

# Opportunities for Advancing Coastal and Ocean Monitoring and Conservation in Cuba – Final Report

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## Sponsor Recognition

The primary sponsor for this project was the Richard Lounsbery Foundation, whose support, encouragement and patience during the execution of this workshop was much appreciated in light of changing relationships between Cuba and the USA. The Harte Charitable Foundation provided support for travel assistance to bring Mexican colleagues to the workshop and the Harte Research Support Foundation added funds for additional logistical needs necessitated by increased costs in Cuba. The Harte Research Institute (HRI) funded participation by additional staff and travel for Cuban, US, and Mexican student participation.



## Introduction

Home of the most biologically diverse archipelago in the Caribbean, Cuba was historically called the key to the Gulf of Mexico. Cuba, larger than all other Caribbean islands combined, sits on a large and highly productive marine platform, which makes it an important source of both marine biodiversity and fisheries resources. Waters of the Caribbean pass along the southern coast of Cuba as they enter the Gulf of Mexico and transport all life stages of Cuba's biodiversity, including important fisheries species, into the greater Gulf. At the same time, what happens in the greater Gulf directly affects Cuba as its water rush past the northern coast of Cuba exiting the Florida Straits into the Atlantic, where it forms the globally important Gulf Stream.

What happens in Cuba can directly affect Mexico and the USA. How Cuba manages its coastal and marine resources can affect the health and productivity of the Gulf. How Mexico and the USA manage their coastal and marine waters directly affect Cuba. The historic "key" to the Gulf of Mexico remains so today and Cuba must be actively integrated into the broader management and sustainability efforts of the world's ninth largest body of water.

The US commercial and economic embargo of Cuba expanded in 1962 to include all exports, except food and medicine. At present, the embargo, which limits American businesses from working directly with Cuban interests, is still in effect and is the most enduring trade embargo in modern history (1). Despite the existence of the embargo, the United States is the fifth largest exporter to Cuba (6.6% of Cuba's imports are from the USA). The impact of the embargo on Cuban science has been significant from both a technological and connectivity perspective. Cuban scientists are uniformly knowledgeable and academically advanced. However, they lack access to the more sophisticated oceanographic and laboratory equipment common in both US and Mexican universities and they have limited capability to access large datasets through internet sources. Additionally, their computing capabilities and access to advanced analytical software are often limited. Cuban scientists can have difficulty with foreign travel, particularly to the USA, and that limits potential collaborations.

In 2016, reestablishment of political and diplomatic ties with the USA introduced a new series of challenges to the management and sustainability of Cuban marine landscapes. The Cuban Ministerio de Turismo (MINTUR, *Ministry of Tourism*) reported that some four million tourists visited the island country in 2016, a 13% increase over 2015, contributing \$3 billion to the island economy. They estimated that the growing trend would slow in 2017, but still reach \$4.1 million. The changing US and Cuban relations also provided opportunities to enhance science collaborations and better integrate Cuba into the larger Gulf of Mexico marine science community. Scientific travel and collaborations greatly expanded as a result.

In June of 2017, President Trump announced that the USA would return to pre-2016 Cuba policies, with some modifications. Specific policies and rules have not been announced and that may not occur until late summer or fall of 2017. Science-based activities and travel will continue, possibly under specific licenses. This was a common requirement in the past and HRI has extensive experience in development and approval of such licenses by the State Department. There will be restrictions on travel for US tourism. The extent of those restrictions is not yet known, but it is anticipated that interaction with the Cuban science community will, at worst, return to pre-2016 conditions.

## Coastal and Marine Science in Cuba

Regardless of swings in US policy, there remains a fundamental need to engage the Cuban coastal and marine science community. A continuing and escalating challenge to the health and productivity of the Gulf of Mexico is a threat to our national security, economy and environmental health. The Gulf of Mexico, ninth largest of the named oceanic waterbodies, is of great strategic importance to the USA. As illustrated in *Gulf 360: State of the Gulf of Mexico* (2), the USA, Mexico and Cuba are integrally linked through demographic, economic and ecological commonalities. The Gulf of Mexico is often called the “Working Gulf” and for good reason. No other coastal water is more important to the nation’s energy security and overall economic health (3). The Gulf economy generates \$230 billion in economic activity each year. If it were a country, it would be the 29th largest economy in the world (3). The Gulf is foundational to our energy security, accounting for 54% of US crude oil, 52% of our natural gas production and hosts 47% of US refining capacity along its margins (4). Twelve of this country’s twenty largest ports are in the Gulf (5).

It can also be called the “Living Gulf” as it is essentially the nation’s fish market, annually yielding 1.5 billion pounds of seafood (6). The Gulf accounts for 44% of all US recreational fishing, a



\$16.2 billion a year economic boost for the region (6). The Gulf has about 40% of the wetlands in the nation, and most, if not all of the nation's seagrass and mangrove habitats (3). It is home to over 15,419 distinct species, making it one of the most biodiverse seas in the world (8). There are numerous threats to the health and productivity of the Gulf that would benefit from trilateral attention. Harmful algal blooms (9), oil spills (10), invasive species (11), sea level rise (12), and overfishing (4) lead the list of environmental concerns common to all Gulf countries.

## Science Diplomacy

The diplomacy of science can provide a sustained link between the three Gulf countries, even when other aspects of that relationship are strained or nonexistent. Science based diplomacy can bear fruit on which to build good relationships and sustain the momentum for positive change. HRI and partners, often supported by the Robert Lounsbery Foundation, has a long history of engagement in both Cuba and Mexico, with a focus of bringing together scientists from the three Gulf countries in common cause. HRI was a founding partner of the Trilateral Initiative (13) in 2000 and has sustained working relations in Cuba ever since.

In March 2017, the Department of Interior's Bureau of Ocean Energy Management (BOEM), the National Academy of Science Gulf Research Program, the National Oceanic and Atmospheric



Foundations of trilateral science diplomacy

Administration (NOAA) and HRI hosted some 165 Gulf researchers for a special workshop as part of the fourth State of the Gulf Summit in Houston, Texas. This event, the Gulf of Mexico Workshop on International Research (GOMWIR), was the largest gathering ever of Gulf scientists (all three countries were well represented) with a goal of agreeing to research priorities and building partnerships to accomplish them. A significant goal of the gathering was to build partnerships between international scientists.

The Robert Lounsbery Foundation-funded workshop, *Opportunities for Advancing Coastal and Ocean Monitoring and Conservation in Cuba*, held in Havana, Cuba, July 8-9, took advantage of the results of GOMWIR, even before publication of its proceedings, to structure the agenda for

the Havana workshop. The goal was to focus on priorities identified in Houston and better integrate those Cuban scientists who were not able to directly participate in GOMWIR into the Gulf science community.

HRI established international chairs in both Cuba and Mexico in 2017 to facilitate trilateral research collaboration and scientific undertakings related to assuring an economically and environmentally sustainable Gulf of Mexico. One of the initial duties of these individuals will be to advance the research priorities developed from both GOMWIR and the Havana workshop. This readily fits into the broader purpose of establishing these chairs to continue to build and sustain a trilateral network of Gulf scientists working towards common goals.

A commitment to science-based conservation and resource management can assure an economically and environmentally healthy Gulf. The only way of doing so is by working together on an international scale. This must be a priority for all three countries bordering the Gulf of Mexico. It can be the foundation to progress on all other policy issues and one that can be, and must be, sustained through the ups and downs of the diplomatic, political and policy travails that face us. Science diplomacy can be an important and consistent platform on which to build for the future.

## An Exercise in Adaptability

The original idea for the workshop was to identify existing gaps in ocean observing in Cuba and develop specific capacity building activities (both research and technological) to advance international collaboration. The workshop was rescheduled or restructured three times.

First, the workshop was delayed in response to the impact of reestablishing diplomatic ties at the time we were planning for it. Hotels generally refused to book large groups for the fall of 2016 anticipating higher rates because of soaring US tourism, which occurred. Hotel rates went from approximately US\$120 to US\$400, well outside our budget. We responded by moving the dates to low season (summer) and making an exclusive arrangement with the Sheraton Four Points Hotel located away from the city center to secure a reasonable price for both rooms and meeting venue.

Second, the workshop was further delayed and restructured in response to requests from partnering Cuban institutions who were overwhelmed by the flood of US researchers and federal agencies that came with reestablishment of relations. They simply did not have the capacity to respond to all demands being placed upon them. Because we have long-term and positive relationships with them, they felt comfortable asking our understanding and we felt obligated to accommodate their concerns.

One of those newly possible government meetings was of special interest. The National Oceanographic and Atmospheric Administration (NOAA) acted quickly to arrange a working meeting with Cuba's Oficina Nacional de Hidrografía y Geodesia (ONHG, *National Office of Hydrography and Geodesy*), with the same general focus as our workshop. The basis for our funding request was because such official meetings could not occur. That workshop was held in Havana, June 13-14, 2016 and was successful in establishing relationships and advancing some very basic and important joint oceanographic activities, especially related to coastal mapping and data standardizations. To the best of our knowledge these activities continue. Both parties sought HRI out to help further the outputs of that initial meeting. We worked closely with both US and Cuban leads for this official activity to make sure our workshop was complimentary and built on that ground-breaking meeting. The Director of the Centro de Investigaciones Marinas (CIM, *Center for Marine Research*) of the Universidad de La Habana also asked that we expand the agenda to better mesh with their most important annual international convention on the environment and development. Doing so made it easier for Cuban participants to minimize travel and attend both events.



Larry McKinney speaking at the 11th International Convention on the Environment and Development in Havana, Cuba, July

Third, the workshop agenda was modified to account for anticipated changes in US and Cuban relations by the Trump Administration and potential adverse impacts on the execution of projects and activities that might evolve from the workshop. An important goal of the workshop was to facilitate international collaborations and this was made more problematic because of uncertainties in potential US restrictions. Our approach was to emphasize low risk projects that would likely not invoke concerns by the Office of Foreign Assets Control (OFAC) (14)

The flexibility of the Robert Lounsbery Foundation, the Universidad de La Habana, and all of our US, Mexican and Cuban participants, allowed for all of these complications to be successfully addressed and the workshop was held on July 8-9, 2017. The delay proved beneficial as the agenda was expanded to include topics that were not thought to be possible when the workshop was conceived. This delay also made it possible for the Universidad de La Habana to



co-host the workshop, which greatly enhanced Cuban participation. As a result of the delay, the workshop became a special addendum to the XI International Convention for the Environment and Development, also held in Havana from July 3-7, benefiting the status of the workshop in Cuban academic circles.

## Workshop Goals

The initial goal of the workshop was to identify existing gaps in ocean observing in Cuba and develop specific capacity building activities (both research and technological) to advance trilateral collaboration. Because our workshop was unexpectedly informed by the NOAA/ONHG meeting, we were able to include goals related to the collection of critical baseline information and improved access to data and information relevant to ocean observing and monitoring. We were also able to add broad conservation goals related to advancement of more integrated efforts between these disciplines. Projects that evolve out of this expanded workshop will inform USA, Mexico and Cuba in understanding and conserving the Gulf of Mexico in ways not initially thought possible.

An additional goal was added to seek Cuban, Mexican and US coordination and enhancement in ocean observing and monitoring to better link these improvements to trilateral efforts to assess the health and productivity of the Gulf of Mexico and inform trilateral conservation efforts. The Gulf Report Card, Marine Biodiversity Observation Network, and the Global Ocean Acidification Network were featured during the workshop as ways to better integrate Cuba with international programs.

Success in developing projects to meet these goals can be used to inform best practices in sustainable fisheries; identify coastal restoration activities to adapt to or counteract sea level rise; and, to evaluate the efficacy of existing coastal and marine protection measures in Cuba to better manage and conserve its coastal and marine resources. As Cuba makes decisions about coastal development, oil and gas exploration, and other economic decisions with marine implications, they will need better tools to understand the value of natural resources and the implications of their loss or degradation on their sustainable future. If these efforts are informed by and linked to ongoing international efforts, especially in Mexico and the USA, the Gulf of Mexico and all who depend upon it will benefit.

## Workshop Participants



Discussion among researchers during a workshop break

A total of forty-six researchers participated in the workshop, twenty from the USA, nine from Mexico and twelve from Cuba. Five HRI staff also participated in facilitation or support roles including Larry McKinney, Principal Investigator, Gail Sutton, Chief Operating Officer, Victoria Ramenzoni, International Engagement Officer, Mark Besonen, Associate Research Scientist, and Jim Gibeaut,

Endowed Chair for Geospatial Sciences. A listing of participants and affiliations is attached. These participants provided a good mix of expertise in the two focal areas. The workshop was especially strong in representation of oceanographic sciences from the USA and Mexico and in conservation from Cuba, but there was adequate representation across all disciplines to reach workshop goals.

## Workshop Structure

The workshop was held at the Sheraton Four Points Hotel in Havana, Cuba on July 8-9, 2017. The workshop was co-hosted by the Harte Research Institute (HRI) – Larry McKinney, Executive Director and the Centro de Investigaciones Marinas of the Universidad de La Habana (CIM) – Silvia Patricia González Díaz, Director. Some 46 invited scientists from the USA, Mexico, and Cuba participated, and live, on-the-fly, bilingual English-Spanish translation services were available for all participants as needed. HRI and the Harte Charitable Foundation (HCF) provided funding, matching that of the Robert Lounsbery Foundation, to accommodate increased costs and assure all of the participants originally thought needed for a successful workshop could attend and make sure we had adequate supporting staff for the workshop.

The workshop was structured in two parts: plenary and interaction. The plenary session was divided into two themes: Ocean Observing/Monitoring and Conservation.

Panel one was titled Linking Ocean Observing and Marine Conservation across the Gulf of Mexico. Panel members were asked to summarize what is known about the dynamic interactions that define the large marine ecosystem we know as the Gulf of Mexico. Each panel member was asked to identify and prioritize challenges to cooperative actions; outline existing activities that could be expanded to meet this challenge; and, lay the groundwork to action.

Panel members included: Tony Knapp – Gulf Environmental Research Group (GERG); Julio Morell – Caribbean Regional Association for Coastal Ocean Observing (CARICOOS); Monty Graham – University of Southern Mississippi; Juan Carlos Herguera – Consorcio de Investigación del Golfo de México (CIGoM) – Mexico; Barb Kirkpatrick – Gulf of Mexico Coastal Ocean Observing System (GCOOS); Gustavo Arencibia Carballo – Centro de Investigaciones Pesqueras (CIP) – Cuba.



Panel discussion (from L to R, G. Arencibia, J. Morrell, B. Kirkpatrick, M. Graham, and J.C. Herguera)

Panel two was titled Assessing Ecosystem Health and Productivity across the Gulf of Mexico. There are several efforts underway across the Gulf of Mexico that are attempting to evaluate the health and productivity of the Gulf as a large marine ecosystem. Panel members were asked to provide overviews of these activities and how they might engage Cuban colleagues and institutions through these international programs. Panel members included: Larry McKinney (HRI) – Gulf of Mexico Report Card; Porfirio Álvarez (Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe – CiiMAR-GoMC) – Mexico Report Card; Frank Muller-Karger (University of South Florida) – Marine Biodiversity Observation Network; James Gibeaut (HRI) – Habitat Mapping in Marine Environments; David Yoskowitz (HRI) – Ecosystem Services a Framework for Assessment; Libby Jewett (NOAA) – The Global Ocean Acidification Network; Rafael Puga (CIP) – Fisheries Science in Cuba; and Silvia Patricia González Díaz (CIM) – Status of Conservation Science in Cuba.

On day two of the workshop, participants were asked to self-sort into two groups that aligned with the plenary structure. They are designated the Ocean Observing Workgroup (OOW) and Cuban Conservation Workgroup (CCW) for ease of reference. After listening to plenary presentations, and based on their own interests and expertise, workshop participants were asked to prepare a list of the highest priority research areas or specific projects that would require or benefit from international cooperation. They were then asked to identify potential

joint projects be between – USA and Cuba; USA and Mexico; Cuba and Mexico; or, between all three countries. Finally, participants were asked to prioritize these project ideas into three priority groupings of high, medium and low feasibility, and enumerate both challenges and opportunities. Time was provided for subgroups of each larger working group to develop specific project ideas, if they felt it was possible to quickly initiate the project in some reasonable time after the completion of the workshop. The working groups were further encouraged to outline more ambitious projects and identify how these might be developed and who should be involved.

## Workshop Results

The two workgroups took different approaches to their task, which is not unexpected given the international nature of the participants and the diversity of disciplines they represented. The OOW used a discipline and prioritized project focus, while the CCW used a spatial oriented process that also focused on scalability. In both cases, the end results yielded the desired products and more importantly specific projects that had a high probability of implementation. Several projects were, in fact, initiated at the workshop and others were well into detailed planning.

### Ocean Observing Workgroup (OOW)

Participants in the Ocean Observing Workgroup represented the leadership of Gulf of Mexico and Caribbean efforts in this area from both the USA and Mexico. This provided a great opportunity to interact with Cuban academic leaders and representatives. The first part of the workgroup breakout session was dedicated to a discussion of priorities for international research and the second half of the workshop was focused on developing potential projects that workshop participants might undertake or develop.

#### Trinational Research Priorities

Research priorities developed by the OOW participants included a broad range of bio-physical topics. A great deal of discussion and consideration was also given to the importance of linking across disciplines. The workgroup identified three of the highest priorities, but also discussed several additional specific priorities that they agreed should be included in the prioritizing effort, but at a lower priority. The following order of discussion represents the consensus of the workgroup as to the highest priorities for trinational research to the lowest.

A high priority for trinational research was developing a better understanding of connectivity in the Gulf of Mexico as a large marine ecosystem. Connectivity was mostly expressed in relationship to biodiversity and better understanding transport from coastal to oceanic water

within the Gulf and between the greater Caribbean and the Gulf, on the large marine ecosystem scale. Connectivity issues between the deep Gulf and remainder of the Gulf ecosystem was an important additional concern.

A second issue of high priority was the need for a better understanding of Gulf Loop Current origin, generation and fate. The Loop Current has significant impact on biological, economic and even safety issues across the entire Gulf. Before the workshop, the National Academy of Sciences Gulf Research Program reached out to HRI and asked that we make both Cuban and Mexican researchers aware that they were funding a special effort on the Loop Current. They were hoping that the workshop would provide an opportunity link these researchers into their effort and perhaps develop joint activities. A related research effort is being led by CIGoM, a large consortium of Mexican universities with significant federal funding. The workshop was the first time scientists with common goals in Loop Current research from all three Gulf countries met and discussed cooperative research. Workshop participants made a special point of not only focusing on the science, but recommending that communicating its importance to the general public should be a priority objective in this research effort. Also, there needs to be increased attention to biochemical and biological aspects of loop current, in addition to the ongoing efforts to better understand the physical oceanography.



OOW breakout session (from L to R, C. Pyc, G. Arencibia, and J. Morrell)

The third highest priority centered on the development of sentinel sites around the Gulf of Mexico. As defined by NOAA's Sentinel Sites Program, these sites can be defined as specific areas in the marine environment that have the operational capacity for intensive study and sustained observation sufficient to detect and understand physical and biological change in the ecosystem they represent (15). Ocean noise is an issue many participants felt was especially ripe for inclusion in any such program in the Gulf of Mexico, and new acoustic technology was making it more feasible in both cost and dependability. Workshop participants felt that a trilateral effort was possible if focused on marine protected areas around the Gulf of Mexico.

A series of additional research priorities were also discussed and agreed to by the OOW. No particular priority order is assigned in the following listing:

- Ocean acidification was identified as a priority and an opportunity to better integrate the Gulf of Mexico into global efforts to address this important issue.
- Developing high resolution bathymetry for the Gulf would significantly accelerate a broad range of efforts to better understand both connectivity and the Loop Current.
- A better understanding of genomic connections between Cuba and Florida would benefit fisheries management across the Gulf.
- Trinational efforts to track and better understand *Sargassum* distribution and origin would have economic benefits to tourism.
- Data transfer and accessibility between the three Gulf countries is an ongoing challenge and greatly hinders efforts to address the full range of environmental and management challenges across the Gulf.
- It was felt that the area of community informatics was especially ripe for trinational attention. The term is defined as an interdisciplinary field concerned with using information and communication technology to empower communities with common interest to support social, cultural and economic development while protecting their environment. A common thread that ran through priority discussions was the need for enhanced information exchange between trinational countries with community informatics as a means to that end.
- An objective assessment of the health of the Gulf of Mexico that could also be applicable to a smaller spatial scale was also agreed upon as a much needed tool to promote trinational cooperation and better focus on priority issues.
- The three Gulf countries should work together to better integrate the Gulf into international assessment efforts like OBIS (16).

The discussion of trinational research priorities informed subsequent discussion and planning for potential trinational projects and energized OOW to move quickly from discussion, to planning projects, to initiating several on the spot.

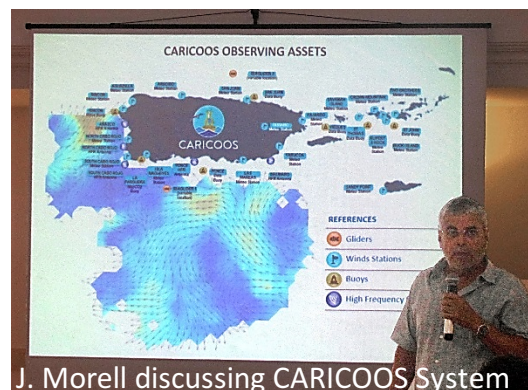
### Projects Initiated

Several projects were identified during the workshop that were initiated right away because the appropriate individuals attended. Several of the projects related to improving science communication between trinational countries, an especially acute issue for Cuba where connectivity issues prevail.

There are several long series of Cuban marine science journals and publications not readily available outside of Cuba. Workshop attendees identified two: the Cuban Journal of Fisheries Research and the Geology of Cuba. The fisheries publication will be digitized and made available in all three Gulf countries. The geology book needs to be translated into English and then published. HRI will develop costs estimates and seek funding for this project.

The Gulf of Mexico Coastal Ocean Observing System (GCOOS) and the Caribbean Coastal Ocean Observing System (CARICOOS) support very sophisticated and useful websites where they project and make available all of the data and information they collect and generate. Neither site provides a Spanish language mirror site. Both organizations agreed to develop those sites as a project initiated through the workshop.

The National Academy of Science Gulf Research Program established the Committee on Advancing Understanding of Gulf of Mexico Loop Current Dynamics in the Fall of 2017. Their goal was to develop recommendations to design a suite of activities, including research, observations and analysis needed to characterize Loop Current dynamics and improve the effectiveness of modeling efforts. The Committee approached HRI and asked to be included in the workshop with the specific goal of incorporating Cuban scientists in the Loop Current Program. The initial communications



J. Morell discussing CARICOOS System

established at the workshop were productive and helped establish important connections. HRI will facilitate participation of Cuban scientists in the Committee's 2018/2019 campaign.

Institutes in both Mexico and the USA are developing Report Card tools to assess health and productivity in objective ways that are useful in management decisions and policy development. HRI's Texas Report Card and CiiMAR-GoMC's Yucatan Report Card are models that were discussed in detail during the workshop. Representatives from the Cuban agency (CIM) that oversees marine protected areas expressed interest in exploring and developing a Report Card for Cuba. Project leads agreed to hold an initial planning session in Havana on October 1-3, 2017.

Two habitat mapping projects were initiated at the workshop. The island of Cuba hosts a vast array of marine habitats, most of which have not been characterized adequately, simply because it is hard for Cuba researchers and resource managers to study their long coastline (over 5,700 km long). Cuba has had a much harder time characterizing its broad continental shelf, including several large semi-enclosed gulf regions. These areas are of great importance for the sustainable development of Cuba. They are critical for the marine life living in these areas, but also for marine life in the USA. Some species living in Cuban habitats migrate or are connected with US habitats by currents. The proposal being developed has two components.

- **Characterization of the fundamental, long-term variability in environmental factors around the entire island of Cuba.** The outcome will be a synthesis of the state and variability of physical processes and variables (e.g. currents, temperature) and biomass of

the lowest levels of the food web (phytoplankton) in coastal waters around Cuba, and capacity building in remote sensing science and applications.

- **Local-scale Study: Mapping of the benthic habitat and water column turbidity in the Gulf of Guanahacabibes.** The outcome will be the detailed mapping of wetlands as defined under the Ramsar Convention (i.e. mangroves, seagrasses, corals, and shallow sandy areas), and capacity building in remote sensing science and applications. The CIM has conducted extensive in situ surveys of the Gulf of Guanahacabibes. These data are inadequate to map the entire Gulf but they are critical ‘sea truth’ to develop a highly-detailed map of the region using satellite data.

This study addresses the high priorities of Cuba in marine research, including the mapping of currents and phytoplankton concentration in Cuban waters and a study of ocean connectivity between Cuba and the USA using satellite images.

## Cuban Conservation Workgroup (CCW)

The Cuban Conservation Workgroup was composed of a broad array of Cuban, Mexican, and US scientists and leaders representing organizations with a focus on a range of themes including conservation, biodiversity, fisheries, fates and effects of pollutants, geospatial and data sciences, and similar. The opportunity for extended, face-to-face contact with one another fomented a vigorous discussion about Gulf-wide research priorities and knowledge gaps during the first breakout session.



Similar vigorous discussion and consensus-building during the second breakout session allowed the group to develop joint research priority questions, and a list of specific actions and a general plan to advance activities for addressing the priorities at various scales.

### Joint Research Priorities

Given the varied interests of the CCW participants, a wide range of suggestions for specific priority research themes to address knowledge gaps in the Gulf of Mexico were offered during an initial roundtable discussion. Several common threads linking the various suggestions emerged through further discussion, and these guided the workgroup in developing two broad and encompassing research priority questions to serve as a flexible, umbrella framework for advancing our understanding of Gulf-wide conservation and ecosystem themes at a variety of scales. These two main research priority questions were developed simultaneously and with the same level of support and enthusiasm; thus, neither is assigned priority over the other. The two main research priority question are discussed below.



The first research priority question is, “**How effective are MPAs (marine protected areas)?**” It is clear that MPAs, and networks of MPAs, can play a fundamental role in helping to protect and preserve marine biodiversity and ecosystems, which, in turn, help to sustain resilient and healthy human populations (17). But it is also equally clear that a variety of factors moderate the overall effectiveness of MPAs in actually reaching their intended conservation goals (18, 19, 20). Our present limited knowledge about the overall effectiveness of these MPAs is directly related to many of the fundamental knowledge gaps we have about Gulf biodiversity and ecosystems at all scales both spatially (from the micro- to meso- to macrocosm scale) and temporally (from the real-time to seasonal to decadal scale). These gaps run the gamut from understanding simple species distributions and biodiversity (for example, via mapping) to a comprehensive identification of stressors and their effects (both common ones like contamination and fisheries practices to our understanding of newly emerging issues like acoustic stress). For this reason, the workgroup decided that this simple question should serve as a joint focal research priority.

The second research priority question is, “**What are the patterns of connectivity that exist?**” Connectivity within the Gulf, but also into and out of it, is relatively poorly understood, and this is true for both the biological and physical elements that are involved. For example, we are not able to answer many basic questions like: is a certain area a source of fish larvae, or a sink for them? Similarly, we are still working to understand basic physical mechanisms



like the Gulf Loop Current and other circulation patterns. Importantly, these physical flows, which also transport biological components, are one element that undeniably links the Gulf together as a single natural system. This fact emphasizes the fundamental need for trilateral collaboration as all three nations are both upflow and downflow from one another. And similar to the first research priority question above, an understanding of connectivity at all scales both spatially and temporally is needed. For this reason, the CCW participants decided that patterns of connectivity should be another one of our joint focal research priorities.

In addition to the two main research priority questions discussed above, a secondary set of priorities and recommendations was distilled from the workgroup discussions. These secondary level elements are generally more specific, and inevitably support the two main research priority questions to some degree. Many of these actually form the basis for suggested pilot projects (see “Projects Initiated and In Planning” section below) that serve as stepping stones to help the community address the two larger research priority questions. These secondary

priorities and recommendations are listed below, and the order is not representative of any particular priority, i.e. they are all equally prioritized.

- There was a common sentiment that efforts should be made to take advantage of preexisting data that has never really been used. For example, there are tremendous archives of satellite and remote sensing imagery that have simply never been examined in detail. Also, scientists may be sitting on data sets that they have never released, and much data also exists only in printed, hard copy form, which makes accessibility difficult, and essentially impossible via remote access in another country. A related issue is that of English  $\leftrightarrow$  Spanish language difficulties. Importantly, many of these data sets potentially contain valuable baseline data and observations that document marine ecosystems from decades ago before the significant impacts that are noted today. Overall, a mechanism is needed to allow for better a flow and exchange of data between scientists in the three nations.
- The workgroup stressed that a better understanding of links between terrestrial and marine systems was really important. This is especially true in the coastal realm where impacts may be more direct, but also in offshore and even deeper water given that fine-grained sediments and contaminants may travel significant distances from their sources.
- The workgroup unequivocally agreed that learning exchanges and capacity building between the three nations are fundamental, and that increased collaboration and coordination is needed even though it requires extra effort, persistence, and patience on the part of scientists. It was noted that some groups have extensive experience with restoration efforts, for example, with mangroves, and that sharing such expertise with others via workshops and similar will help such efforts take root Gulf-wide. Other concrete examples are given in the “Projects Initiated and In Planning” section below.
- The workgroup determined that an effort should be made to better integrate work between the biological and physical science sides. For example, tracking of physical flow and circulation patterns is interesting, but when combined with biological aspects, this is an absolutely essentially tool for tackling questions related to patterns of connectivity at different spatial and temporal scales.
- It was stressed that connectivity between the human/social/economic realm and the biological/physical science realm should not be an afterthought, but should be involved as an integral part of planning as much as possible. It was noted that for efforts towards protection and conservation, buy-in by users can really help push a project towards success (for example, the mangrove restoration pilot site in Laguna de Términos).



P. Álvarez discussing CiiMar-GoMC

### Projects Initiated and In Planning

The workshop setting proved to be an extremely rich environment for allowing participants to enthusiastically discuss and develop opportunities for joint collaborations for both existing projects and completely new ventures. In fact, during the second breakout session when the CCW participants were charged with developing plans for projects to address the decided research priorities, at least two new collaborative efforts had already emerged organically. These include:

- **A seagrass and benthic habitat mapping project** in northern central Cuba based on combining results from long-term field work observational efforts with modern, high-resolution, visual and multispectral satellite imagery. This collaboration offers an excellent opportunity for capacity-building, and indeed, it will involve training a Cuban biologist in remote sensing techniques in the USA for a 2-3 month period. Following this training, the Cuban scientist will be able to pass on this knowledge and skill set to other Cuban scientists, in particular, graduate students in marine science. Expanding this effort to involve a second US institution and additional Cuban scientists (graduate students) was also discussed during the workshop, and final details of this expansion are currently being determined.
- **A collaborative effort with the Centro de Observación Oceánica (COO) in Puerto Rico regarding drifter deployments.** Discussions between conservation and fates/effects scientists with workshop participants from the COO resulted in an offer to facilitate drifters during periods of conservation and fates/effects sampling cruises to help track circulation, and thus, begin work towards deciphering patterns of connectivity in the area.

Given the two broad research priority questions that had been chosen by the CCW participants in the first breakout session, it was determined that directly addressing these priorities with two large, head-on projects was simply not feasible. For example, to successfully answer questions about the effectiveness of MPAs and patterns of connectivity, many years of effort involving significant resources such as for ship time is needed. Furthermore, organizing a cruise requires 2-3 years of lead time for establishing a scientific plan, organizing a crew, securing the necessary international permits and licenses, and importantly, for procuring funding.

Instead, the group decided that the best option was to immediately start building on the enthusiasm, energy, and goodwill that characterized the workshop, and thus, a multi-scale nested strategy was devised. Smaller scale pilot projects that can be started immediately will be undertaken. These projects will involve limited spatial extents, shorter time spans (1-3 years), and more modest resource requirements, but will serve as stepping stones that lead the group toward answers for the broader scale research priority questions.

This multi-scale nested strategy offers some excellent advantages. First, it capitalizes on the current enthusiasm from the workshop, and only requires modest resource amounts. Second, it

allows the CCW participants to demonstrate that they are capable of organizing themselves and managing the various administrative and bureaucratic hurdles that are an inevitable part of international work. Finally, it will provide the needed 2-3 years of lead time that are necessary for organizing a larger scale cruise as mentioned above. In sum, the group is putting into place plans for immediate action to move forward starting right now with smaller scale pilot projects. Simultaneously, it is setting in motion longer-term planning efforts for actions that can build on the first wave of pilot projects when they are completed over the next few years.

Characteristics of the pilot projects were sketched out rather easily given the earlier robust discussion. These pilot projects will have three main characteristics as outlined below:

- 1.) Discussions pointed out the **fundamental need for evaluating ecosystems**, and the first step will be focused on identifying gaps in knowledge and studies. This effort directly builds on the results of GOMWIR in March 2017. Part of the GOMWIR effort involved developing a database of literature and data resources focused on the southern Gulf of Mexico, and this database will soon be made available as a public resource. A second important step in this process focuses on the characterization of ecosystems themselves. This means documenting biodiversity by traditional means such as field studies, but also mapping efforts such as the previously mentioned **seagrass and benthic habitat mapping project**. There was also the specific interest in not confining this work to only traditional methods, but also involving newly emerging technologies such as acoustic mapping and classification. A final aspect of characterization will involve the development of report cards for regions of interest like those currently being developed for some points in the Gulf.
- 2.) Given the MPA focus of one of the research priority questions, a second important characteristic of the pilot studies will be the effort to **identify the stressors that affect these MPAs**. In particular, there will be a focus on stressors such as contamination, tourism, population density, resource extraction, shipping and marine transport, fisheries, sea level rise, climate change, ocean acidification, and invasive species. Much discussion occurred about how to effectively undertake these studies given the limited scope of the pilot studies. A framework that involves gradients in these stressors was suggested, and this is discussed further below.
- 3.) A final important characteristic for these pilot studies, as agreed upon by CCW participants, is that they should necessarily include learning exchanges and capacity



building efforts between the three nations. These efforts are already actively underway (for example, the seagrass and benthic habitat mapping project mentioned above). Related efforts will involve international graduate students that enroll in degree programs in one of the other Gulf nations, or organizing workshops on specific themes like restoration experiences with mangroves, coral reefs, and other coastal environments.

Choosing actual locations for pilot study projects is difficult given the desire to make the efforts as fruitful as possible. The CCW participants decided that a gradient-based approach is probably the most effective method for maximizing returns on these efforts. In particular, a small quantity of sites (2-4 maximum) will be selected in MPAs in each of the three nations. These sites will ideally span a gradient of stressors from highly affected to lightly affected, and thus, the effects of these stressors should be obvious. Pilot sites for each country were suggested, but are not finalized, and still open for discussion.

1. In Cuba, from E→W, suggested sites would include RF Cayo Levisa, RE Los Pretiles, Banco de San Antonio, and Guanahacabibes National Park.
2. In Mexico, from E→W, suggested sites would include Yum Balam Flora and Fauna Reserve, Laguna de Términos, Veracruz Reef System National Park, and Lobos-Tuxpan Reef System National Park.
3. In USA, the suggested focus was the Florida Keys National Marine Sanctuary, and from E→W, suggested sites would include Key Largo, and Fort Jefferson/Garden Key.

A final note regarding these pilot study projects is that many of the efforts can be directly tied to components of the GEF-UNIDO Gulf of Mexico Large Marine Ecosystem (GoM-LME) initiative, that has recently received six years of funding to cover the period from 2017-2022. This is a binational initiative that involves only Mexico and the USA at the moment, and thus, funding is already available for these two countries for some aspects of the suggested pilot work. Cuba was not involved in this initiative originally because during its planning stages, political realities precluded the possibility. But following the changing relationship between the USA and Cuba, there has been great interest in involving Cuba as much as possible, and this theme was promoted repeatedly in CCW discussions. One goal of the GoM-LME initiative is a Gulf-wide expansion of several successful pilot projects that they have already undertaken in the past like a mangrove restoration effort in Laguna de Términos, and the development of Report Cards. Additional funding would be needed to cover Cuban participation, however, the GoM-LME National Project Coordinator, who participated in the Workshop, noted that there is already an appropriate legal agreement in place between the Cuban Secretary of the Environment and the Government of Mexico. The existence of this infrastructure is an important step that actually makes it easier to get funding to Cuba once it is encountered.

## Going Forward

The planning, execution and report preparation for this workshop occurred during an extraordinary time for Cuba, both politically and environmentally. Changes in US policy have swung from one extreme to another. Hurricane Maria devastated much of Cuba. Many of our Cuban participants and their institutions suffered devastating losses. There is considerable uncertainty as we move forward to implement many of the ideas and projects that developed because of the workshop but I am happy to report that all our participants have urged us to move forward and we will endeavor to do just that.

Several relief efforts to assist our Cuban colleagues were launched immediately after Hurricane Maria cleared land and moved into the open Atlantic Ocean. Thousands of dollars were raised and more is coming in. It will be a long effort to restore what was lost, but all are committed to that goal.



Progress on actions coming out of the workshop have been delayed but are now on course. HRI has submitted a license request to pursue these ideas to the US State Department in anticipation of new requirements and restrictions. Once approved it will expedite coordinated efforts. The workshop helped gain approval for the establishment of an international chair for Cuban Conservation for HRI and Texas A&M University–Corpus

Christi. That individual will be the Cuban Co-Chair of the workshop, Silvia Patricia González Díaz the Director of the Centro de Investigaciones Marinas of the Universidad de La Habana. It is a joint appointment and one of her priorities will be to advance the outcomes of the workshop. HRI has already been contacted by the National Academy of Science and several of the federal agencies that participated in the workshop to facilitate further collaborations with counterparts in Cuba. As with all aspects of the workshop, HRI will continue those efforts. Thanks to the Richard Lounsbery Foundation, the Harte Charitable Foundation and the Harte Research Support Foundation and the researchers and staff of HRI the workshop did achieve its goals and will be recognized as the platform from which many trinational marine research and conservation projects were launched over the coming years.

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# Appendix

## Appendix A – Workshop Agenda

### **July 8 (Saturday)**

#### **8:30 AM**

Opening remarks from Workshop organizers Dr. Larry McKinney and Dr. Patricia González

#### **9:00-10:30 AM**

##### **Linking Ocean Observing and Marine Conservation across the Gulf of Mexico**

Understanding the dynamic interactions that define the large marine ecosystem we know as the Gulf of Mexico is critical to conservation and management actions. This can only be achieved with international cooperation between the USA, Mexico and Cuba. Panel members will: identify and prioritize challenges to cooperative actions; outline existing activities that could be expanded to meet this challenge; and, lay the groundwork to action.

Panel members: Tony Knapp – GERG; Julio Morell – CARICOOS; Monty Graham-USM; Juan Carlos Herguera CIGoM – Mexico; Barb Kirkpatrick – GCOOS; Cuba – to be invited. Each panel member given 10 minutes to provide overview and perspective on ocean observing issues

#### **10:30-11 AM: Coffee Break**

#### **11:00-12 PM**

##### **Linking Ocean Observing and Marine Conservation across the Gulf of Mexico**

Discussion between panel members and interactions with other workshop participants

**12 PM-1PM: Lunch** Trinational Initiative – A History of Collaborative Science. Fernando Bretos  
Cuba Marine Research & Conservation Program.

#### **1-2:30 PM**

##### **Assessing Ecosystem Health and Productivity across the Gulf of Mexico**

There are several efforts underway across the Gulf of Mexico that are attempting to evaluate the health and productivity of the Gulf as a large marine ecosystem. Panel members will provide overviews of these activities and how they might engage Cuban colleagues and institutions.



Larry McKinney – Gulf of Mexico Report Card; Porfirio Álvarez -Mexico Report Card; Frank Muller-Karger – international biodiversity

**2:30-3:00 PM: Coffee Break**

**3:00-4:30 PM**

**Assessing Ecosystem Health and Productivity across the Gulf of Mexico-Part II**

James Gibeaut – Habitat; David Yoskowitz- Ecosystem Services; Libby Jewett – NOAA, ocean acidification; Dr. Gustavo Arencibia Carballo – fisheries science in Cuba

**July 9 Sunday**

**8:00-9:00 AM**

Cuban conservation and/or oceanographic research presentation and discussion led by Dr. Patricia González

**9:00-9:30 AM**

Guidance for remainder of workshop. Two working groups Ocean Observing and Marine Conservation will be formed and asked to address specific topics.

**9:30 AM-10:00 AM Coffee Break**

**10:00-12:00 Workgroups meet independently**

The two working Groups meet and work on assignments. Dr. McKinney will lead the ocean observing workgroup and Dr. González the marine conservation group

Assignment: After listening to plenary presentations and based on your own interests and expertise what would a good joint project be between – USA and Cuba; USA and Mexico; Cuba and Mexico; or, all three countries? Prepare a list of the highest priority research areas or specific projects that would require or benefit from international cooperation. Please prioritize these in some manner, either rank all ideas individually or place into three priority groupings of high, medium and low.

**12 PM-1PM: Lunch Break**

**1-2:00 PM Workgroups meet independently**

If it is possible for some subset(s) of the working groups to work independently on a particular project. The group should prepare a short summary of:

1. The idea or problem statement – a short abstract that describes why it is important.
2. Geographic scope of the project

3. What type of international cooperation would be needed
4. What international difficulties might need to be overcome
5. Timeframe
6. What likely result could be expected

The workgroup could all together work on identified projects, rather than subgroups, if the working decided that is the best way forward

**2:00-2:30 Coffee break**

**2:30-3:30 Workgroups meet independently**

Continue workgroup activities

**3:30-4:30 Plenary Closing session**

**Open discussion on workgroup outputs and possible collaborations.**

- Next steps in developing final report on workshop
- Next steps in developing research proposals.
- Links to policy, resource managers, and decision-makers.
- Synergies between workshop participants.

## Appendix B – Workshop Participants

NAME	LAST NAME	COUNTRY	INSTITUTION
Dr. María	Allende Arandía	Mexico	UNAM
Dr. Porfirio	Álvarez Torres	Mexico	CiiMar-GoMC
MS, Romina	Alzugaray	Cuba	CIP
Dr. Gustavo	Arencibia Carballo	Cuba	CIP
Dr. Maickel	Armenteros	Cuba	CIM-UH
Dr. Mark	Besonen	USA	HRI
BA, Angel	Braestrup	USA	Munson Foundation
Dr. Fernando	Bretos	USA	The Ocean Foundation
MS, Yenizeys	Cabrales Caballero	Cuba	CEAC
Dr. Julio	Candela Pérez	Mexico	CICESE
Dr. Dorka	Cobián Rojas	Cuba	PNG
Dr. Judson	Curtis	USA	HRI
MS, Diana	Del Angel	USA	HRI
Ulises	Fernández	Cuba	CITMA
María	García	Cuba	CNAP
Dr. James	Gibeaut	USA	HRI

Dr. Gerardo	Gold Bouchot	Mexico/USA	TAMU
Dr. Roberto	González de Zays	Cuba	CIEC
Dr. Silvia Patricia	González Díaz	Cuba	CIM-UH
Dr. William (Monty)	Graham	USA	SOST-USM
Dr. Juan Carlos	Herguera	Mexico	CICESE/CIGoM
MS, Leslie	Hernández Fernández	Cuba	CIEC
Dr. Elizabeth	Jewett	USA	NOAA
Dr. Barbara	Kirkpatrick	USA	GCOOS
Dr. Beatriz	Martínez Daranas	Cuba	CIM-UH
Dr. Larry	McKinney	USA	HRI
Dr. Richard	McLaughlin	USA	HRI
Dr. Paul	Montagna	USA	HRI
MS, Julio	Morell	USA	CARICOOS
Dr. Frank	Muller-Karger	USA	USF
Dr. Alain	Muñoz Caravaca	Cuba	CIEC
Dr. Steven	Murawski	USA	USF
Dr. Alejandra	Navarrete	Mexico	UNIDO-GoM-LME
MBA, Donald	Perkins	USA	HCF
Dr. Rafael	Puga	Cuba	CIP
MS, Cynthia	Pyc	USA	JASCO
Dr. Victoria	Ramenzoni	USA	HRI
Dr. Mark	Spalding	USA	The Ocean Foundation
Dr. Greg	Stunz	USA	HRI
MS, Gail	Sutton	USA	HRI (Organizer)
Dr. Carlos	Torres Navarrete	Mexico	CENDO @ UABC
Dr. Marco	Ulloa	Mexico	CICATA
Dr. Jonathan	Vallarta Hernández	Mexico	JASCO
Dr. David	Yoskowitz	USA	HRI

**Acronyms:**

CARICOOS – Caribbean Coastal Ocean Observing System

CEAC – Centro de Estudios Ambientales de Cienfuegos

CENDO @ UABC – Centro Nacional de Datos Oceanográficos @ Universidad Autónoma de Baja California

CICATA – Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada

CICESE – Centro de Investigación Científica y de Educación Superior de Ensenada

CIEC – Centro de Investigaciones de Ecosistemas Costeros

CiiMar-GoMC – Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe

CIM-UH – Centro de Investigaciones Marinas, Universidad de La Habana

CIP – Centro de Investigaciones Pesqueras, La Habana, Cuba

CITMA – Ministerio de Ciencia, Tecnología y Medio Ambiente

CNAP – Centro Nacional de Áreas Protegidas

GCOOS – Gulf of Mexico Coastal Ocean Observing System

HCF – Harte Charitable Foundation

HRI – Harte Research Institute for Gulf of Mexico Studies

JASCO – JASCO Applied Sciences

NOAA – National Oceanic and Atmospheric Administration

PNG – Parque Nacional Guanahacabibes

SOST-USM – School of Ocean Science & Technology, University of Southern Mississippi

TAMU – Texas A&M University

UNAM – Universidad Nacional Autónoma de México

UNIDO-GoM-LME – United Nations Industrial Development Organization-Gulf of Mexico Large Marine Ecosystem

USF – University of South Florida