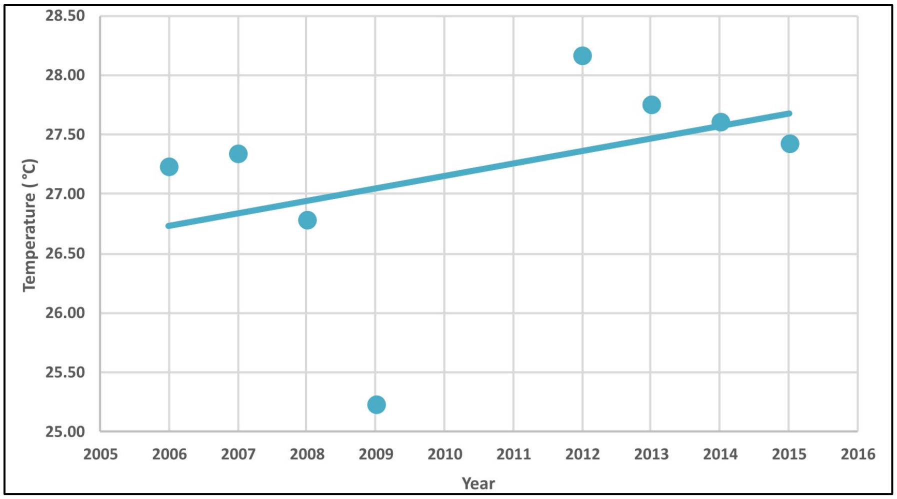

Figure 16. Trend of increasing temperature based on measurements (every 30 minutes) from a Hobo data logger on a reef in front of Havana city (2006–2016).

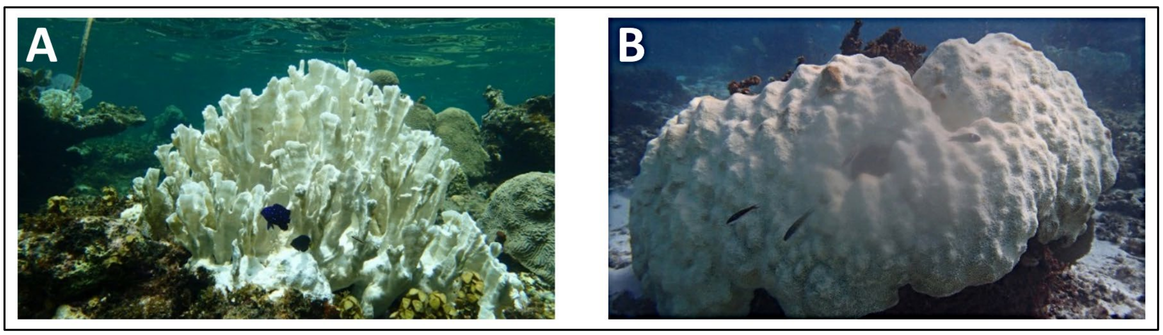

Figure 17. Possible cumulative effects of increased temperature due to the absence of hurricanes caused strong bleaching of Cuban reefs in 2015.
The photos show (A) *Millepora complanata* in Punta Frances, Isle of Youth, and (B) *Orbicella faveolata* in Cayo Largo del Sur. Both photos were taken in November 2015 by P. González-Díaz.

1.2.6.6 What Can Cuba Do to Get Out in Front of This Scenario?

To avoid or diminish the natural and anthropogenic impacts on coastal marine ecosystems, and taking into account the economic constraints faced by Cuba, we have three main strategies:

1. Combine research with capacity building.

   These actions involve not only undergraduate and graduate programs in the universities, but any kind of research actions or projects that are delivered by any institution such as trainings, workshops, or courses (Figure 18). Thanks to such efforts, for example, in Guanahacabibes National Park, almost all the park guides have Master of Science degrees and speak two or three languages. Also, many park guides can conduct monitoring studies in the area and help with data analyses. Regarding undergraduate and postgraduate programs, the majority are delivered by CIM-UH. The most famous are the MS and PhD programs in Marine Biology and Aquaculture.

Also, the universities of Havana, Cienfuegos, and Oriente deliver a joint Master's program in "Integrated Coastal Zone Management." A special characteristic of this last program is that it encourages students to provide recommendations, through research, on how to solve any coastal zone conflict. This is possible because the program has been designed to focus on themes that range from larger scale general issues to smaller scale problems that are specific to particular provinces or municipalities. This allows students, through their thesis research, to analyze problems that affect their local area of interest, propose appropriate solutions, and thus, contribute to local development.

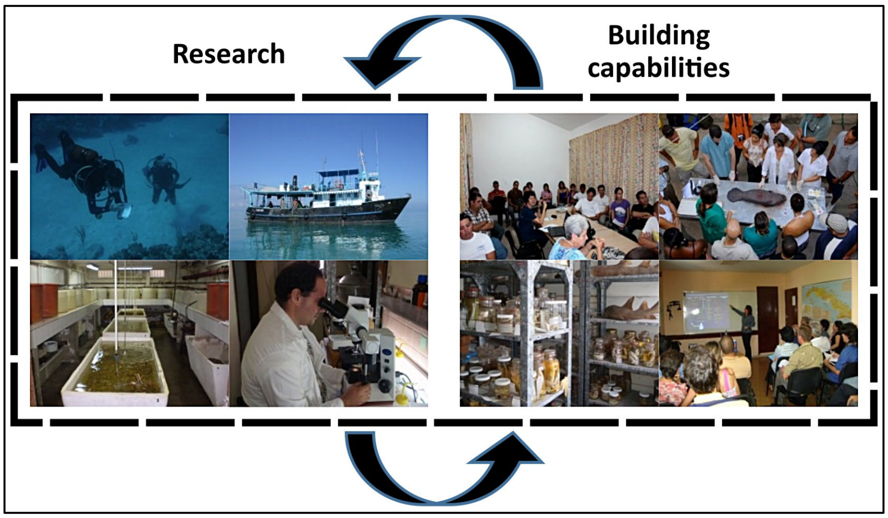

Figure 18. One of the main strategies to avoid or solve impacts on coastal marine ecosystems is to combine research with capacity building for Cuban scientists.

2. Establish research themes and priorities.

   Even when each institution has its own mission and vision, general research lines distinguish our efforts. Every three to five years, scientific councils at each institution analyze the research lines and priorities. Basically, these research lines are based on scientific questions, on a gap in knowledge, or on a specific problem that it is necessary to solve. Usually, the final component of the research is to provide our recommendations to different agencies in our government. The main users of scientific results are the Ministry of Tourism (MINTUR); the Ministry of Science, Technology and Environment (CITMA); MINAL; the Ministry of Public Health (MINSAP); and different levels of the government (e.g., local, municipal and provincial), among others. This is a very general list showing the main research lines that are being pursued at different Cuban marine institutions:

   a. Oceanographic, ecologic and genetic connectivity
   b. Population genetics
   c. Coastal processes
   d. Marine meteorology
   e. Biodiversity patterns
   f. Paleoclimatic reconstructions
   g. Effectiveness of MPAs
   h. Endangered species (sharks, manatees, turtles)

i. Invasive species (lion fish, clarias)
j. Bioproducts
k. Fisheries management and research in stock fisheries
l. Effects of natural and anthropogenic impacts
m. Health of coastal marine ecosystems (mangrove, seagrass beds and coral reefs)
n. Global change
o. Resilience processes in coastal marine ecosystems
p. Conservation and management of coastal ecosystems

3. National and international collaboration.

We deliver the research lines mentioned above, in part, thanks to strong national and international collaboration. These two kinds of collaboration have different characteristics and benefits. In general, both are based on established projects and continuous academic exchange. One very useful tool for collaboration is networks. At the university level, we have two very prestigious networks: the Local Development network and the Environmental network. At the international level, networks such as Integrated Coastal Zone Management, Ibermar, among others, are also very active.

At the national level, we have different Ministries (Ministry of Higher Education [MES], CITMA, and MINAL) that oversee universities, agencies, aquariums, research centers, academic institutions, and similar, all of which usually work very closely with one another (Figure 19). This close integration has the advantage of permitting the integration of knowledge and complementing scientific results while saving resources. Some of these institutions directly deliver research projects while others such as the National Center for Protected Areas (CNAP) are responsible for conservation strategies and implementing management.

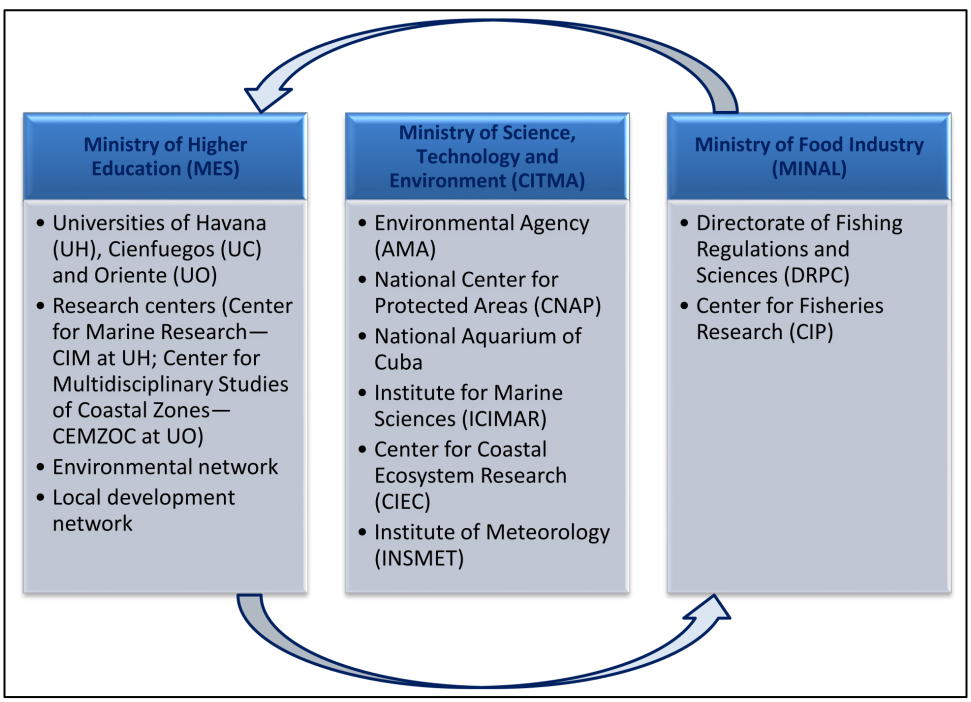

Figure 19. Cuban institutions from different ministries that work closely together on marine research and conservation.

At the same time, international collaboration helps provide financial support for research, integrates our scientists into international knowledge and research networks, and increases knowledge in many different research areas through common projects or academic graduate programs. It also allows us to publish our results in prestigious scientific journals and to attend international conferences. In particular, the roles of several different institutions and universities (e.g., HRI at TAMUCC, the Gund Institute at University of Vermont, and Florida Atlantic University) have been crucial. Non-governmental organizations have also been very important in supporting our research, and some have had ongoing work in Cuba in collaboration with various national institutions for more than ten years (e.g., The Ocean Foundation, Environmental Defense Fund).

1.2.6.7 One Last Noteworthy Aspect: Cuba´s "Women of the Sea"

One noteworthy aspect of our science in Cuba is the large number of women that not only work as researchers and faculty, but also have high positions as heads of institutions or even as ministers in the government. In Cuba, there exists much sociological research related to gender and the different views and perspectives that men and women have about the best way to solve problems. Some of this research concludes that women are more organized and better at managing conflicts and creating development strategies. Whether the conclusions of this research are true or not, the reality is that the heads of two ministries, CITMA and MINAL, are women. The same is true for three vice ministers of MES. Among different centers or institutions, the Environmental Agency (AMA), the National Aquarium of Cuba (regulated by CITMA), and CIM-UH, are led by women; the president of the University of Oriente is also a woman, and in the University of Havana, four vice presidents are women, too. In Cuba, women have exactly the same rights as men, and this includes access to the same work positions with the same salary.

The success of women as heads of institutions has resulted in some of them staying in their positions for long periods. For example, Dr. María Elena Ibarra Martín (Figure 20) was the Director of CIM-UH for almost 25 years. She is very well known not only among marine scientists, but also among the greater Cuban environmental scientific community. She is much respected for her encouragement and brilliant efforts in opening new avenues and directions for the development of Cuban marine research. One of the most successful projects that she led was the conservation and protection of marine turtles on the Guanahacabibes Peninsula. The results of this project resulted in better knowledge about migration patterns of turtles, reproduction, nesting and genetic characteristics, and the impact of hurricanes changing beach profiles and the consequences for turtle's nests. This research effort lasted for more than 15 years, and she was involved in all of the research projects. Because of this, when she passed away in May 2009, her ashes were spread over a beach on the Guanahacabibes Peninsula. This marine turtle project is just one good example of the many projects that she conducted herself or strongly supported.

Figure 20. Dr. María Elena Ibarra Martín was the Director of CIM-UH for almost 25 years.
All of Cuba's environmental and marine scientific communities are very grateful to her and remember her with great fondness. Photograph © David E. Guggenheim (2003) and used with permission.

Another aspect of her work is related to her very special role in establishing successful bridges for international collaboration projects in marine science and academic exchange, mainly with US institutions. She was the first marine scientist that opened the doors and made space for academic exchange with American colleagues. She understood very well that marine species do not understand political boundaries, and instead, they migrate through regions, countries, seas, and oceans, which keeps us close. She had the idea that if we really want to understand the environment around us, work seriously to manage our GOM and Caribbean Sea from a sustainable perspective, and avoid the effects of climate change, we must work together as an alliance. Cuba, Mexico, and the United States are environmentally close because of the marine environment that we share and the common problems that we face, but also because of the good science that we produce together and our fruitful and productive academic exchanges. Many different institutions in the three countries are part of this alliance, but without doubt, the role of HRI in this effort has been crucial and impressively productive. Dr. Ibarra recognized this in different scenarios and we appreciate her understanding of this need for collaboration as another important lesson about scientific sisterhood and human values.

1.2.6.8 Acknowledgements

I would like to express my gratitude to HRI for inviting the Cuban delegation to the State of the Gulf of Mexico Summit and the Gulf of Mexico Workshop on International Research meetings in March 2017. I am especially grateful to Dr. Larry McKinney for his constant efforts and support in working towards solving the common problems that face the three Gulf countries (Cuba–Mexico–United States). Also, I really appreciate Dr. Mark Besonen's assistance with polishing the grammar and figures for this manuscript.

1.2.6.9 References

Alcolado PM., Claro R, Martínez-Daranas B, Menéndez-Macías G, García-Parrado P, Cantelar K, Espinosa J, del Valle R, Martínez JC, Neff T. 2000. Estado general de los arrecifes coralinos de Cuba y propuestas de manejo ambiental. Havana, Cuba: Informe Instituto de Oceanología.

Álvarez MA. 2016. (Coordinador): La Bahía de La Habana. Memoria urbana, refuncionalización y valorización del patrimonio industrial. Gijon, Spain: Editorial CICEES.

Anuario estadístico de Cuba 2014. 2015. Oficina Nacional de Estadística e Información. Havana, Cuba.

González G. 2000. Biodiversidad marina y desarrollo: Conflictos y soluciones en el Caribe. Cádiz, Spain: Servicio de Publicaciones Universidad de Cádiz.

González S. 2004. Corales pétreos. Jardines sumergidos de Cuba. Havana: Editorial Academia.

González-Díaz SP. 2010. Efecto acumulativo de agentes estresantes múltiples sobre los corales hermatípicos de la región noroccidental de Cuba [dissertation]. [Havana, Cuba]: Universidad de la Habana.

González-Díaz SP, Díaz López C, Salinas Chávez E, González Sansón G, Gómez Luna L. 2015. Componentes y procesos de la zona costera. In: González-Díaz SP, editor. Manejo integrado de zonas costeras en Cuba. Havana, Cuba: Imagen Contemporánea. Chapter 6.

Guardia E. 2000. Evento de blanqueamiento en un arrecife de coral en la costa de La Habana, Cuba. Revista Investgaciones Marina 21(1-3): 108-109.

[INSMET] Instituto de Meterología de la Repubúlica de Cuba. 2017. Perspectiva climática para el período lluvioso mayo – octubre. http://www.insmet.cu/asp/genesis.asp?TB0=PLANTILLAS&TB1=PERSPECTIVASC&TB2=/clima/PerspectivasClimaticas.htm.

Martínez-Daranas B. 2006. Macroalgas y fanerógamas marinas asociadas a los manglares. In: Menéndez L, Guzmán JM, editors. Ecosistema de manglar en el Archipiélago Cubano. Havana, Cuba: Editorial Academia. p. 191–198.

Ripoll R, Viamontes EC, Monzón Y, Caraballo Y. 2015. El marco político, legal e institucional del MIZC en Cuba. In: González-Díaz SP, editor. Manejo integrado de zonas costeras en Cuba. Havana, Cuba: Imagen Contemporánea. Chapter 3.

Suárez AM, Martínez-Daranas B, Alfonso Y. 2015: Macroalgas marinas de Cuba. Havana: Editorial UH.

Wilkinson, C. 2008. Status of coral reefs of the world: 2008. Townsville, Australia: Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre.

Wilkinson C, Souter D. 2008. Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Townsville, Australia: Global Coral Reef Monitoring Network, and Reef and Rainforest Research Centre.