



Workshop on Telepresence-Enabled Exploration of the Caribbean Region

Workshop Summary

15-18 November 2012

Miami, Florida

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More information on the Workshop on Telepresence-enabled Exploration of the Caribbean Sea can be found at <http://www.oceanexplorationtrust.org>.

Database of White Papers, Transects, and High Priority Target Areas can be accessed here: <https://www.google.com/fusiontables/DataSource?docid=1EErrCPh32Tziq-idNEQ16ZqtkKDkkP3e2FRTcPl>

1 Overview

In November 2012, the Ocean Exploration Trust, in partnership with the NOAA Office of Ocean Exploration and Research (OER), hosted a workshop in Miami, Florida, with members of the scientific community to identify and discuss potential targets for telepresence-enabled exploration in the Caribbean Region, including the southeastern Gulf of Mexico. This document summarizes the background, workshop objectives, key discussions, recommended targets, and other important topics identified by the participants.

2 Background

On June 12, 2000, President Clinton announced the commencement of a new era of ocean exploration. In an Executive Directive to the Secretary of Commerce, the President announced steps to develop a long-term strategy for such exploration. This action led to the creation of the Ocean Exploration Panel, which consisted of America's leading experts in ocean exploration. Their final report, entitled "Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration", recommended that any new ocean exploration program have a dedicated ship of exploration mounting "Voyages of Discovery", with signature missions forming the centerpiece for such a program.

Following this report, NOAA formed the Office of Ocean Exploration. On September 12, 2000, the House passed HR 2090, the Exploration of the Seas Act sponsored by Representative Jim Greenwood (R-PA) that directed the Secretary of Commerce to contract the National Academy of Sciences to establish a Coordinated Oceanography Program Advisory Panel to report to Congress on an international oceans exploration strategy. In 2003, the "Exploration of the Seas: Voyage into the Unknown" report was issued by this Panel, that also recommended that the ocean exploration program have as its centerpiece a dedicated flagship.

As a result of the Oceans Act of 2000, President Bush created the U.S. Commission on Ocean Policy. That Commission, among other issues, reviewed America's ongoing program in ocean exploration, as well as the findings on the President's Panel on Ocean Exploration and the National Academy of Sciences report. Based upon its three years of deliberations, which involved hundreds of expert witnesses, on July 22, 2004, the Commission issued its final report "An Ocean Blueprint for the 21st Century," included in which was the following recommendation:

The National Oceanic and Atmospheric Administration and the National Science Foundation should lead an expanded national ocean exploration program with additional involvement from the U.S. Geological Survey and the U.S. Navy's Office of Naval Research. Public outreach and education should be integral components of the program.

In June 2009, President Obama established the Interagency Ocean Policy Task Force, composed of 24 senior-level officials from executive departments, agencies, and offices across the Federal government and led by the Chair of the Council on Environmental Quality. The President charged the Task Force with developing recommendations to enhance the nation's ability to maintain healthy, resilient, and sustainable ocean, coasts, and Great Lakes resources for the benefit of present and future generations. "The Final Recommendations Of The Interagency Ocean Policy Task Force" was issued in July 2010, and among other recommendations adopted the policy to "Increase scientific understanding of ocean, coastal, and Great Lakes ecosystems as part of the global interconnected systems of air, land, ice, and water, including their relationships to humans and their activities." In addition, in its implementation strategy the Task Force stated as a national priority interest "...ocean, coastal, and Great lakes observations, mapping, and infrastructure: Strengthen and integrate Federal and non-Federal ocean observing systems, sensors, data collection platforms, data management, and mapping capabilities into a national system and integrate that system into international observation efforts."

In 2008, *Okeanos Explorer* became the first NOAA Ship dedicated to ocean exploration. The privately owned and operated Exploration Vessel (E/V) *Nautilus* became the second national platform dedicated to ocean exploration. In 2007, with funding from the Richard Lounsbery Foundation and with guidance of the Ocean Exploration Advisory Working Group, two workshops were held, one at the Monterey Bay Aquarium and Research Institute focusing on the technological requirements for ocean exploration on the *Okeanos Explorer*, and the other at the National Geographic Society Headquarters in Washington, D.C. that invited the ocean science research community to help determine the priority areas for exploration in the Pacific Ocean. The results of these workshops defined instrumentation and methodologies that began to be implemented during *Okeanos Explorer's* initial season of deployment in 2010, as well as during the *Nautilus* 2009 and 2010 field programs. Both ships have suites of deep submergence vehicles to collect data for mapping, sampling, and imaging the oceans. Both ships also employ the latest in advanced telecommunications technology to access experts within the ocean community the moment they are needed, when a discovery is made.

On May 9-10, 2011, NOAA OER held a workshop at the University of Rhode Island's Graduate School of Oceanography. This workshop focused on the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Fifty scientists, archaeologists, and agency representatives reviewed a series of white papers that had been solicited to define the biggest priorities for exploration in those regions, with 12 papers submitted for work in the Gulf of Mexico and 11 in the Caribbean Sea. Some of the papers extended or built upon existing primarily biological research, and some of the papers laid out a more general program to survey unexplored terrain.

In order to develop more fully the opportunities for exploration in this region, and again with funding from the Lounsbery Foundation, OET proposed to develop collaborative ties with countries that border on highlighted areas by hosting a follow-up workshop in to which OET invited members of the research community and other stakeholders from these countries, based on white papers submitted to an open call to the community. Sixty five white papers were submitted, and based on a

number of factors, including quality, feasibility, relevance, multidisciplinary nature, and educational potential, thirty seven scientists were invited to participate in this workshop, the Workshop on Telepresence-Enabled Exploration of the Caribbean Region. Including OET and NOAA/OER staff, a total of fifty people participated in the workshop, which is the fourth in a series to identify unknown and underexplored regions of the world's ocean that merit exploration.

3 Purpose

This workshop and resulting report will support the continuing mandate to strengthen the nation's understanding of the Caribbean Region, including the southeastern Gulf of Mexico, through the use of mapping and exploratory technologies. This workshop report will also provide valuable input to NOAA OER as it prepares for field programs on the *Okeanos Explorer*, which will be operating in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea for the foreseeable future. In 2013, the *Nautilus* will be transiting from the Mediterranean across the mid-Atlantic and will conduct 2-3 years of field expeditions before transiting through the Panama Canal and continuing to explore the Pacific Ocean. This workshop report will be used by the *Nautilus* team to develop field programs during the period that the ship is operating in the Caribbean Region. Having two ships of exploration in the region will be a key to successful implementation of this report, but we also anticipate that other research platforms, perhaps from regional countries, can be enlisted to undertake exploration programs based on this report.

In addition to identifying key priority areas for exploration, OET and OER are further developing the "Doctors on Call" model of engaging a broad range of scientific expertise through live satellite-based interaction with the ships of exploration. Working with partners identified during the workshop, we also plan to include education and outreach programs in the evolving plan for this region. Telepresence capability will enable us to work with partner countries to foster real-time interaction by their research communities and stakeholders, and open opportunities for engaging the next generation of regional scientists. Because of the possibility for live access to field programs, we expect that participating regional scientific communities will generate broader public support for and interest in exploration of the Caribbean Region and ocean exploration in general.

4 Summary of Plenary Discussions

On the first day, the morning session was dedicated to presenting the concept and operating principles of telepresence-enabled exploration to workshop participants. Robert Ballard, OET President, Tim Arcano, NOAA/OER Director, and John McDonough, NOAA/OER Deputy Director, presented an overview of the history of the development of systematic and telepresence-enabled exploration. Dwight Coleman, Director of the URI Inner Space Center, presented the technical capabilities and possibilities available through supporting exploration cruises from shore, both from scientific and educational perspectives.

Craig Russell, *Okeanos Explorer* Program Manager, detailed the technical capabilities of *Okeanos Explorer*. Jamie Austin, member of the NOAA Ocean Exploration Advisory Working Group and

Nautilus Advisory Board, and Catalina Martinez, NOAA/OER Rhode Island Regional Program Manager, illustrated examples of telepresence-enabled expeditions during which dedicated teams of scientists and students, called “Doctors on Duty,” stood watches ashore.

Katy Croff Bell, *Nautilus* Chief Scientist, presented the technical capabilities of E/V *Nautilus*. Examples of expeditions supported by “Doctors on Call”, on-shore experts who are called upon when discoveries are made within their expertise, were presented by Larry Mayer, co-chair of the NOAA Ocean Exploration Advisory Working Group and member of the *Nautilus* Advisory Board.

Finally, Lorna Inniss, Co-Chair of the World Ocean Assessment Group of Experts, presented the initial results of the first assessment on the Wider Caribbean Region, and how exploration programs can interface with upcoming assessments, which will be conducted worldwide.

The overall purpose of this initial set of presentations was to ensure that all participants were informed of the missions and capabilities of the *Nautilus* and *Okeanos* exploration programs, so that discussions over the following two days could focus on how best to implement the paradigm and utilize the vessels to the maximum advantage for all participants.

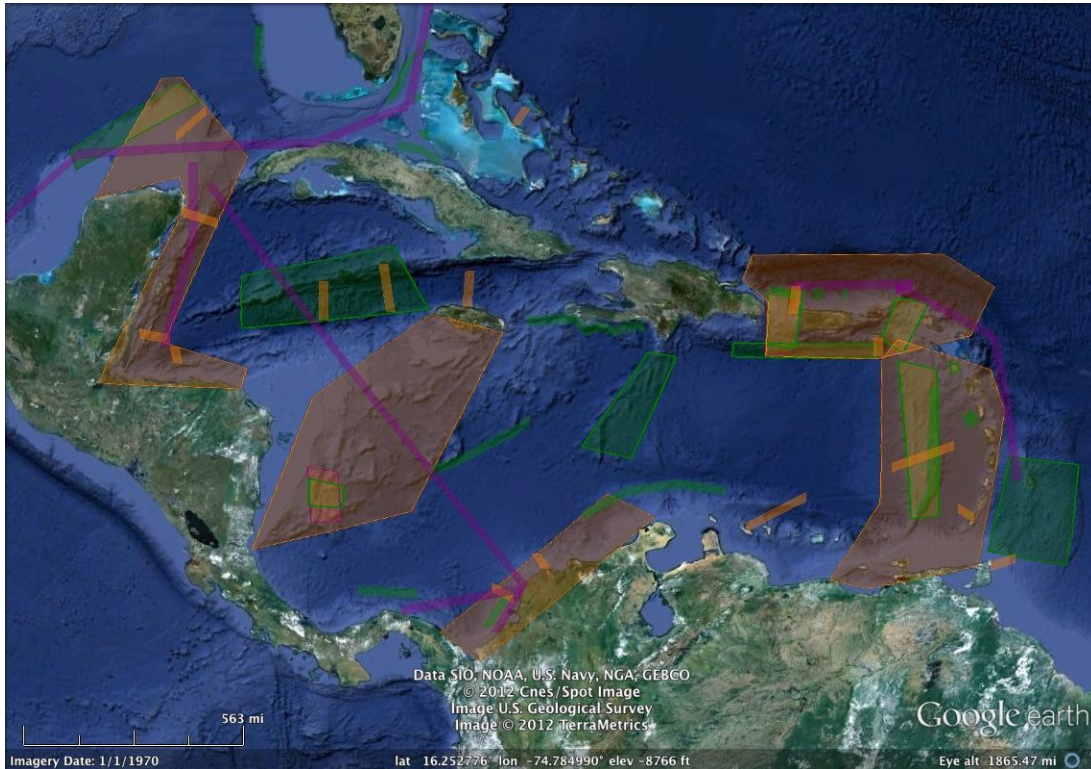
5 Summary of Breakout Discussions

There were two rounds of breakout discussions. The first consisted of three breakout groups divided by discipline - biology, geology, and archaeology. The major goal of the discipline-based breakout discussions was to identify major Caribbean-wide questions that span multiple regions, for example biogeography of deep reefs, regional tectonics, trade routes, etc., which can be answered through telepresence-enabled exploration. A secondary goal was to identify areas/transects that can be conducted to answer the key questions. The groups identified a number of key questions within the realms of biological, geological/physical, and archaeological oceanography that span the Caribbean region, as well as 42 areas/transects that can be explored to address those key questions.

These areas/transects were overlain on a map of the Caribbean, and six overlapping priority areas were identified, two in the northwest, two in the mid-Caribbean, and two in the southeast. On the second day, participants were broken up according to geography - northwest, mid, and southeast Caribbean - to further narrow down exploration target areas in each of the six priority areas. The groups were asked to identify up to 6-10 high priority target areas in each of their regions that address the key questions identified in the first breakout sessions, have high potential for discovery, apply available technologies appropriately, are multidisciplinary in nature, have high potential for education and outreach activities, and are politically feasible (with respect to permitting).

The final result is a list of twenty high priority target areas that will be considered when identifying areas of exploration in the Caribbean Region.

6 Summary of Discipline-based Breakout Discussions



Composite map of the Caribbean region, including the southeastern Gulf of Mexico, showing the areas of interest identified by the Biology (orange), Geology (green), and Archaeology (purple) breakout groups.

6.1 Biology

6.1.1 Overview

This group set out to develop a list of key questions in biology that represents issues relevant to many (if not most) ecosystems. This was accomplished by asking participants to present the questions they thought were most critical. These questions naturally fell into four themes:

BQ-01: What is the nature (community composition, size, age) and extent (distribution over space and time) of deep-sea soft-bottom, hard-bottom, coral, seep and vent communities (DSRI 2012)?

BQ-02: What is the relationship between chemical, physical, and biological processes in the shallow and deep ocean?

BQ-03: To what degree are these communities connected, and how is this “connectivity” influenced by oceanographic processes (and when appropriate, anthropogenic activities)?

BQ-04: What are the kinds of data that we need to develop a better capacity to predict the location and apparent health of deep sea ecosystems, including their response to anthropogenic activities such as increasing atmospheric CO₂?

The participants also noted that there remains a paucity of fundamental data, e.g. bathymetric and geochemical data, in many regions of the Caribbean region and southeastern Gulf of Mexico. They also noted that, in general, there is substantially more known about the central and northern Gulf of Mexico, largely due to the continued research activities of US-based scientists in academia, government, and industry. This led workshop participants to explicitly focus on the southeastern Gulf region and the Caribbean region, in particular on how the Gulf of Mexico “interacts” with the Caribbean, and how that ultimately influences the ecology and evolution of both midwater and benthic communities. There was a great interest in generating additional physical and geochemical information that will enable the broader community to start developing predictive models on where benthic communities (e.g. coral and seep communities) might be located.

The questions deemed most relevant by the participants included:

- 1 What is the role of hard substrate in facilitating the settlement of corals (scleractinian, octocorals and black corals) and their associated communities?
- 2 What governs the distribution of benthic communities, e.g. coral and seep communities below 70 meters, in both the Caribbean region and southeastern Gulf of Mexico? NOTE: “Coral communities” refers to the assemblage of corals and associated fauna including sponges and other invertebrates, fish and sharks, and protists and microbes.
- 3 What is the biodiversity and biogeography of deep coral communities in both the Caribbean region and southeastern Gulf of Mexico?
- 4 To what degree do epipelagic processes, e.g. varying terrestrial flux, influence deep sea benthic ecosystem processes and their apparent health?
- 5 To what degree do these epipelagic processes influence mesopelagic and benthopelagic ecology, e.g. population dynamics of elasmobranchs and bony fishes?
- 6 What is the distribution of biological “hot spots” and “cool” spots, and how do these relate to the physical and chemical conditions in the surrounding ocean?
- 7 What is the vertical distribution of indicator species, e.g. lionfish, and how robust a proxy are these for changes in the physical and environmental conditions?
- 8 How do the myriad of different oceanographic conditions in the region, e.g. deepwater circulation, influence deep sea ecology?
- 9 How can we better use maps and mapping to address biological questions?
- 10 What is the connectivity between deepwater benthic habitats in the Caribbean region and southeastern Gulf of Mexico? Is this connectivity similar or different in the midwater communities?
- 11 How do we best conduct exploration in a manner that furthers our knowledge of the deep sea, while also being highly relevant to conservation and resource management in the EEZs of developing nations?
- 12 Question/statement: We need to measure more fundamental biogeochemical characteristics (pH/alkalinity/redox, pO₂, pCO₂, bioluminescence, available nitrogen,

pollutants such as DDT and crude oil) in some or all of these deep sea habitats to understand better if and how they are changing over time.

- 13 Question/statement: We need to develop better approaches to assessing the “apparent health” of deepwater ecosystems, and do so in a manner that is inclusive of their structure and function, as well as microscopic organisms.

6.1.2 Addenda

This breakout group also wanted to raise a number of issues for consideration. These have been distilled into the following addenda:

- 1 There is substantial need for better biological sampling tools and protocols. *Nautilus* appears to be well-equipped with tools, but currently does not have a “standardized” protocol for biological sampling, storage, and archiving. It will be important to define this need for *Okeanos Explorer* as well.
- 2 We also suggest that other tools be considered for use between ROV dives, especially when operating in well-mapped areas. These might include but are not limited to: midwater nets, AUVs, benthic free vehicles (i.e. elevators) equipped with ADCP or ADCM, baited camera platforms, etc.
- 3 The central Caribbean region is in many ways highly appropriate for exploration, in particular areas such as the Colombia Trench and Beata Ridge. Some information is available on the biodiversity of these and other sites that may be relevant when picking areas in which to do transects: <http://www.siam.invemar.org.co/siam/index.jsp>, Miloslavich et al., 2010.

6.1.3 Proposed Areas of Interest

This group was asked to identify a number of areas of interest and/or transects in the Gulf of Mexico/Caribbean region that would be most informative to furthering our understanding of physical, chemical, and biological processes in this region.

In the biology breakout session, we began this discussion by developing a series of assertions and making some assumptions. Our first assertion is that the data resulting from these transects would be more valuable if the transects encompassed shallow-water areas that were reasonably well-characterized. This would provide some “frame of reference” when studying processes in the deeper waters, and when comparing the results of transects to one another. For example, conducting transects from deep water up to a shallow bay where there is ample river runoff, as well as from deep water up to areas with far less runoff, affords an opportunity to place constraints on the degree to which epipelagic and terrestrial processes influence deeper waters. Our next assertion was that these transects should include some “sticks”, meaning the exploration of areas previously uncharacterized. In addition, there is value in conducting these transects in areas where previous characterizations have occurred (note that, in most cases, previous studies occurred over twenty years ago).

We assumed that concerns about the distance between the proposed transects and other, longer-term study sites were beyond our purview. We also made reasonable assumptions about the ROVs,

including 4,000 m depth rating and the continued availability of the current suite of biological sampling systems.

Also, to illustrate the linkages between these transects and our “recommended areas of study,” we have provided the number corresponding to each area of study in parentheses.



Proposed areas of biological interest in the Caribbean region.

BT-01: Florida Straits

Data on deep coral communities as well as many *Alvin* dives in this area make this a good choice for a transect, which can provide a nice frame of reference for more detailed investigations.

BT-02: Bahamas: Lee Stocking Island

BT-03: Yucatan Channel, south of Cancun

Addresses connectivity of communities (BQ-03).

- 1 Abundant previous data from shallow depths
- 2 Samples collected from a Mexico-U.S. collaboration in 1991 from shallow to deep transects along the escarpment, including shark & fish observations, other transects from personal submarine observations from Johnson SeaLink surveys for comparison (E. Escobar).
- 3 Region of connectivity between Gulf of Mexico and Caribbean
- 4 Historical (Pillsbury) surveys indicate exceptional richness of deep-sea corals; recent German cruise collected deep sea corals.
- 5 Deep freshwater infiltration and its effect on deep-water communities.

BT-04: Four transects off Belize: Glover's, Turneffe, Lighthouse, Carrie Bow Cay

Addresses connectivity of communities (BQ-03).

- 1 These deep reef sites and offshore ocean environments along the three atolls are unknown.
- 2 The three atolls sit on a geological limestone platform that may have interesting biological communities associated with them.
- 3 Smithsonian station at Carrie Bow Cay
- 4 Two MPAs that encompass deep-water but have never been mapped or explored deeper than 30 meters.
- 5 Part of Mesoamerican Reef system
- 6 Johnson SeaLink surveys from 1990s years ago for comparison.

BT-05: Bay Islands, Honduras (inc. Roatan, Utila, Guanaja)

Addresses connectivity of communities (BQ-03).

- 1 Extensive hardbottom habitat down to 3000 m
- 2 Extensive colonial trade activity off the Mosquito Coast suggests good probability of shipwrecks.
- 3 Multibeam data will be collected in July 2013 by the Schmidt Ocean Institute
- 4 Reported abundance of large, presumably very old deep-sea corals including *Lophelia pertusa* and *Paramuricea* sp.
- 5 Local upwelling conditions support high-productivity
- 6 Part of a continuous Mesoamerican Reef system with high potential for connectivity to Gulf of Mexico
- 7 Johnson SeaLink surveys from 20 years ago for comparison

BT-06: Cayman Trench

Little Cayman Island: a 1999 and 2010 large-scale shallow reef comparison has been assembled, and other long-term data are available. There have been 23 DSV *Alvin* dives in the Cayman Islands, mainly in Cayman Trough and two off Grand Cayman in 1976. See:

<http://www.marine.who.edu/divelog.nsf/e2e558427a2dd4cc8525649e005ea63e?OpenView>

BT-07: Two transects off Jamaica: north coast, Discovery Bay

Discovery Bay Marine Lab (DBML) operated a submarine for several years in the 1980s. Several papers were published based on its exploration. DBML is one of the oldest marine labs in the Caribbean and has a database of over 600 scientific papers published based on work in the area. The dropoff is <1 km from shore and is unmapped.

BT-08: Puerto Rico/ US Virgin Islands

Addresses location and apparent health of deep sea ecosystems (BQ-04). Waters off Isla Desecheo, as well as the Puerto Rico Trench.

- 1 Northeastern part of Mona Passage, which is a unique feature connecting water bodies that may be an ideal locale for biogeography studies
- 2 Off Desecheo Island, Puerto Rico Trench is at least 800 m deep

- 3 The Puerto Rico Trench is among the deepest places in the ocean, over 9 km deep and 800 km in length
- 4 High potential relevance for biodiversity, etc.

BT-09: South coast of St. Croix

Addresses location and apparent health of deep sea ecosystems (BQ-04). The insular shelf is small and a nice vertical drop-off is within 5 km of shore. The US Virgin Islands has two marine protected areas along the coast. - East End Marine Park and Mutton Snapper Marine Conservation Area. Information is needed about the vertical distribution of lionfish, the presence/timing of fish spawning aggregation and the abundance and distribution of stalked crinoids. The insular shelf has recently been mapped by NOAA, but there are no maps in waters >50 m. The West Indies Marine Lab was an important focal point for marine researchers until its closure in 1995. There are many scientific papers published based on work around St Croix.

BT-10: Sinu Belt, Rosario Island, and San Bernardo Island

Addresses relationship between chemical, physical, and biological processes (BQ-01, BQ-02).

- 1 Caricomp and several other research programs around Sinu Belt, Rosario Island, and San Bernardo Island
- 2 MPA for shallow waters and a “projected” deepsea MPA
- 3 Volcanic activity (Mud diapirism)
- 4 Methane cold seeps and associated communities
- 5 Run-off flux from two major rivers (Magdalena and Sinu)
- 6 Reef-building corals and associated communities
- 7 Multiple Spanish galleon shipwrecks reported
- 8 Programs with local communities for outreach
- 9 Potential to set up several ECCs in three Colombian cities

BT-11: Curacao, Dutch Antilles

Addresses location and apparent health of deep sea ecosystems (BQ-04).

- 1 Multibeam data available from Dutch hydrographic surveys
- 2 High feasibility of successful international relations
- 3 Local submersible capable of follow-on work to 300m
- 4 Close proximity to well-studied shallow reef systems
- 5 Interested in further understanding their biodiversity

BT-12: Cariaco Trench, Aves Ridge

Addresses nature and extent of benthic communities (BQ-01).

- 1 Two ~1000 m in depth trenches with anoxic conditions below 250 m due to limited circulation and areas of high primary productivity
- 2 Within the highest primary productivity area in the Caribbean due to upwelling system and Orinoco River influence
- 3 Long term database of oceanographic conditions: <http://www.imars.usf.edu/CAR/> (joint between US and Venezuelan institutions)

- 4 The Aves Ridge is almost totally unexplored. Long submarine mountain extending for hundreds of kilometers, only emerged sector is Isla de Aves in the north
- 5 Particular geological, physical, and chemical features that may provide key information to understand distribution of marine fauna and the origin of the Caribbean Plate
- 6 Potential high marine biodiversity and stepping zone connecting Atlantic with Lesser Antilles arc and Caribbean fauna

BT-13: Kick'em Jenny

Addresses nature and extent of benthic communities (BQ-01). Candidate for hydrothermal vents.

BT-14: Trinidad: La Brea seeps

Addresses nature and extent of benthic communities (BQ-01).

6.2 Geology

6.2.1 Overview

The geology breakout group gathered to examine the key, over-arching geological and physical oceanographic questions in the Caribbean region that could be addressed by ocean exploration. Once the group identified these questions we then asked where the most appropriate places were to address these questions. Our initial identification of key questions was without regard to the technical capabilities or limitations of the exploration tools but once locations were identified, we used the capability of the systems to limit our recommendations to achievable objectives.

The Caribbean region is a remarkably complex geologic and physical oceanographic environment with numerous current and past plate boundaries juxtaposed in a small but highly productive geographic area. This intensity of tectonic activity results in a highly productive area, resulting in a combination of faulting and the growth of carbonate platforms that have produced some of the steepest escarpments known in the world's oceans. Associated with these escarpments is slope failure and the great potential for tsunamigenic events in a highly populated region. Additionally, the presence of active volcanism (both subaerial and subsurface) adds to the potential of exotic vent communities, as well as the potential for geohazards associated with volcanism. From a physical oceanographic perspective, the Caribbean is a region of very constrained (but poorly understood) inflow of Atlantic waters through mostly shallow passages (there is only one known deep passage into the Caribbean) and the region of confluence of North Atlantic Deep Water and Antarctic Bottom Water. The combination of these features all in a relatively small geographic area make the Caribbean region, ideal for an ocean exploration program.

The key geological/physical oceanographic questions for the Caribbean identified by the breakout group were:

GQ-01: What are the routes and volume of Atlantic inflow into the Caribbean, and how do they influence biodiversity? (Badan & Candela)

GQ-02: What is the relationship between Antarctic Bottom Water and North Atlantic Deep Water in the Puerto Rico Trench?

GQ-03: What is the origin and nature of the formation and erosion of steep escarpments in the Caribbean?

GQ-04: What is the nature of slope failure of carbonates and volcanoclastics in the Caribbean, and what is the relationship of these failures to tsunamigenesis?

GQ-05: What is the nature of faulting in the Caribbean, including offshore expression of onshore faults, activity, and relationship to degassing?

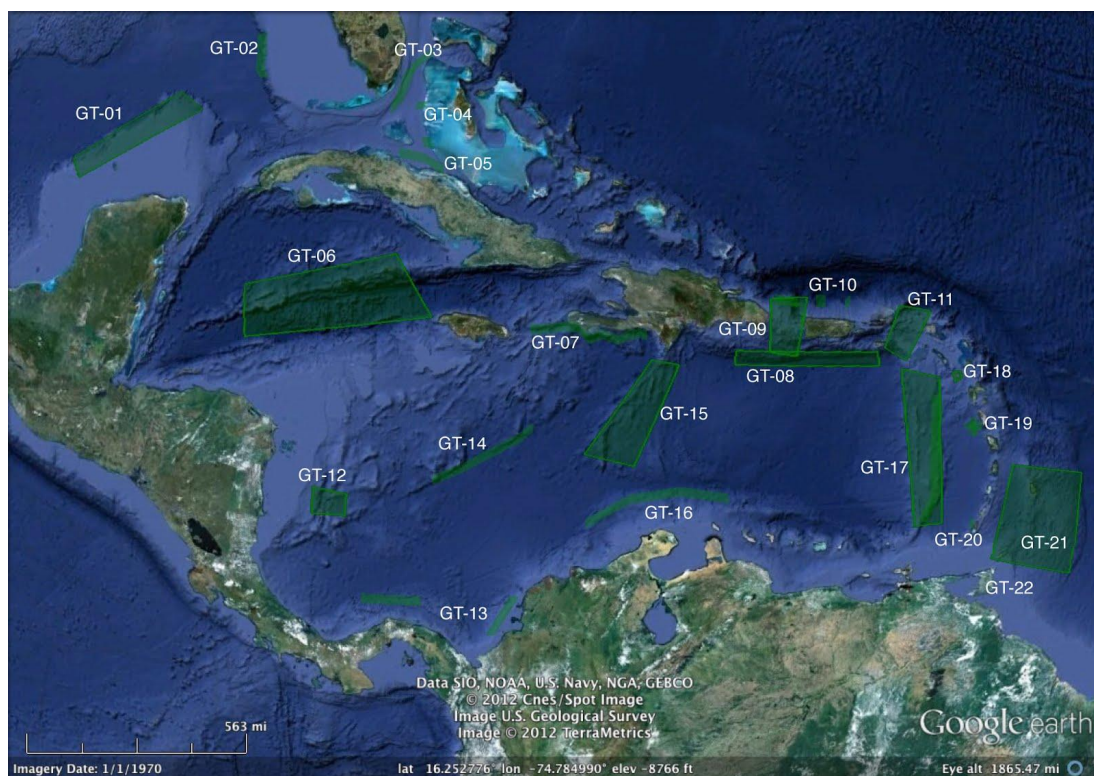
GQ-06: What is the nature of active volcanism and venting in the Caribbean, including their relationship to natural hazards, benthic communities?

GQ-07: What is the distribution of mud volcanoes, cold seeps, and vent communities in the Caribbean?

GQ-08: What is the nature of deformation in the Caribbean?

GQ-09: Where are the least studied, least known areas of the Caribbean that are prime targets for exploration?

6.2.2 Proposed Areas of Interest



Proposed areas of geological and physical oceanographic interest in the Caribbean region.

GT-01: Campeche Escarpment

Addresses question about steep escarpment (GQ-03). There is German data, multibeam 302 and 102 and shallow seismic data. There may be additional private data, but not public. Prime suspect for tsunami hazard. It's in part a salt dome. Permitting may be difficult. there is natural oil and gas seepage. Previous PEMEX exploration site with seismic. UNAM swath bathymetry data, CTDs and benthic samples collected during SIGSBEE cruises, trawls and other samples collected by UNAM and physical oceanography characterization by CICESE, currently Mexican ANDERA buoy monitoring [POC: E. Escobar]. German cruise studied deep sea corals.

GT-02: Florida Escarpment

Addresses question about steep escarpment (GQ-03). ECS mapping here. NOAA/OER and Schmidt Ocean Institute have extensive new high resolution multibeam and backscatter data at high (to 10 m) resolution in waters down to 3,000 m. Germans also have data here.

GT-03: Straits of Florida

Potential for significant impact of flow on biology. Approximately 80% of the Florida current flows through upper 300 m at about 5 kts. There is a high concentration of deep water corals. Area was mapped for the first time in 2005 (G. Eberli). Straits are ~800 m deep.

GT-04: Western Great Bahama Bank

Has multiple slope failures (GQ-04). Multibeam bathymetry data have been collected here, but no ROV dives.

GT-05: Cuban thrust belt

Addresses nature of faulting (GQ-05). Data are restricted – seismic, chemistry of seds, multibeam. Active? Degassing? Permitting likely difficult because area is within Cuban waters.

GT-06: Mid-Cayman Rise

Addresses nature of active volcanism and hydrothermal venting (GQ-06). Multibeam survey and ROV dives have been done on the Mid-Cayman Rise. Areas of interest within 3,500 m to 5,500 m.

GT-07: Enriquillo Fault

Addresses nature of faulting (GQ-05).

GT-08: Muertos Trough

GT-09: Mona Passage & Mona Ridge

Addresses multiple questions, including steep escarpments (GQ-03), nature of faulting (GQ-05), and slope failures (GQ-04). In 1918, a cable broke in Mona Passage during an earthquake and tsunami, which resulted in many deaths in Puerto Rico. A tsunami model shows that the 1918 tsunami could have been caused by a landslide, rather than an earthquake. Multibeam data exist; streaks and sediment waves can be seen. Shallowest multibeam ~150 m deep, but almost arched and cut by

faults. Archaeological interest here, as we. Should be evidence of inflow from Atlantic. How much is tidal and how much is true motion? Fundamental question not well understood.

Mona Canyon is N/S and very deep. Then there is a fault running E/W. 4500 m depth at Mona. 2K-3K is Septentrional Fault system. Very near each other but not connected. Multibeam and seismic data from USGS. From Mona Canyon, there are navy dives/photos from 1970s.

GT-10: Arecibo & Loiza Amphitheaters (Puerto Rico Trench)

Addresses question about slope failures (GQ-04). Dan Fornari (WHOI) looking for freshwater seeps here. USGS has multibeam and seismic data. Edge of carbonate platform has evidence of extensive landslides.

GT-11: Anegada Passage

Addresses multiple questions, including steep escarpment (GQ-03), and faulting (GQ-05). Not carbonate escarpment. Have multibeam and seismic data to ~1900 m, but shallowest areas not covered. Strong currents.

GT-12: Alicia Passage

Addresses unknown area (GQ-09). Colombian waters. Could be very interesting biologically.

GT-13: Sinu Belt

Addresses unknown area (GQ-09), and distribution of mud volcanoes, cold seeps, and chemosynthetic communities (GQ-07). Colombian waters. Could be very interesting biologically.

GT-14: Hess Rise

Addresses unknown area (GQ-09). 3,500 m water depth.

GT-15: Beata Ridge

Addresses unknown area (GQ-09). Northern part explored by French and Spanish, but further south, and especially going near seafloor, not sure there has been much done. Some dredging maybe. 1500 m shoal. Seabeam data available: http://earthref.org/cgi-bin/sc-s2-list.cgi?database_name=sc&search_start=main&selected_smnt_id=1761

GT-16: Northern South America fold belt

Addresses distribution of mud volcanoes (GQ-07), and nature of deformation (GQ-08). Good to learn about tectonic activity here. Venting. See white papers on bio here.

GT-17: Aves Ridge

Addresses unknown area (GQ-09). Origin, effect on through flow, sea level change, relic corals. Another stepping stone to Caribbean. Venezuelan waters. 500 m shoal. Have seismic data across it.

GT-18: Montserrat

Addresses nature of active volcanism and hydrothermal venting (GQ-06). British Geological Survey did multibeam survey. 100 m - 900 m.

GT-19: Dominica

Largest slope avalanche here (GQ-04). French have multibeam data. Have been tremendous seismic swarms the past few years and there is a lot of concern for hazard. Extends to ~300 meters.

GT-20: Kick'em Jenny

Addresses nature of active volcanism and hydrothermal venting (GQ-06). Transect from Grenada Basin to encompass Kick'em Jenny debris avalanche – have seismic and multibeam. 200-3,000 m.

GT-21: South of Barbados

Addresses distribution of mud volcanoes (GQ-07). Accretionary prism, multibeam data available.

GT-22: Trinidad & Tobago

Addresses distribution of mud volcanoes (GQ-07). Multibeam and 3D seismic data collected by industry, held by U Texas/Austin (Bureau of Economic Geology).

6.3 Archaeology

6.3.1 Overview

The objective of this session was to identify areas of interest for archaeological-based exploration in the Caribbean region for *Nautilus* and *Okeanos Explorer* telepresence-enabled exploration. The group consisted of members of both ships operations and science teams and a few archaeologists who specialize in research in this area. This group took a somewhat different approach to this session than biology and geology and focused on the following points:

- The Caribbean region holds the potential to discover archaeological sites everywhere, as it has been a highly active area for maritime traffic since the Colonial period. Therefore, during exploration anywhere in the region, there is the probability that we will encounter shipwrecks. We therefore need to have a response to:
 - Handling politics and permits with the coastal states in whose waters we are operating;
 - Have a team of archaeologists either on board or ashore, prepared to organize and direct the documentation, characterization, and identification of sites; and,
 - Be prepared to tailor our outreach efforts to both students and the general public to understand and learn about the sites and their history as well as underwater archaeology methods and ethics.
- The group developed two objectives for the breakout session, to identify (a) areas of interest and of high potential for archaeological exploration and (b) what might be encountered in the Caribbean region during general exploration by *Nautilus* and *Okeanos Explorer* and how we should respond.

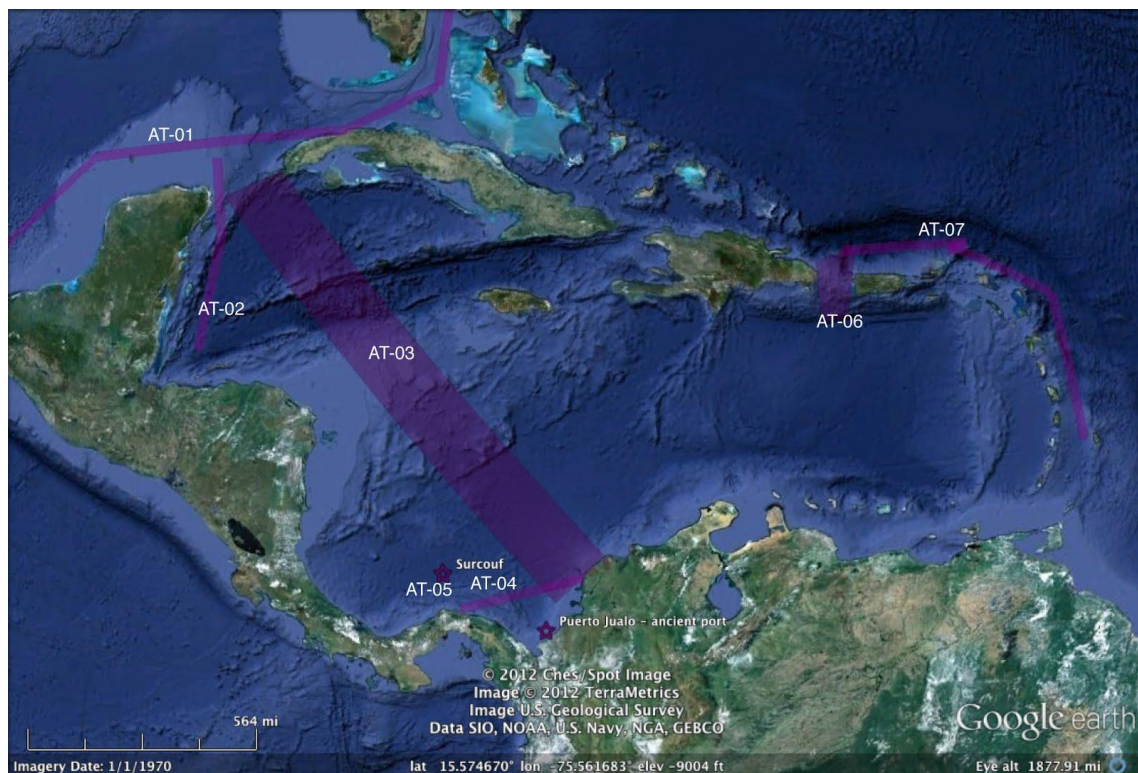
To address the larger issue of how we should prepare to respond as a community to archaeological sites we inevitably come across while exploring, we turned to the example of the copper-hulled

wreck located in the Gulf of Mexico explored by *Okeanos Explorer* in the spring of 2012. While this was a target effort on a known wreck site, the paradigm of having the science team ashore may be an effective way of accommodating an archaeological team “on call” for potential unexpected finds.

We also discussed the possibility of encountering a treasure ship or one laden with other potentially sensitive materials (e.g. valuables, gold, human remains, etc.) and should develop a standard operating procedure agreed upon by both exploration programs with archaeological advisors as a general policy to follow in such event, including protecting coordinates and working with coastal states to protect sites.

6.3.2 Proposed Areas of Interest

The group used the white papers that mentioned or proposed archaeology as a general reference, but broadened the discussion to include other areas that may be of interest, as well. We noted in particular that there were no proposals for the basin in open water east of the Nicaraguan coast along the known route from Colombia to Mexico/Cuba. We targeted this area as a high priority for reasons outlined below, but primarily because it fit the recommended transect identification goals for the geology and biology breakout discussions.



Proposed areas of archaeological interest in the Caribbean region.

AT-01: SE Gulf of Mexico to Strait of Florida

A swath was identified ranging from Veracruz in the the southwest Gulf of Mexico across the Campeche Escarpment to Havana and up into the Straits of Florida. This is a trade route that picks

up ships that would have come from Cartagena to Havana and out of the Caribbean via Florida. We are conscious of the high priority such areas are for biological and geological exploration. This area has been studied by INAH in Mexico, including deep waters with the MIR submersibles in a Mexican-Russian collaboration.

AT-02: Mesoamerican Reef

The primary emphasis here was placed on areas where little or no deep water exploration has ever been done. First among these was the Mesoamerican Reef along the eastern coast of the Yucatan Peninsula, spanning the coasts of Mexico, Belize, and Honduras. This area is of priority biologically because the deep parts of the barrier reefs are largely unexplored. It was also proposed for archaeological surveys due to the region's history of pirate havens among the islands and some naval battles between the British and Spanish over logging rights in Belize.

AT-03: Cartagena to Yucatan Channel

This priority area was a swath across the western Caribbean from Cartagena, Colombia, to the Yucatan Channel. This was a major trade route for Colonial period ships utilizing the clockwise currents and sailing toward Havana. As with the Mesoamerican region, we also took into consideration areas that could be important for other types of exploration, e.g. biological and geological. The fact that there was no white paper submitted on this area made it a higher priority because it is so unknown and unexplored. We also consider anywhere along this route of importance and with a high potential for finding shipwrecks.

AT-04: Panama to Cartagena

Part of the trade route in the southwest Caribbean is a leg from Panama, where ships from the Pacific would march their goods over the isthmus, to Cartagena, Colombia. We identified this as a section of the route that could potentially be multibeam mapped with 100% coverage, so separated it from the other, longer section of the trade route to the north.

AT-05: Shipwrecks in the SW Caribbean

Three isolated wreck targets were also identified in the southwestern Caribbean: the French submarine *Surcouf*, and two American ships, USS *Dorado*, and USS *Kearsarge*. These are general search areas for these ships; if exploratory work is done in this region, these are sites that could be located by either exploration program.

AT-06: Mona Passage

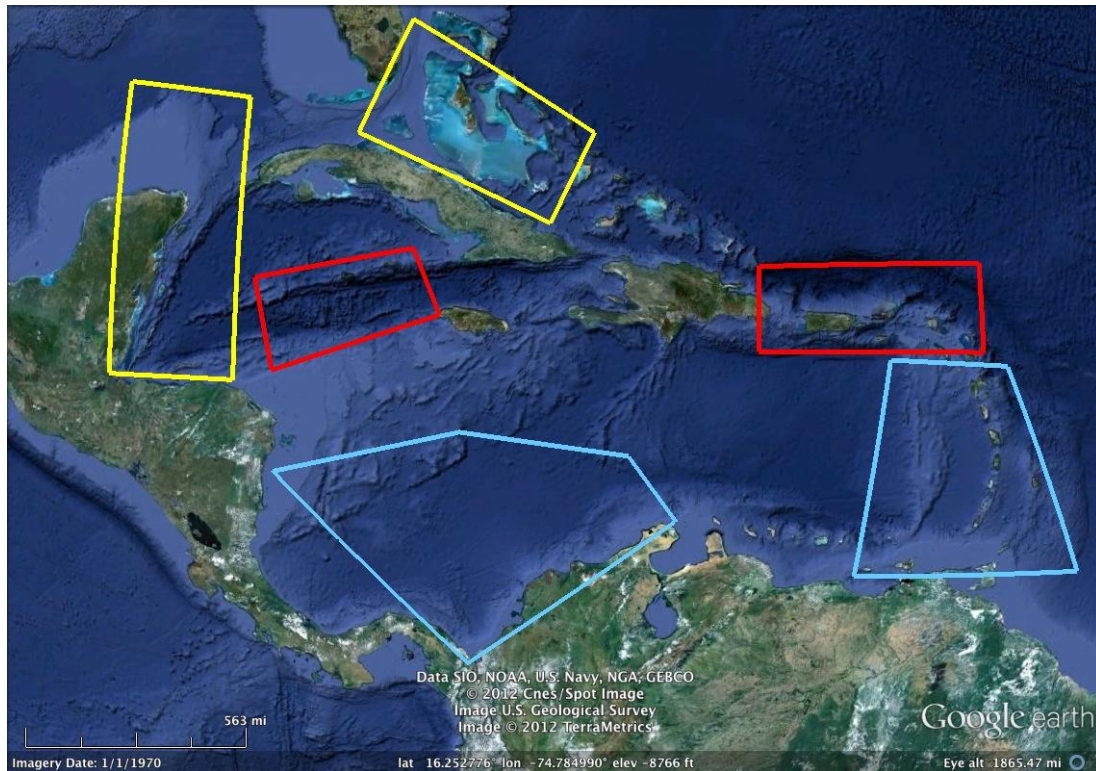
A priority area was identified in Mona Passage between Puerto Rico and the Dominican Republic. Not only were multiple white papers submitted for this region, but it is partially in U.S. territorial waters. In addition to a high potential for unexpected archaeological finds, two submitted white papers include a sunken WWII naval graveyard and Bobadilla's fleet that was sunk in a hurricane.

AT-07: Anegada Passage and Windward Islands

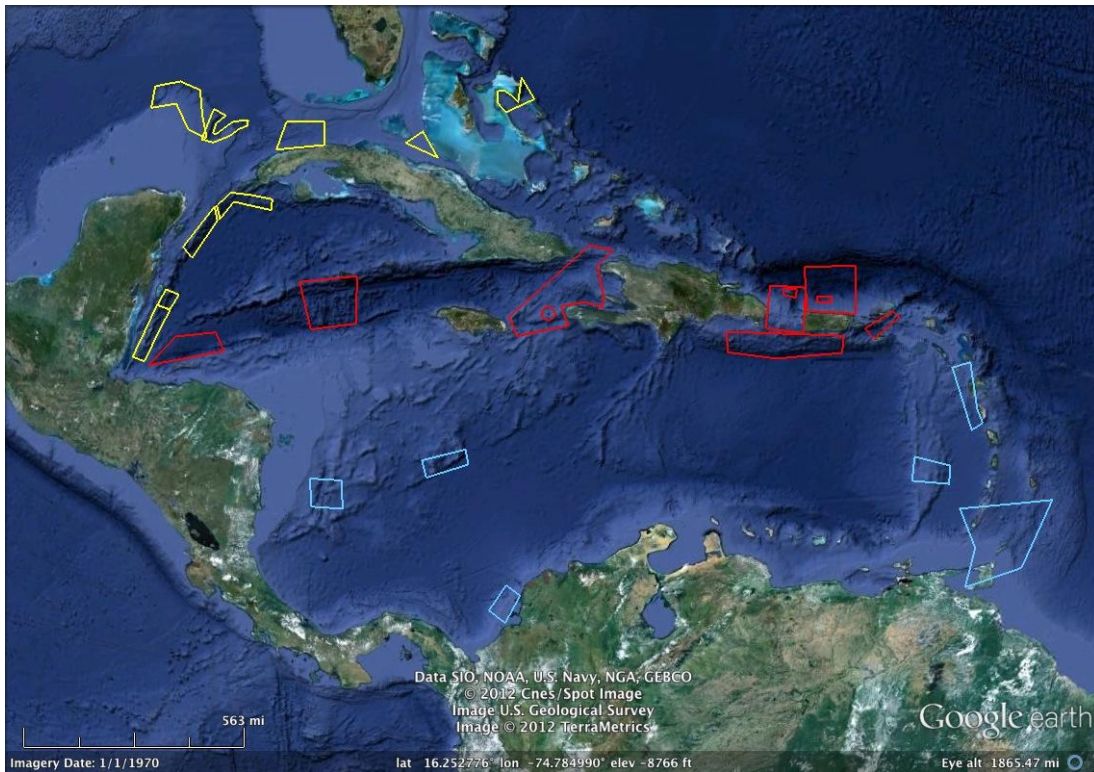
A region was identified in an arc east of Puerto Rico for potential slave trade shipwrecks or artifacts, as well as ships sunk during the initial passage through islands leading into the Caribbean.

7 Summary of Regional Breakout Discussions

Based on the results of the discipline-based breakout discussions, six areas were identified in which geological, biological, archaeological, and physical exploratory interests overlapped. These areas were divided between three groups (two areas each) for regional breakout discussions. Regional breakout groups were charged with identifying high-priority target areas within the priority areas that merit exploration on the basis of geological, biological, and archaeological priorities, as well as educational interest, technical feasibility, and likelihood of permitting.



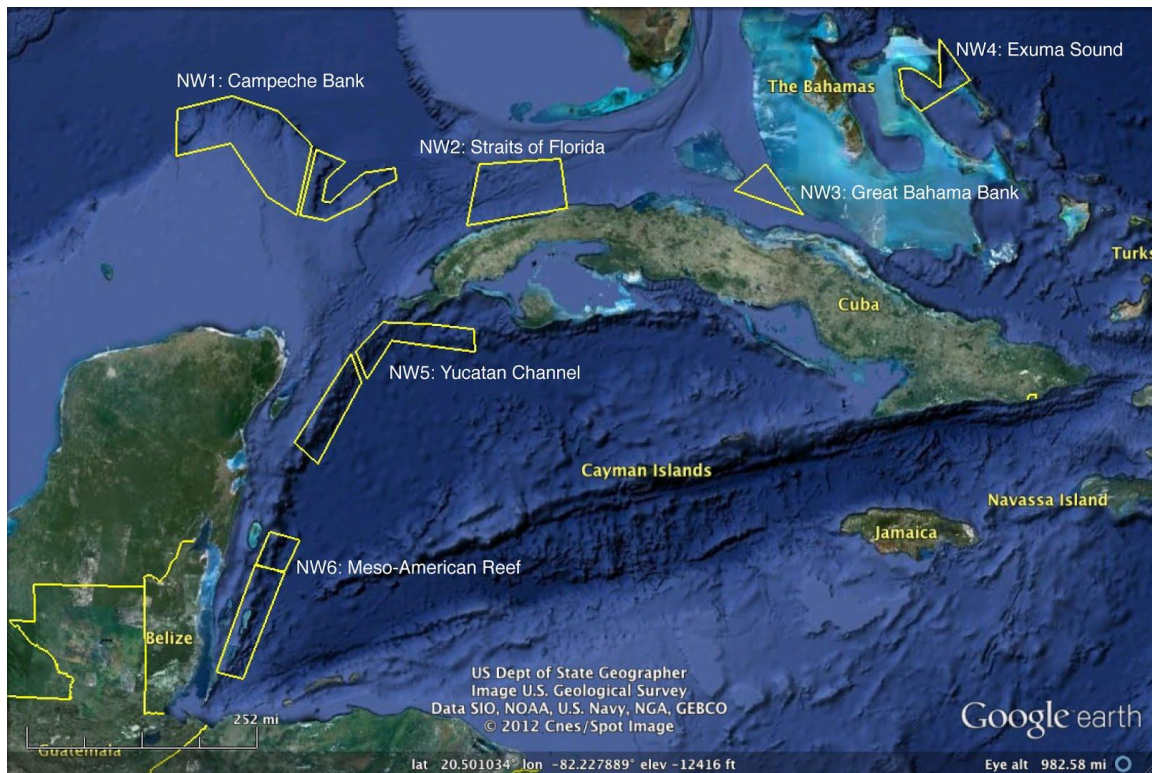
Priority areas identified for the region-based breakouts. The northwest group (yellow) focused on the Yucatan Peninsula and Florida Straits to the Bahamas, the mid-Caribbean (red) discussed Cayman Rise and the Greater Antilles, and southeast (blue) included the Caribbean Basin and Lesser Antilles.



Twenty high-priority target areas were identified by breakout group discussions by region. Some are ready for 2013 expeditions, while others may not be ready until 2014 or beyond.

A database of White Papers, Transects, and High Priority Target Areas can be accessed here:
<https://www.google.com/fusiontables/DataSource?docid=1EErrCPh32Tziq-idNEQ16ZqtkKDkkP3e2FRTcPl>

7.1 Northwest Caribbean



High priority target areas identified in the northwest Caribbean and adjacent areas.

7.1.1 NW-01: Campeche Bank

Depth Range	400 - 3,800 m
Territory	Mexico, Cuba
Overview	Interesting for biological, geological, and archaeological reasons. Propose vertical transects for biological and geological exploration, and horizontal survey for archaeological exploration.
Biological	Abundance of coral reefs
Geological	The Catoche Tongue, an embayment in the Campeche region, probably fault or joint controlled, may also be an erosional feature (see deep sea current along the Escarpment, there is also collapse of carbonated blocks).
Archaeological	Kabul-San Antonio (western tip of Cuba): If sailing a ship into the region, one would stay close to shore in order to not get pulled away by the

	current.
Physical	Strong currents; see results from Canek studies.
Education & outreach	UNAM interested in telepresence. Opportunity for trinational collaboration between U.S., Mexico, and Cuba.
Existing data	German cruise mapped the Campeche Bank edge, alignment of deep-water coral reefs and 100 m drift deposits. Piston cores and box cores were done on Campeche Escarpment. No visual surveys. Did not get into Cuban waters. ROV work was also done here. [POC: Eberli]. Schmidt Ocean Institute will multibeam map this area in 2013 [POC: C. Paull, MBARI]. Mexico has swath bathymetry CTD, and benthic samples [POC: E. Escobar]. Samples were obtained in 1993 within a Honduras, USA, and Mexico collaboration cruise.
Technical feasibility	Mexico box: ~20 days to multibeam map. UNAM's SIGSBEE cruises have mapped part of this section.
Ancillary benefits	Marine protected areas on Chinchorro Bank. High-resolution multibeam mapping of these areas would help justify expansion of these protected areas into deeper waters.
Permitting details	The authority to obtain permission to conduct archaeological work is a different entity.
Interested parties	E.J. Dahlgren, L. Soto, E. Escobar, F. Solis, P. Blanchon, P. Luna, B. Kiene
Other information	UNAM's R/V <i>Justo Sierra</i> is a potential platform to undertake collaborative exploration in the Gulf of Mexico, Caribbean Sea, and western tropical Atlantic Region

7.1.2 NW-02: Straits of Florida

Depth Range	100 - 2,400 m
Territory	Cuba
Overview	One of the least explored areas in the Straits of Florida is the western approach to Cuba.
Biological	Deepwater corals, species connectivity between northern and southern straits.
Geological	
Archaeological	
Physical	Tsunamigenesis a big concern in the Straits of Florida.

Education & outreach	Opportunity for trilateral collaboration between U.S., Mexico, and Cuba.
Existing data	
Technical feasibility	Currents may be too strong to do ROV work, at least in the center of the Straits.
Ancillary benefits	
Permitting details	Seems more politically acceptable to use a Mexican ship in Cuban waters than a U.S. ship. Potentially create a cooperative program with Mexico to use U.S. deep submergence assets on a Mexican ship in Cuban waters.
Interested parties	L. Soto, P. Luna, B. Kiene
Other information	UNAM's R/V <i>Justo Sierra</i> is a potential platform to undertake collaborative exploration in the Gulf of Mexico, Caribbean Sea, and western tropical Atlantic Region

7.1.3 NW-03: Great Bahama Bank

Depth Range	200 – 2,600 m
Territory	USA, Cuba
Overview	
Biological	
Geological	
Archaeological	
Physical	Tsunamigenesis
Education & outreach	
Existing data	Multibeam mapping has been done, but no ROV work [POC: G. Eberli]
Technical feasibility	
Ancillary benefits	
Permitting details	
Interested parties	G. Eberli

Other information	
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7.1.4 NW-04: Exuma Sound

Depth Range	0 - 4,000 m
Territory	Bahamas
Overview	
Biological	A huge diversity of vertebrates in deep water, in northeast corner near Eleuthera. Sixty deep-water long-line surveys identified over 12 different species. Large spawning aggregations of marlin and oceanic white tips around Rum Key.
Geological	Bahama Escarpment – great place to study the evolution of carbonate platforms. Could work on the escarpment east of Eleuthera. Bridge on east side a fantastic place to look as well. Area goes down to as deep as 1600 m. Best charts are 1800s-vintage with a lead-line. Broken away from the edge of the wall outside of Eleuthera show blocks detaching/separation. Not soft sediments. Seeps, fluid escape, and hydrocarbons; tar encountered in one ODP Leg 101 site in this area.
Archaeological	The original hub for the British colonization of the islands was located to the west of the corner of our box.
Physical	Current coming up from Cat Island upwells on the Rum Key. The three islands (Cat, Rum, and Eleuthera) create a huge amount of upwelling and convert the flow up into the sound – about a knot of current up the sound. A big zonal area for north Atlantic deep-water coming down along the escarpment from the Northwest.
Education & outreach	Long-standing record of education and outreach with the Cape Eleuthera Institute, which is very closely linked to the Bahamian government.
Existing data	Drilling (ODP Leg 101) done here
Technical feasibility	~7 days of multibeam mapping to cover proposed area
Ancillary benefits	
Permitting details	~6 months in advance. POC: E. Brooks
Interested parties	E. Brooks, J. Austin
Other information	

7.1.5 NW-05: Yucatan Channel

Depth Range	2,000 - 4,500 m
Territory	Mexico, Cuba
Overview	
Biological	Deep sea corals, connectivity of Escarpment fauna. The biological communities in deep and shallow water in the area are linked to Gulf of Mexico ecosystem through the Loop Current and the rest of the Caribbean.
Geological	
Archaeological	
Physical	Strong currents described and studied by Mexican scientists. CICESE interested, previous work described by their physical oceanography group.
Education & outreach	Telepresence of interest to UNAM. Opportunity for trinational collaboration between U.S., Mexico, and Cuba.
Existing data	Johnson SeaLink exploration in collaboration with UNAM in the 1990s. Mexican publications from previous and ongoing deep sea studies.
Technical feasibility	Strong current at some locations, but in general feasible to study the Escarpment and document with both video and still photomosaic techniques in addition to sampling.
Ancillary benefits	Protected areas, drowned reefs being studied in the Caribbean borderland.
Permitting details	6 months required for Mexican EEZ through the U.S. State Department to the Mexican Ministry of Foreign Affairs.
Interested parties	L. Soto, B. Kiene, E. Escobar, F. Solis, P. Blanchon
Other information	UNAM's R/V <i>Justo Sierra</i> is a potential platform to undertake collaborative exploration in the Gulf of Mexico, Caribbean Sea, and western tropical Atlantic Region

7.1.6 NW-06: Mesoamerican Reef

Depth Range	200 - 4,000 m
Territory	Mexico, Belize, Honduras
Overview	Area of interest includes the area from the 200 m isobath down to the

	base of slope along the Mesoamerican Reef. Johnson SeaLink exploration studies on shark, fish and Escarpment communities in collaboration with Mexico (E. Escobar).
Biological	Deep water corals, associated fauna
Geological	Drowned reefs
Archaeological	Possible trade route along east coast of Yucatan Peninsula.
Physical	According to the Navy, surface currents are stronger north of Chinchorro than to the south. Anything in the southern Mesoamerican Reef should be easier for ROV deployments. Currents change seasonally. Existing information from ongoing studies by CICESE.
Education & outreach	Mesoamerican Reef is an established priority for the Caribbean by the United Nations Environmental Program (UNEP). Deep-sea exploration of these habitats would help to empower this initiative, and therefore serve local and international community. UNAM interested in telepresence.
Existing data	There is quite a bit of seismic data here, and submersible dives off the reef near Smithsonian Institution station. There is single and multi-channel seismic data available, not multibeam. [POC: Gregor Eberli, E. Escobar]
Technical feasibility	Southern box: 10-15 multibeam days; northern box: 7 days to multibeam. UNAM could contribute with R/V support for multibeam, magnetometry, and CTD.
Ancillary benefits	There is a network of marine protected areas along the Mesoamerican Reef shelf that are situated adjacent to the deep-water escarpment. Among these are (from North to South) Chinchorro Bank (Mexico), Half Moon Caye, Glover's Reef, and Gladden Spit (BE); and then (to the east) is Roatan and Utila (HN). High-resolution multibeam mapping of these areas would help justify expansion of these protected areas into deeper waters.
Permitting details	~6 months for both Belize and Mexico.
Interested parties	G. Thompson (Belize archaeology), L. Cho-Ricketts (Belize biology), M. Brennan, P. Etnoyer, P. Luna, E. Escobar, F. Solis, P. Blanchon
Other information	March-July is a good time frame. Impacted by hurricanes Sept-Oct. UNAM's R/V <i>Justo Sierra</i> is a potential platform to undertake collaborative exploration in the Gulf of Mexico, Caribbean Sea, and western tropical Atlantic Region

7.2 Mid-Caribbean



7.2.1 MC-01: Western Cayman Rise

Depth Range	1,800 - 5,000 m
Territory	Honduras
Overview	
Biological	Deep water corals
Geological	Along fault, north of Bahia
Archaeological	Trade route through SW corner near Belize
Physical	
Education & outreach	
Existing data	
Technical feasibility	
Ancillary benefits	
Permitting details	

Interested parties	
Other information	

7.2.2 MC-02: Central Cayman Rise

Depth Range	1,500 - 6,000 m
Territory	UK
Overview	
Biological	Benthic-pelagic coupling; walls of interest for steep vertical transects from 4,000 m to 2,000 m
Geological	
Archaeological	
Physical	Hydrothermal plume dynamics
Education & outreach	Vents and charismatic biology
Existing data	C. German cruises on <i>Okeanos Explorer</i> and others, several ships to go here in 2013; Multibeam data from the 1970s (Ballard & ten Brink)
Technical feasibility	2-3 weeks of mapping will fill in multibeam throughout Cayman Trough
Ancillary benefits	
Permitting details	
Interested parties	C. German, S. Pomponi, N. Prouty, B. Phillips, E. Escobar
Other information	

7.2.3 MC-03: Windward Passage

Depth Range	500 - 4,000 m
Territory	Cuba, Haiti, Jamaica
Overview	
Biological	Deep sea corals

Geological	Indication of faults to 1,700 m depth; landslides off northern peninsula of Haiti
Archaeological	High likelihood of cultural material
Physical	Atlantic-Caribbean water exchange; currents could be problematic; measure geostrophic flow
Education & outreach	
Existing data	Haiti has multibeam data of their waters; French/Spanish multibeam planned for 2013; might be data from ships going to/from Guantanamo
Technical feasibility	
Ancillary benefits	
Permitting details	French/Spanish have their own, M. Cormier has a permit
Interested parties	M. Cormier (partners in Haiti), B. Schmidt
Other information	

7.2.4 MC-04: Navassa Island

Depth Range	0 - 1,400 m
Territory	USA
Overview	
Biological	
Geological	
Archaeological	
Physical	
Education & outreach	Opportunity to link scientists and students in Haiti, Cuba, and Jamaica.
Existing data	
Technical feasibility	
Ancillary benefits	

Permitting details	
Interested parties	
Other information	

7.2.5 MC-05: Southern Slopes of Puerto Rico & Dominican Republic

Depth Range	500 - 4,000 m
Territory	USA, Dominican Republic
Overview	
Biological	
Geological	Thrust features
Archaeological	
Physical	
Education & outreach	
Existing data	Multibeam bathymetry (U. ten Brink)
Technical feasibility	
Ancillary benefits	
Permitting details	
Interested parties	U. ten Brink, E. Escobar
Other information	

7.2.6 MC-06: Mona Passage

Depth Range	0 - 5,000 m
Territory	USA, Dominican Republic
Overview	
Biological	Push cores of dinoflagellates to study Ciguatera; vertical transects to study deep-water corals and other benthic biology

Geological	Mona Block; 45 degree slope going 1500m down beyond 7km. Interest in exploring slope, vertical transects.
Archaeological	Bobadilla's fleet, probably also other shipwrecks
Physical	ADCP measurements for currents
Education & outreach	
Existing data	Multibeam bathymetry (ten Brink)
Technical feasibility	
Ancillary benefits	
Permitting details	Dominican Republic permits are not difficult to obtain through State Dept. (U. ten Brink)
Interested parties	A. Catsambis, D. Rissolo, B. Schmidt, U. ten Brink, R. Appeldoorn, P. Tester
Other information	

7.2.7 MC-07: Puerto Rico Trench

Depth Range	200 - 7,000 m
Territory	USA
Overview	
Biological	
Geological	Fissures; carbonate platform tilted down into trench; two amphitheaters, including Luiza amphitheater; karst topography connects terrestrial features with submarine slope
Archaeological	
Physical	Midwater profiles for...?? (B. Schmit)
Education & outreach	
Existing data	Multibeam bathymetry (U. ten Brink); <i>Okeanos Explorer</i> ROV field trials will be in Puerto Rico Trench in 2013
Technical feasibility	

Ancillary benefits	
Permitting details	
Interested parties	U. ten Brink, B. Schmidt, S. Pomponi, E. Escobar
Other information	Transects upslope for geological and biological survey

7.2.8 MC-08: Anegada Passage

Depth Range	200 - 4,000 m
Territory	USA, UK
Overview	
Biological	
Geological	1867 earthquake (historical significance)
Archaeological	
Physical	Water exchange between Atlantic and Caribbean
Education & outreach	A lot of community interest in lionfish distribution
Existing data	Multibeam bathymetry (U. ten Brink)
Technical feasibility	
Ancillary benefits	
Permitting details	
Interested parties	U. ten Brink, N. Quinn
Other information	

7.3 Southeast Caribbean



7.3.1 SE-01: San Andres Province

Depth Range	80 - 3,000 m
Territory	Colombia
Overview	Off Nicaraguan Rise exposed inactive volcanic island with most oceanic-like deep sea corals.
Biological	Second longest coral reef barrier in all of Caribbean (unknown - Alucia Passage)
Geological	Atolls; volcanism; coralline/biogenic origin; no terrestrial input/runoff; lots of seamounts
Archaeological	Possible wrecks; sister ship of <i>Mayflower</i> visited Old Providence Island; global interest in baseline before proposed expansion of Panama Canal in 2018
Physical	Greatest oceanic features; eddies; pattern of speciation; important endemic features; no terrestrial runoff

Education & outreach	Link whole community to look at changes from near margin to oceanic environment; biosphere reserve
Existing data	Multibeam first; good hydrographic/bathymetry; some seismic; very scarce cores samples; oceanographic data (currents)
Technical feasibility	Multibeam first
Ancillary benefits	International biosphere - reserve - Sea Flower; marine conservation; global interest in baseline pre-2018 Panama Canal expansion
Permitting details	
Interested parties	F. Arias, L. Duenas, J. Sanchez, P. Sierra, C. Jaramillo (Smithsonian), C. Andrade, A. Gracia, E. Escobar
Other information	Avoid continental shelf

7.3.2 SE-02: Hess Escarpment

Depth Range	2,000 - 4,000 m
Territory	Colombia, Jamaica
Overview	Steep escarpment on southeastern side of Nicaraguan Rise with oceanic-like deep sea corals. Least known in the region.
Biological	Pre-oceanic; stepping stone; likely very rich; very unknown; hardbottom communities; connectivity
Geological	Origin of escarpment; traverses of wall; slip boundary; unknown area
Archaeological	On probable trade route
Physical	Pre-outflow to Gulf of Mexico
Education & outreach	Opportunity for international collaboration between U.S. and Colombia. ECC setup in several locations; work with schoolchildren using existing programs (Baru Island); existing auditorium in Bogota and Santa Marta; expand to Jamaica.
Existing data	
Technical feasibility	Multibeam first
Ancillary benefits	36 hrs from port

Permitting details	
Interested parties	F. Arias, L. Duenas, J. Sanchez, P. Sierra, C. Jaramillo (Smithsonian), C. Andrade, A. Gracia, Jamaican POCs TBD, N. Quinn POCs, E. Dakin POCs (biology, Jamaica), D. Webber POCs, E. Escobar
Other information	

7.3.3 SE-03: Sinu Belt

Depth Range	80 - 4,000 m
Territory	Colombia
Overview	Southwest Caribbean region in the Sinu-Cartagena compressional area with active mud volcanoes and evidence of likely chemosynthetic and other benthic communities. Outflows from continent are very important. Very specific seismic data; no visual data.
Biological	Unknown, include deep sea reefs/corals (known by trawl sample) and cold seep/chemosynthetic communities (unknown), and other communities; biological connectivity; shallow data exists; deep sea fauna influences/changes from Panama Canal; would want to know Pacific side of Canal as well; lionfish.
Geological	Mud volcanoes (very likely), gas bubbles/seeps, venting; seismic data exists; platform at 80m; submarine canyons, sedimentary plains; different substrates;
Archaeological	Route to Cartagena (predicted - no specific targets); two adjacent ships not high priority targets; connectivity to Panama Canal.
Physical	Strong counter current, connectivity questions; sink of Caribbean, highest genetic diversity.
Education & outreach	Opportunity for international collaboration between U.S. and Colombia. ECC setup in several locations; work with schools using existing programs (Baru Island); existing auditoriums in Bogota and Santa Marta.
Existing data	Oil industry, coral samples from trawl (in 2000's <250m); existing information resources online with host of data; would add to this repository; old photographs from 1980's French cruises; http://siam.invemar.org.com/siam/index.jsp ; http://gis.invemar.org.co/PERCaribe/
Technical feasibility	No existing data there; need to map, ROV to 4,000m; sampling coral and rock; existing data from oil industry
Ancillary benefits	Existing proposal to establish submarine MPA; allows an ask for tools not

	available (stimulating capacity building)
Permitting details	Sample Permits: Standard surveying permit exists to take samples; repository in another institute; need authorization for biological permits; preference given to institutions with agreements with Colombian institutions - form research collaborative.
Interested parties	F. Arias, L. Duenas, J. Sanchez, P. Sierra, C. Jaramillo (Smithsonian), C. Andrade, A. Gracia, E. Escobar, L. Levin
Other information	

7.3.4 SE-04: Montserrat & Dominica

Depth Range	100 - 2,500 m
Territory	UK, Dominica
Overview	Active volcanic islands in the Lesser Antilles impact of eruption products on biological communities, debris avalanche collapse hazard, unexplored submarine volcanoes, and possible venting. Archaeological investigation of village blown into the sea.
Biological	Effects of eruptions on shallow water corals; potential for deep corals; ciguatera fish poisoning (<200 m); biological connectivity; possible offshore vent communities; lionfish affecting reefs - unknown depth distribution.
Geological	Eruptions of Monserrat (island building); Complex morphology, subsea volcanism (Montserrat); Dominica - largest sector collapse in W. indies; debris avalanche; S coast of Dominica 2 seismic swarms; possible site of next major eruption in W. Indies; irregular seafloor morphology; tsunamigenesis; champagne venting (shallow water venting).
Archaeological	Debris outfall of St. Patrick's (1997) village offshore in 800 m (off Dominica); British Naval presence in island of Antigua in close proximity to Monserrat.
Physical	Flowthrough from Atlantic to Caribbean.
Education & outreach	Interesting story in general; ongoing eruption; land to sea story of volcano; tsunami education; lionfish invasiveness a big regional issue.
Existing data	French Seabeam multibeam (Montserrat); Seabeam avail (Dominica); lionfish data.
Technical feasibility	

Ancillary benefits	Lionfish management issues
Permitting details	
Interested parties	S. Carey, C. Roman, J. Latchman, P. Tester, N. Quinn, J. Morris, E. Escobar
Other information	

7.3.5 SE-05: Aves Ridge

Depth Range	1,500 - 3,100 m
Territory	St. Vincent and the Grenadines, Venezuela
Overview	Aves Ridge in the eastern Caribbean probable extinct volcanic feature with stepping stone and connectivity between basins. Least known area.
Biological	Connectivity - first stopping point in flowthrough from Atlantic to Caribbean; relic reefs possibly; lionfish.
Geological	Origin of Aves Ridge; understanding of Caribbean Plate; high mud potential; relic arc; back-arc basin.
Archaeological	
Physical	Flowthrough from Atlantic to Caribbean
Education & outreach	A lot of potential in Venezuela side re: Bird nesting site, wildlife refuge on Aves Island (1500 sq km); first campaign to look at reefs and biodiversity recently.
Existing data	Rock outcrops dredged off Aves Ridge; seismic data across Aves Ridge, limited multibeam.
Technical feasibility	Require new mapping; dredge samples or find outcrops.
Ancillary benefits	Bird nesting site, wildlife refuge on Aves Island (1500 sq km); first campaign to look at reefs and biodiversity recently. Navy station on Aves Island.
Permitting details	
Interested parties	P. Miloslavich, J. Gobin, N. Quinn, J. Morris, S. Carey, C. Roman
Other information	

7.3.6 SE-06: Southeast Caribbean

Depth Range	To 3,800 m
Territory	Venezuela, Grenada, Trinidad & Tobago, Barbados
Overview	Southeastern Caribbean region active underwater volcanism and hydrothermal vents, mud volcanoes, high productivity area off of Orinoco, and debris avalanche hazard.
Biological	Communities under influence of Orinoco Delta; high productivity; corals on west side near Kick'em Jenny; look for lionfish under 300 m.
Geological	Volcanoes, mud volcanoes, hydrothermal vents; Kick'em Jenny, tsunamigenic avalanche hazards; natural oil seeps.
Archaeological	Colonial trade route
Physical	Orinoco Current; third in world for sediment discharge; Gulf of Paria
Education & outreach	Very strong education possibilities; very interesting features; tsunami/hazards/earthquakes education; University of West Indies for command centers (existing web teaching capabilities)
Existing data	Oil industry data (limited availability) on east side. Multibeam for Kick'em Jenny; Multibeam for mud volcanoes south of Barbados
Technical feasibility	
Ancillary benefits	RAMSAR site for international protection for mangroves; conservation in Gulf of Paria
Permitting details	
Interested parties	S. Carey, J. Gobin, P. Miloslavich, L. Inniss, J. Latchman, E. Escobar, S. Brooke
Other information	

8 Next Steps

8.1 Feedback & Reports

We seek feedback in the form of comments and other input for discussion from the scientific community on this draft report on the Workshop on Telepresence-enabled Exploration of the Caribbean Region. Please comment directly on the Google Doc (preferred):

<https://docs.google.com/document/d/1K9sUwl4Viyl1a0dl8gKTdpovdfZ1y9esArTgwqvO4Y/edit>

Or send comments or questions to Katy Croff Bell, katy@oceanexplorationtrust.org, no later than Friday, 21 December 2012.

The final report will be available by Monday, 7 January 2013 at www.oceanexplorationtrust.org, and a summary report will be published in the Supplement to *Oceanography* magazine in March 2013.

8.2 Develop Caribbean Exploration Database

Based on the Caribbean Workshop Report, White Papers, and community feedback, we will develop a database on exploration of the Caribbean region and southeastern Gulf of Mexico for use by the *Nautilus* Exploration Program, NOAA Office of Ocean Exploration and Research, and other programs that are interested in using it for reference in planning exploratory missions in the Caribbean.

8.3 Develop *Nautilus* schedule

The Workshop Report will be discussed on February 11, 2013, with the *Nautilus* Advisory Board, with a view to building a 2-3 year exploration campaign in the Caribbean Region.

8.4 Develop Engagement Strategy

The schedule approved by the *Nautilus* Advisory Board will be used to develop an engagement strategy with workshop participants, as well as other members of the scientific community, local Caribbean governments, and education and outreach partners, to include as many stakeholders as possible in the planning and execution of the *Nautilus* Exploration Program in the Caribbean Region.

Appendices

A Participants

A.1 List of Workshop Participants

* Members of the *Nautilus* Advisory Board

^ Members of the NOAA Ocean Exploration Advisory Working Group

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Ms. Angela Murphy Sea Research Foundation, USA
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Ms. Sandra Witten Ocean Exploration Trust, USA
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A.3 Breakout Groups by Discipline

(f) - Facilitators, (m) - Mappers, (r) - Rapporteurs

Biology (orange)	Archaeology (purple)	Geology (green)
Richard Appeldoorn Francisco Arias Isaza Jeff Book Edd Brooks Leandra Cho-Ricketts Amanda Demopoulos Luisa Duenas Peter Etnoyer Peter Girguis (f) Judith Gobin David Gruber Lorna Inniss Eric Jordan-Dahlgren Brian Kennedy (m) Patricia Miloslavich John Ogden Brennan Phillips (r) Shirley Pomponi Nancy Prouty Andrea Quattrini Norman Quinn Juan Sanchez-Munoz Patricia Tester	Roy Armstrong James Austin (f) Michael Brennan (f) Alexis Catsambis Dwight Coleman Kelley Elliott (r) Graciela Garcia-Moliner Bill Kiene Meme Lobecker (m) Chris Roman George Thompson	Steve Carey Marie-Helene Cormier Gregor Eberli Keene Haywood Catalina Martinez (r) Larry Mayer (f) Nicole Raineault (m) Bill Schmidt Paula Sierra-Correa Luis Soto Uri ten Brink Art Trembanis

A.4 Breakout Groups by Region

(f) - Facilitators, (m) - Mappers, (r) - Rapporteurs

Northwest (yellow)	Mid-Caribbean (red)	Southeast (blue)
James Austin (f)	Richard Appeldoorn	Francisco Arias Isaza
Michael Brennan	Roy Armstrong	Steven Carey (f)
Edd Brooks	Alexis Catsambis	Luisa Duenas
Leandra Cho-Ricketts	Dwight Coleman (f)	Judith Gobin
Amanda Demopoulos	Marie-Helene Cormier	Keene Haywood
Gregor Eberli	Peter Girguis	Lorna Inniss
Kelley Elliott (r)	Meme Lobecker (m)	Larry Mayer
Peter Etnoyer	Catalina Martinez	Patricia Miloslavich
David Gruber	Brennan Phillips (r)	Nicole Raineault (m)
Eric Jordan-Dahlgren	Shirley Pomponi	Chris Roman
Brian Kennedy (m)	Nancy Prouty	Craig Russell (r)
William Kiene	Norman Quinn	Juan Sanchez-Munoz
John Ogden	Bill Schmidt	Paula Sierra-Correa
Andrea Quattrini	Uri ten Brink	
Luis Soto	Patricia Tester	
George Thompson	Art Trembanis	

A.5 Comments

Many thanks to those who did not attend the workshop, but provided valuable comments in improving this report.

Dr. Elva Escobar Universidad Nacional Autónoma de México

Dr. Lisa Levin Scripps Institution of Oceanography

Dr. Andrea Polanco Marine and Coastal Research Institute (INVEMAR), Colombia

B Workshop Agenda

DAY 1: November 15, Thursday

Location: Mutiny Hotel

All day	Participants arrive, to Mutiny Hotel
1700-1800	Reception, meet at greet
1800	Dinner
1830-1845	Welcome (Ballard & Arcano)
1845-1900	Workshop overview (Bell)
1900-1930	Preliminary results of WCR workshop (Inniss)
2130-2200	Meeting of Workshop Organizing Committee

DAY 2: November 16, Friday

Location: Mayfair Hotel

	0800-0830	Walk from Mutiny Hotel to Mayfair Hotel
Ballroom	0800-0900	Coffee & refreshments
	0900-0915	Summary of Day 1, overview of Day 2 (Bell)
	0915-0940	History of telepresence-enabled exploration (McDonough)
	0940-1005	Telepresence technology & the Inner Space Center (Coleman)
	1005-1030	<i>Okeanos</i> Exploration Program (Russell)
	1030-1100	Doctors on Duty - Gulf of Mexico (Austin) & Cayman (Martinez)
	1100-1130	BREAK and group photo
	1130-1155	<i>Nautilus</i> Exploration Program (Bell)
	1155-1225	Doctors on Call - Eratosthenes Seamount (Mayer)
	1225-1245	Questions, discussion & instructions for breakout groups (Bell)
Havana	1245-1330	LUNCH
	1330-1500	Convene in breakout groups by discipline (Session 1)
Alexander 1		Archaeology
Alexander 2		Geology
Kentia 3		Biology
	1500-1530	BREAK
	1530-1700	Reconvene in breakout groups by discipline (Session 2)
Ballroom	1700-1730	Plenary, summary of Day 2, plan for Day 3, discussion (Bell)
	1730	ADJOURN
Mutiny Lobby	1830	Meet to walk to dinner
Scotty's	1900	Dinner at Scotty's Landing
Mutiny	2130	Workshop Organizing Committee meeting

DAY 3: November 17, Saturday**Location: Mayfair Hotel**

	0800-0830	Walk from Mutiny Hotel to Mayfair Hotel
	0800-0900	Coffee & refreshments
	0900-0915	Summary of Day 2, overview of Day 3 (Bell)
	0915-0945	Summary from Archaeology Breakout Group (Brennan)
	0945-1015	Summary from Geology Breakout Group (Mayer)
	1015-1045	Summary from Biology Breakout Group (Girguis)
	1045-1115	BREAK
	1115-1230	Plenary discussion
	1230-1330	LUNCH
	1330-1500	Reconvene in breakout groups by region (Session 3)
	1500-1530	BREAK
	1530-1700	Reconvene in breakout groups by region (Session 4)
	1700-1730	Plenary, summary of Day 3, plan for Day 4, discussion (Bell)
	1730	ADJOURN
Mutiny Lobby	1800	Meet in Mutiny Hotel Lobby for transport to RSMAS
RSMAS	1830	Dinner at the Rosenstiel School of Marine and Atmospheric Science
	2100	Bus transport from RSMAS to Mutiny Hotel
Mutiny	2130	Workshop Organizing Committee meeting

DAY 4: November 18, Sunday**Location: Mutiny Hotel**

	0800-0900	Coffee & refreshments
	0900-0915	Summary of Day 3, overview of Day 4 (Bell)
	0915-0945	Summary from Region 1 Breakout Group (Austin)
	0945-1015	Summary from Region 2 Breakout Group (Coleman)
	1015-1045	BREAK
	1045-1130	Summary from Region 3 Breakout Group (Carey)
	1130-1200	Workshop conclusions, questions, and next steps (Bell)
	1200	ADJOURN
		Participants depart

C References

Deep-Sea Research I 69 (2012) 82–99 and other papers published in DSR II, special volume devoted to the Gulf of Mexico.

Miloslavich P, Díaz JM, Klein E, Alvarado JJ, Díaz C, et al. 2010. Marine Biodiversity in the Caribbean: Regional Estimates and Distribution Patterns. PLoS ONE 5(8): e11916. doi:10.1371/journal.pone.0011916