Accelerating deep-sea expedition leadership via a new COBRA Master Class

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Understanding the deep ocean is critical, now more than ever. For example, the rapid development of industrial-scale tools for mining of deep seafloor mineral deposits has outpaced the scientific understanding of the environmental impacts, which could rival or exceed in scale the impacts of fishing. Likewise, there is accelerating interest in carbon sequestration below the seafloor as a strategy to mitigate climate change, but short- and long-term effects are poorly understood. The Crustal Ocean Biosphere Research Accelerator (COBRA, https://cobra.bigelow.org/) is a US National Science Foundation (NSF)-funded initiative to accelerate research on the structure, function, resilience, and ecosystem services of the crustal ocean biosphere – the rocky parts of the seafloor such as deep-sea seamounts, hydrothermal vents, volcanic crust, and manganese nodules – to inform decision making.

Accelerating deep-sea research to meet these societal needs requires having a broader community of deep-sea expedition leaders. To train future ocean leaders in inclusive ocean exploration, policy, research, and data accessibility, in 2022, COBRA launched its inaugural virtual COBRA Deep Sea Expedition Leadership Master Class. This 13-week course equipped early-career Fellows with the skills and tools to successfully design, propose, and execute deep-sea oceanographic field research, with a collaborative, just, equitable, diverse, and inclusive approach. To plan expeditions,

Figure 1. 2022 COBRA Master Class Fellows and Core Instructors

Fellows engaged in topics related to choosing the appropriate deep-sea research asset for their project, learning how to find funding and write proposals, develop concepts respectfully with regard to geographic and cultural considerations of their intended study sites, and work through an essential checklist of pre-cruise planning and operations. At-sea expedition training included details of at-sea operations and ship-board etiquette, the strengths and challenges of telepresence, and data management. For post-cruise training, Fellows were introduced to a variety of data types and analyses, including data management strategies, and also discussed cruise report development and agency reporting needs. Throughout the Master Class, Fellows also discussed education and outreach, international ocean law and policy, and the importance and unique joys and challenges of team science. The Fellows were compensated for their participation. The course will be held annually for at least five years, each time contributing content freely and publicly (https://cobra.pubpub.org/) to make these topics accessible to all.

Through these Fellows, their networks, and the accompanying open-access materials, COBRA hopes to enlarge and diversify the community of scientists engaged in deep-sea research, policy, and engagement. The push for ocean exploration is primarily driven by a fundamental need to understand our planet and its ecosystems, but it is also driven by the increased potential for ocean exploitation as well as ocean conservation. In recognition of this urgency, we are in the midst of the UN Decade of Ocean Science for Sustainable Development. We invite all interested future deep-sea expedition leaders to apply for and engage with materials from the COBRA Master Class, in an effort to accelerate scientific understanding of deep-sea crustal ecosystems and their resilience to inform decision making, prevent serious harm, and provide benefit to society.

NGO Beneath The Waves launches expansive deep-sea biodiversity monitoring throughout The Caribbean

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Researchers at the NGO Beneath The Waves and University of West Florida have embarked on an ambitious project to survey patterns of biodiversity throughout some of the most poorly-studied deep-sea ecosystems on earth. Prior to 2022, Beneath The Waves had performed a series of preliminary deep-sea biodiversity assessments throughout deep waters of several Caribbean islands including The Bahamas, Turks and Caicos, and The Cayman Islands. These findings prompted the need for more expansive and systematic efforts to survey regions for which almost no biological information currently exists.

The research team uses a combination of non-invasive deep-sea landers (Fig. 1A) and environmental DNA, in addition to targeted specimen collection. They will apply a suite of molecular assays to quantify several aspects of community structure, gene flow, and identify major energetic pathways supporting faunal biomass. In 2022, initial sampling throughout The Tongue of The Ocean and northwest Exuma Sound, The Bahamas has revealed that deep-sea communities adjacent to the regions extensive carbonate banks, house an incredible diversity and abundance of large fauna. The team has observed and sampled several species of deep-sea elasmobranch, including bluntnose sixgill sharks, gulper sharks (Fig. 1B), Cuban dogfish, and sharpnose sevengill sharks (Phillips *et al*. 2019). Also common were giant isopods (*Bathynomus* sp, Fig. 1C), including the newly described species *Bathynomus maxeyorum* (Shipley *et al.* 2016). These species will be the focus of genetic barcoding to explore patterns of gene flow with neighboring regions, such as the Gulf of Mexico.