Duke Restore at Reef Futures

This December, two members of DukeRestore's Coral Team, Nicolas Dávalos and Elizabeth Kroger, had the opportunity to attend the Reef Futures conference in Quintana Roo, México, with the support of Duke Restore. Reef Futures is an annual gathering dedicated to coral research and conservation, and this year brought together over 800 coral scientists and conservation practitioners. Nicolas and Elizabeth had the chance to connect with coral restoration practitioners, scientists, and government officials, to bring new knowledge and collaborations to Duke Restore, as well as learn about new and upcoming techniques to use in their careers.

Nicolas Dávalos (left) and Elizabeth Kroger (right) at the Reef Futures Conference at Iberostar

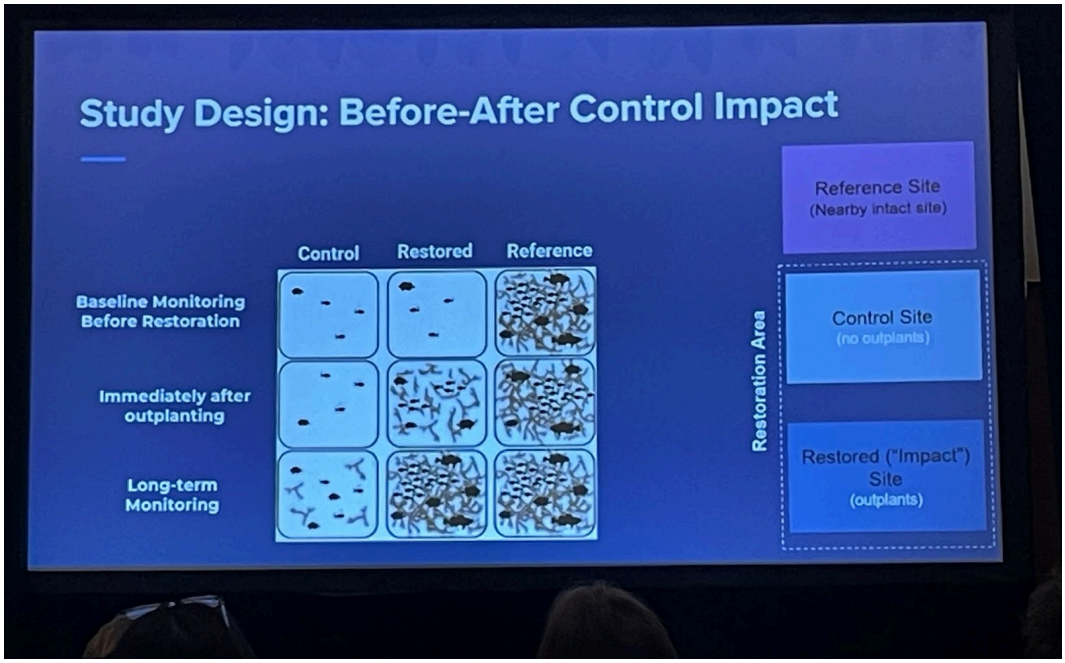
The conference was held at an Iberostar hotel, which is a hotel group committed to responsible tourism and sustainability. They focus on circular economy, nature-based

solutions, climate action, blue foods, and destination stewardship. The property was free of all single-use plastics and instead had purified water fountain systems and all reusable cutlery and plates. We were also impressed to learn that 100% of the seafood served at Iberostar in Mexico is responsibly sourced, and that they have their own coral restoration project right in front of the hotel. After attending this conference, we are curious to continue learning about the ways that international conservation gatherings like these can reduce their carbon and waste footprint as well as create positive local impact.

The Iberostar Convention Center, where the conference was held

A highlight of the conference was attending the workshop “Restoring with Intent: Site-specific Planning Scenarios for Pacific Islands Coal Restoration” which provided participants the opportunity to plan a coral restoration project using real case studies. First, we reviewed the steps of a site assessment, which included disturbance history and restoration need, environmental conditions and accessibility, historical coral community, and proximity to nursery or source corals. Next, we learned about the study design needed

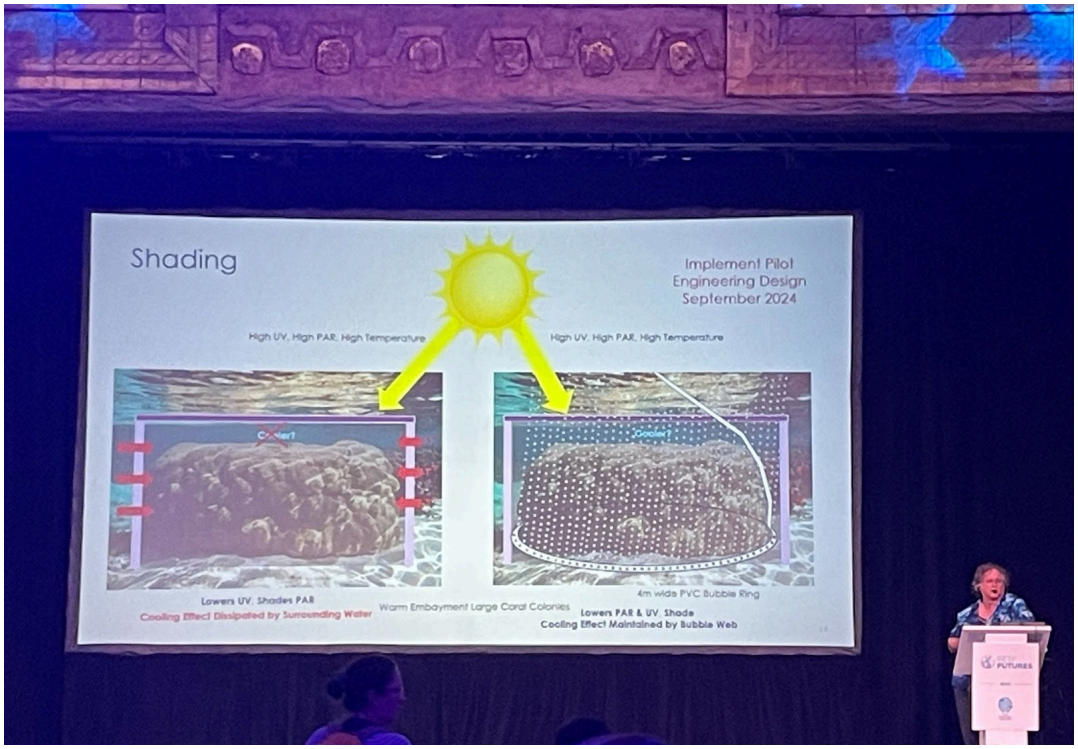
to effectively monitor a coral restoration project, with a control (unrestored) site that was damaged, a test (restored) site that was damaged, and a reference (undamaged) site. We then worked in teams to create a restoration plan for a site in Guam which had been affected by a hurricane, using a SMART (specific, measurable, achievable, relevant, time-bound) goal and 4 objectives to guide us. The factors we considered in the design were the intervention strategy (coral gardening/outplanting, larval seeding, coral predator management, macroalgae removal, etc), the species of coral used, the coral source, accessibility to the site, and more. We also considered the longevity of the project, both ecologically but also financially and socially, discussing ways to involve volunteers and the community in restoration and provide educational opportunities to ensure the restored site is properly cared for. At the conclusion of the workshop we created a timeline for the project, including steps like permitting, hiring/training, procurement of gear, baseline data collection, and piloting, all before the actual implementation of the project. This workshop was insightful as to the need to spend significant time planning in order to have a successful and long-lasting restoration project.



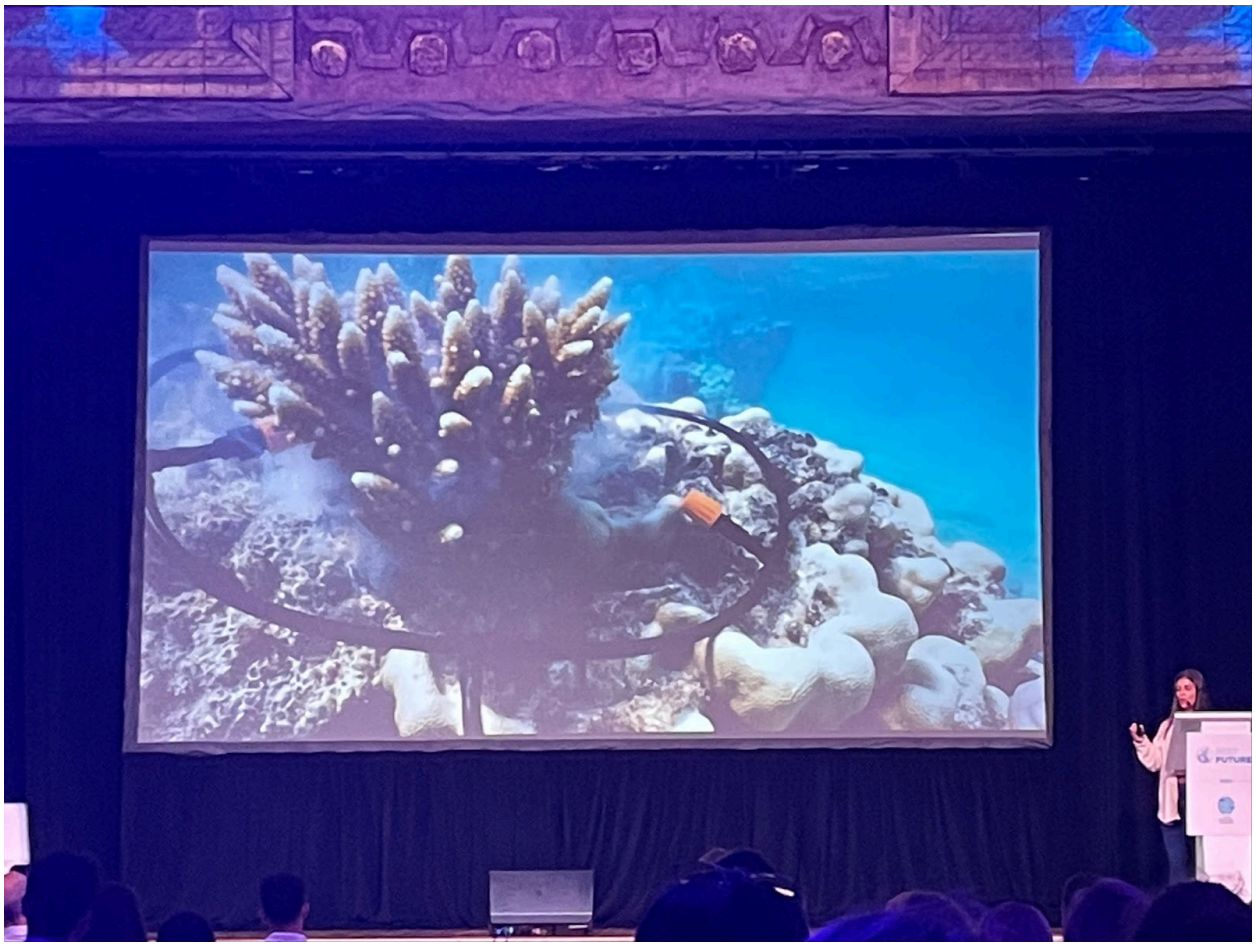
Study design for monitoring of a coral restoration project

Elizabeth's main takeaways and learnings from the conference were related to coral bleaching prevention. Coral bleaching occurs when corals experience warmer-than-usual temperatures that cause them to expel an algae which lives in their tissues called zooxanthellae. Zooxanthellae and coral have a symbiotic relationship where the algae performs photosynthesis, producing sugars that provide the coral with over half of the

nutrients they need, and the coral provides shelter as well as some of the essential inputs for photosynthesis. Therefore, when corals lose this algae, they not only lose their color that the algae provides, but also a significant food source, which can lead to mortality. Elizabeth enjoyed attending a presentation which detailed recent improvements to and discoveries about coral bleaching prevention techniques like shading and cool water mixing, where corals are physically shaded to protect them from excess heat from the sun, or cool water is pulled up from the depths to mix with warmer water and reduce the temperature during warming events. She learned that when shading corals, placing a device that creates a bubble ring around the coral colony and shading structure enables the water under the structure to stay cooler, because it is more difficult to mix with the warmer water outside. She was also excited to learn more about the way coral probiotics can affect survival. Corals have a microbiome which protects their health and includes bacteria, viruses, fungi, and algae like zooxanthellae. This microbiome contributes to nutrient cycling and provision, pathogen control, and zooxanthellae health. A recent study presented by Helena Villela of King Abdullah University of Science and Technology (KAUST) found that probiotic-treated corals had a 79% survival rate whereas un-treated corals had a 61% survival rate. It is always exciting to learn about coral research with positive results that demonstrate all the techniques we have in our toolkit to improve coral reef health.



Shading structure above coral colony to prevent or reduce bleaching, presented by David Gulko



Probiotics being released onto a coral colony in the Red Sea, presented by Helena Villela

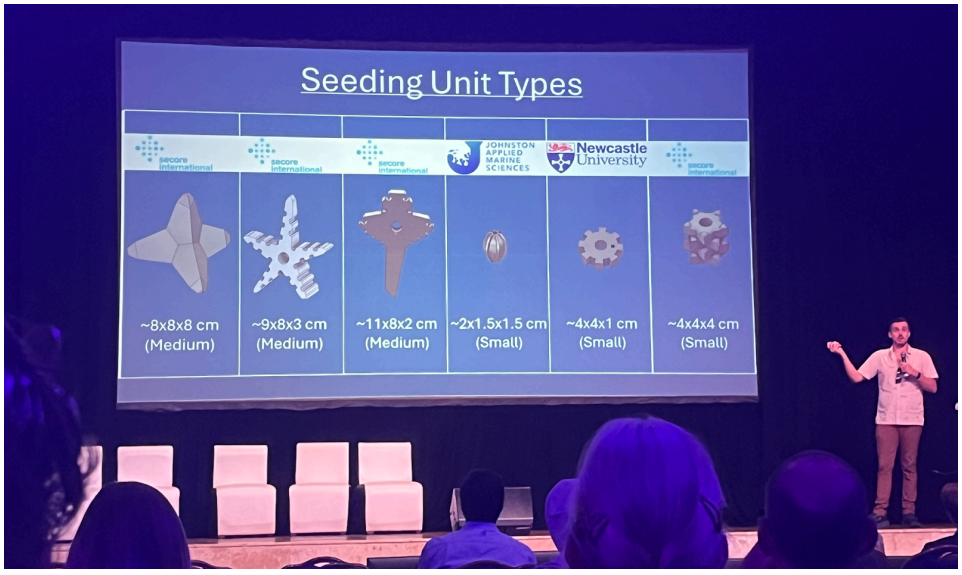
Nicolas is a coral restoration practitioner who founded and leads the organization Reef Revival in the Galápagos Islands. His interest in the conference was immediate, given the opportunity to network and learn about new technologies and innovations in the field. Nicolas's work was highlighted by his colleague and former advisor, Dr. Margarita Brandt, in a presentation titled *"Coral Gardening in the Eastern Tropical Pacific: A Case Study from the Galápagos Islands***."** The presentation showcased the results of Galápagos Reef Revival, featuring his research on coral seasonal growth and survivorship, as well as the restoration impact and potential in the islands.

Nicolas also participated in the workshop titled *"The Eastern Tropical Pacific Coral Restoration Network,***"** a group that has been part of the Coral Restoration Consortium's Regional Practitioners since 2019. This network aims to enhance collaboration and explore mechanisms to address scientific, conservation, and funding challenges for coral

restoration across the region. The workshop facilitated the development of a functional network for practitioners in the Eastern Tropical Pacific (including Mexico, El Salvador, Costa Rica, Panama, Colombia, and Ecuador), fostering alliances and creating a platform for sharing the work being done by its members. Additionally, the workshop established a new board of directors and updated the network's members and organizations. This provided Nicolas not only the opportunity to become a formal member but also to forge valuable connections and create collaboration opportunities with researchers from across the region.

One of the main highlights of the conference for Nicolas was learning about the latest advancements in coral restoration. Reef Futures is renowned for its groundbreaking scientific research, cutting-edge technology, and innovation. Notable topics included coral biorepositories, reef acoustic playback systems, AI models for coral monitoring, scalability technologies, and novel restoration materials.

During the exhibit titled *"Novel Materials and Structures,"* Nicolas had the chance to showcase a prototype he has been testing with ReefCycle, a Duke-led bio-cement startup focused on developing a sustainable substrate for coral restoration and coastal protection. ReefCycle's innovative approach was quickly recognized as an excellent solution for producing sustainable, carbon-negative, enzyme-based cementing materials, ideal for remote locations with limited infrastructure. This method attracted significant interest from other restoration practitioners, including SECORE engineers, who saw the potential for integrating this technology into their seeding units (larval recruitment structures).



SECORE seeding unit types

Additionally, entrepreneurs like Dr. Ulrike Prfeundt, lead scientist and CEO of rrreefs—a Swiss-based enterprise specializing in 3D-printed artificial reef structures—recognized the material's great value for advancing reef restoration projects. The versatility and sustainability of Reefcycle’s technology make it a promising and practical solution for tackling challenges in reef restoration and coastline protection.

Nicolas Davalos sharing ReefCycle prototype with Fernando Bretos - Chair of SECORE International and National Geographic Explorer

Nicolas’s participation in the conference provided valuable opportunities to share his work, connect with experts, network, form collaborations, and explore new approaches to coral restoration.

Reef Cycle prototype being implemented in the field.

Attending Reef Futures highlighted the importance of innovation in advancing reef conservation, with technologies like Reefcycle, engineering systems like deep water pumps, and even medical techniques like coral antibiotics offering valuable potential. By engaging with peers and learning from the latest developments in the field, Reef Futures served as an excellent platform for us to grow as conservationists and restoration practitioners.