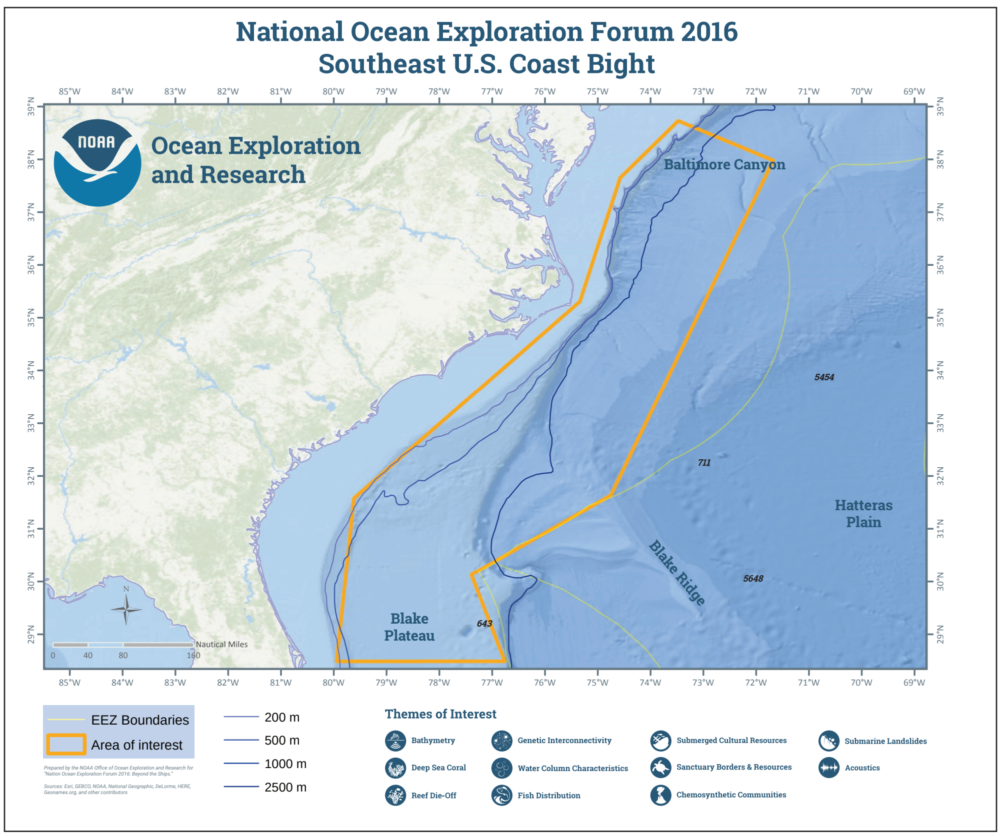
Southeast U.S. Atlantic Bight Campaign Scenario

INTRODUCTION: Two independent Breakout Groups met in two sessions to consider emerging technologies to enable ocean exploration campaigns scheduled to occur in the Southeast U.S. Atlantic Bight in the next few years. A map of the notional campaign scenario area is presented below. Drs. James Austin (University of Texas) and Amanda Demopoulos (U.S. Geological Survey) led one group while Drs. Jerry Schubel (Aquarium of the Pacific) and Mr. Eric King (Schmidt Ocean Institute) led the other. Other forum participants moved among the several Breakout Groups during the course of their discussions. Lists of participants and their provisional group assignments made at registration are available (click here for Breakout Rosters). A narrative of the discussion by each Breakout Group follows.



Southeast U.S. Atlantic Bight Breakout Group
led by

Dr. James Austin (University of Texas) and
Dr. Amanda Demopoulos (U.S. Geological Survey)

The Southeast U.S. Atlantic Bight Breakout Group discussed the context of the campaign involving both federal and nonfederal partners to date, which will span the period from 2016 to 2020. We discussed the opportunity to capitalize on existing/planned resources, including ship time (National Oceanic and Atmospheric Administration vessels) and platforms (remotely operated vehicles [ROVs], autonomous underwater vehicles [AUVs]).

Before developing new technology ideas, we spent some time discussing the impetus behind the campaign, the goals and objectives, and the interest of the Bureau of Ocean Energy Management (BOEM) in particular, with respect to oil and gas leasing in the region. BOEM's request for proposals (i.e., to participate in the campaign) has not yet been released, but the overall plan is for interested groups (generally academic partnerships) to submit proposals around spring 2017, with anticipated awards occurring early summer 2017. (Note: This RFP will not include a marine archaeology component.) The campaign will primarily explore for seeps and deep-sea coral and sponge habitats, from Baltimore Canyon to the Blake Plateau. Additional complementary studies in the region include the Atlantic Deepwater Ecosystem Observatory Network (ADEON) project that includes instrumenting the seafloor with acoustic and ocean environmental monitoring instruments to understand the soundscape along the bight, and NOAA-Office of Exploration and Research funded work (to the U.S. Geological Survey, with added U.S. Department of the Interior funding) to continue to explore seep environments along the shelf/slope break.

We discussed and defined several criteria that facilitate successful oceanographic campaigns, including applications of new and existing technology, engaging the public, and identifying partnership opportunities. These criteria are discussed below.

Technology

The technology discussion followed descriptions of the basic plan for the Atlantic campaign and associated timeline (2016-2020). This region is extremely challenging for ocean science missions, particularly for deploying (seafloor and water column-based) instruments and ROVs, for example, because of the strong currents associated with the Gulf Stream. We identified several potential gaps in the planned Atlantic campaign; that helped stimulate the discussion about new technology. Our discussion raised the question of whether the community is really moving toward shipless operations; it was clear to the group that by 2020, we will continue to require ships to deploy an array of instruments, including autonomous and remotely operated vehicles.

Demopoulos identified several open questions and challenges associated with working in this region. For example, there are extensive areas in the region (e.g., the line of lowest elevation, or thalwegs, of canyons) that lack high-resolution bathymetry. Virmani stated that by 2030, the General Bathymetric Chart of the Oceans (GEBCO) expects to have the entire ocean mapped at 100 m resolution. Does this change our needs or focus for data requirements and exploration? While 100 m resolution is better that nothing, it is not optimal for estimating potential deep-sea coral and sponge habitats and will not be useful for habitat suitability models developed for these groups. There will still be a need to map at higher resolution and pinpoint targets for visual exploration. The issue of bathymetric resolution requirements arose several times in our discussion, as different resolution requirements enable addressing different questions, and levels of exploration for diverse goals and objectives.

Limited bathymetry inhibits AUV and ROV operations, particularly within rugged canyons. While the 2016-2020 campaign will focus on site-specific studies examining discrete features, e.g., canyons and seeps, there are potentially hundreds of seeps, as well as significant hard bottom areas that will not be investigated. In addition, there are no plans to focus on marine mammal distribution, or targeted exploration for marine archaeology applications. Therefore, there is tremendous potential for extensive exploration opportunities from 2020 to 2025.

Demopoulos clarified that need to improve data visualizing and analysis, particularly for exploring connections between biology and geology. Another question that is challenging to address over short-term studies includes understanding the spatial-temporal environmental controls on species distributions (e.g., influence of food supply/quality, oceanographic processes). Given that the 2016-2020 campaign will focus on discrete areas, this limits our understanding of the broader distribution of species, particularly corals, which ultimately constrains our ability to manage these environments.

Based on the scope of potential questions and information gaps identified, Bellingham clarified that virtually all technology that will be used in 2020 is either currently available or in a developmental phase. AUVs in particular are becoming better at operating in rugged terrain, e.g., canyons, and at longer distances from support vessels. There are ongoing improvements to power, energy efficiency, and sensor (optical and chemical) tools, including those for water and genetic sampling. Other improvements in the works include better docking systems for surface vehicles and AUVs. Bellingham described the suite of AUVs currently available, defining what a "shipless survey" might entail. Currently there are six AUVs that can run 500 km transects from shore, and remain offshore for 1.5-3 weeks. Scaling up to several lighter, smaller, more efficient vehicles will be required in cover ground and facilitate exploration over large spatial scales. There are cost savings with deploying AUVs from shore rather than ships, however; navigation is not as reliable as from a ship. Ultimately, a future exploration campaign may involve multiple platforms, including several AUVs with docking capacity on autonomous surface vehicles (ASVs) that allow for recharging and improved navigation, and greater spatial and temporal coverage.

Some challenges to operating these vehicles offshore include addressing how to maintain battery life. ASVs can use waves, wind, and sun, but alternative power supply options include microbial fuel cells and hydrothermal vent fluid energy. These would be useful for moorings and landers, in particular.

Specific ASVs discussed include platforms in development at Autonomous Marine Systems. Paintal (employed by that company) described a wind-powered catamaran autonomous data collection platform with AUV deployment and recharging capacity. This vehicle could stay at sea forever at a relatively low cost (less than $35K). The battery system is powered by solar panels, thus allowing extended time at sea. This type of technology would allow for deployments over the annual cycle. Currently, the instrument suite includes wind speed and direction and currents (to depths of 75-200 feet). Other instruments and sensors can be added, including cameras, but there are limitations to bandwidth and data transmission. The next model will be tested on the Charles River (with Mike Benjamin at MIT), then in the Chesapeake and offshore of Florida. Interested customers include DARPA and the oil and gas industry.

Regarding developments of other AUV/drone vehicles, Virmani explained that more than one team (in response to an X-Prize competition currently underway) is designing these systems for use in both air and water. While the initial phase of the projects requires shallow water depth capabilities, future phases will get deeper (to 1000 m or more). These vehicles will be able to dive up to 2000 m depth and cover 100 sq. km with 5 m resolution in 24 hours. Ultimately, the teams will own the technology and designs, and companies will be established following award.

Regarding data visualization, for scientific applications and public outreach, Virmani discussed several potential instruments coming online or in use now, including underwater robotics and drone deployments, remote communications (e.g., CubeSats), and biological and chemical sensors that have been developed for the medical field. However, some of these tools and sensors will need to be miniaturized. The discussion of medical instruments and technology identified a possible opportunity for developing new partnerships with the medical industry.

Following on the discussion of tools and sensors, Girdhar discussed the development of advanced software that will enable hypothesis-generating systems. Given challenges with limited bathymetry and bottom time, optimizing AUV surveys to improve data coverage, including spatial resolution, will be necessary. Improving the vehicle's ability to make "decisions" through software development, with respect to identifying target habitats or features of interest and avoiding potential hazards, will increase the efficiency of operations. Lastly, we discussed the use of information theory to help gauge success of these operations, including addressing whether the measurements reduced our level of uncertainty about the area in question. This would help refine the definition of exploration success (a subject raised initially by Garcia) to allow for a minimum amount of acceptable information gained through these opportunities and expeditions.

We discussed how to optimize ship operations to improve data collection and information gained. Bellingham stated that scientific experiments are currently progressed through multiple discrete cruises, at escalating levels of resolution. An alternative approach, which may lead to a paradigm shift in at-sea operations, could be conducting operations "in stride" (U.S. Navy term), applying multiple levels of technology at once rather than in sequence. This may not encompass certain types of sampling, but could entail collection of data from multiple sensors, instruments, vehicles, and ships.

Passive acoustics-potential applications for understanding a "healthy" ecosystem should be considered in the scenario timeframe.

Applications of eDNA, rather than counting fish or invertebrates is another emerging technology. However, it is unclear how sampling for eDNA might be possible through remote operations. AUV Sentry has a plankton pump ("Plankzooka") which could filter and preserve large volumes of material at discrete sites for eDNA and other analyses. Thre should be plans to develop instruments that can make in situ measurements for eDNA.

We had a brief discussion on 360-degree visualization in water (Virmani). While time-lapse cameras, including rotating ones, have been used in the deep sea for several years, making these cameras smaller and easier to deploy and recover would be an advancement, facilitating exploration in space and time.

Improving public engagement

For the 2016-2020 Southeast U.S. Atlantic Bight campaign, each federal agency identified its needs and contributions to the planned work, including availability of ships (NOAA), locating and defining the distribution of environmentally sensitive communities and natural hazards (USGS), to help conservation and management of these resources (NOAA), and limit adverse effects from oil, gas, and alternative energy development (BOEM). In addition, by working together and combining missions, each agency can work more efficiently and effectively. However, there needs to be something more than just interest by the federal government to engage the larger public audience. One must articulate why the public should be interested in this, or any, candidate exploration region.

The group spent some time on the topic of public engagement and discussing a framework for "successful" campaigns (Garcia). As campaigns are being formulated, from the outset, there needs to be a strategic plan in advance to identify questions that may interest the public (Garcia). For example, what would we define as a success (e.g., how many square kilometers of seafloor mapped, how many samples taken, how many new species described, etc.)? What new technologies were adapted, advanced, or tested in which new research endeavors (e.g., new applications for eDNA)? What were the obstacles and challenges? With each question identified, there must be simple, straightforward answers that the public (and the sponsoring agency) can understand. To do this effectively, one needs to employ professional storytellers and communicators to engage the broader community and get the message out.

For the Southeast U.S. Atlantic Bight specifically, we discussed several ways to engage the public by first identifying the rich history that is the foundation of the region, but that may be unfamiliar to many. Examples include the importance of the Gulf Stream in transporting not only ocean resources but also humans across the Atlantic. It is an area with significant maritime history, critical to humankind (Austin, Cantelas). By using the Gulf Stream as a "storyline" or educational template, we could include topics that link the water column to the geology, biology, archaeology, etc. (Austin). We consider children to be the prime target audience, as they are attracted to new technology, shipwrecks, and captivating storytelling (Coleman); telepresence has proven effective at engaging the public (Coleman, McDonough).

We discussed technology that can help get the public engaged, including the development of apps that specifically target citizen scientists and students (Virmani). The Blue Button challenge ($100K from the X-Prize) is a crowd-sourcing opportunity for those who want to explore the ocean as a hobby. Improving communications through the deployment of "hot spot" buoys on the ocean surface will help improve telepresence and connectivity in general (Coleman). Additional examples of using technology to engage the public include those currently used (blogs, websites) and new ideas, including apps to track and download instrument data and vessel locations.

Engaging the public could lead to additional partnerships to help crowd-source "citizen science" (Pace). For example, using machine-learning technology for data-heavy applications like seafloor video and deployed sensors. This type of technology could be on board by 2020/2025. Although helpful in addressing science and exploration priorities from the region, citizen-science-acquired data can be challenging to analyze. Girdhar suggested there is a need to "filter" data acquired from the community at large, to minimize the "cacophony" of input and maximize utility and application of the data. Thus, there needs to be input on developing methods, including software, to manage data downstream that stems from public input.

Opportunities for partnerships

Given that the Southeast U.S. Atlantic Bight campaign as it is currently defined primarily includes only federal partners, Demopoulos observed that there are clear opportunities to build and develop additional partnerships at this stage. Given the plan for dedicated ship time over the next four years, there will be opportunities to test new equipment and software, including incorporation of citizen-science facilitated data analysis, in advance of the 2020-2025 timeframe. The current campaign does not include an explicit marine archaeology objective. This may represent one opportunity to build future partnerships, including private foundations.

One challenge to building new partnerships and drawing in additional support is the "ownership" mentality. Virmani suggested that crowd-funding is a realistic option; however, we need to leave (or add to) our (existing funding/planning) silos. Additional partners include the oil and gas industry as they try to lower costs for operations, and also the defense and mariculture communities. Improving partnerships with the U.S. Navy and NASA by providing opportunities to test and refine vehicles and sensors needed in extreme environments, for example, may represent another productive path forward. Lastly, to improve communication from land to sea, it will be necessary to engage and involve commercial and private partners to help fund additional bandwidth and infrastructure.

Southeast U.S. Atlantic Bight Breakout Group led by

Dr. Jerry Schubel (Aquarium of the Pacific) and
Mr. Eric King (Schmidt Ocean Institute)

Every great campaign rewrites the rules. "Do nothing trivial."

To rewrite the rules, we need to add new players, new technologies, new platforms to the mix.

Collaboration with nontraditional partners has not been one of the hallmarks of the academic oceanographic community or of federal agencies. Multiple platforms, multiple sensors, can facilitate collaboration by expanding the opportunities for the partners to advance their own agendas…and to contribute to the larger good…and to try new things

Demonstrate the power of partnerships. A partnership is an arrangement whereby partners agree to cooperate to advance their common interests. The best partnerships involve partners who "stretch us" and where "creative abrasion" exists.

The Southeast U.S. Atlantic Bight is a relatively large area that appears to be relatively intensively studied. Given the new tools we have at our disposal, it's clear that if applied in an appropriate and comprehensive way they would reveal new features we have never seen before…in the biology, geology, chemistry, physics, and the maritime history hidden on and below the seafloor.

Exploration in the U.S. Atlantic Bight is less about going there for the first time and more about showing how new tools allow us to look at the ocean in new and different ways.

Archaeological opportunities are huge. This was a major highway for early settlement of the Americas.

The coverage is deceiving. It is reminiscent of the a stanza in T. S. Eliot's poem "Little Gidding" in his collection *Four Quartets*: "We shall not cease from exploration and the end of all our exploring will be to arrive where we started and know the place for the first time."

First, commission some targeted analyses of existing data around a carefully crafted architecture of questions. Transform these data into information that will put a focus on special areas of opportunity. Create a dedicated fund to support this effort; perhaps 24 person-months of effort. Joint funding by NOAA, Schmidt Ocean Institute, Dalio Ocean Initiative, Simons Foundation, and others should be considered.

Second, make sure the core team is supplemented with specialists in the areas of technology, including data visualization, to make a compelling demonstration of the value of characterizing the "cube of ocean (i.e., deep, shallow, seafloor, water column)" using the most powerful technologies. Re-map areas previously mapped using the latest multibeam technology and show how much we have missed before we had multibeam.

Perhaps even take on the challenge of mapping the entire U.S. EEZ off the East Coast with the latest multibeam technology. One could supplement shipboard systems with a swarm of 50-100 AUVs equipped with multibeam technology. That technology either exists or is on the horizon. Such a survey could be completed for less than $10 million with several million of this available for the backend data analysis, archiving and data distribution.

Third, make sure one has the array of platforms and sensors to cover the area effectively and efficiently; deep, shallow, seafloor, water column … the whole "cube." It will require surface vessels of various sizes, and a variety of gliders, AUVs, etc. This takes one "Beyond THE ships, " that is, beyond the well-known ships of exploration by launching a variety of sensors in swarms. One needs to look beyond the ocean exploration community to other communities, such as DARPA, the oil and gas industry, the U.S. Navy, the medical technology community, etc.

Fourth, transform the data into information on a recurrent basis and develop informational products tailored to the desires of different stakeholder groups. Note Peter Medawar's observation: "Information is data that has been architected to answer a question or to deliver a message."

Engage citizen-scientists in all phases of the campaign.

Set lofty goals for the "cube" by bringing together leaders from different sectors of the community and some "wild cards" from other communities such as medical technology.

Develop mechanisms to engage others through RFPs, incentivizing their participation by making ship time available, for example.

Extend telepresence to other vessels. The partners in the campaign should have an inventory of several portable or mobile telepresence units for loans to other vessels.

This is a rich geographic area in human history. Multibeam sonar exploration will reveal larger structures, but will need to be supplemented with high-resolution visual systems on near bottom AUVs.

Map geochemical properties throughout the "cube" using AUVs, among other vehicles, equipped with the right suite of sensors.

Repeat the Ben Franklin expedition with an armada of inexpensive gliders, AUVs, etc. Release them at the south end and collect them at the north end.

Partnerships in this area are a huge opportunity to nurture innovation and change the way we will explore in the future. Strategic alliances can be formed where the federal government is a partner, not necessarily the lead "agency." NOAA's Office of Exploration and Research is very good, but why are they in the best position to be charting the course? We need to create an environment that incentivizes philanthropic participation, industry, coastal states, etc. The exploration community must prove its ability to move quickly, removing the stigma that things move slowly when they are largely government funded.

Our Breakout Group offers these technology ideas:

- Use multiple autonomous subsurface vehicles capable of seafloor mapping. These vehicles should be deployed, and supported, from ships-of-opportunity for baseline studies. The international oil and gas community is already working with subsurface and surface autonomous systems for mapping and assorted scientific echo-sounder work from "mother ships." Innovative leading systems such as those designed and in use by Saildrone, ASV Global, and Kongsberg are readily available at a fraction of the cost of legacy systems built in university labs still in use today with outdated technology and high manpower demands.
- Software development, massive computing power (high performance) and artificial intelligence should be pushed to the front.

Continually improve public engagement. Establish a campaign Joint Information Center supported by partners and led by key financial stakeholders to build campaign awareness and make the campaign and its data results accessible through trending channels. Periodic findings-of-significance must be big, loud, and visual to keep the public's interest.