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AUGUST 2024



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Q&A: Don Walsh

Technology Aids Marine Conservation

Spotlight on Five Pew Marine Fellows

By Nathan Fedrizzi

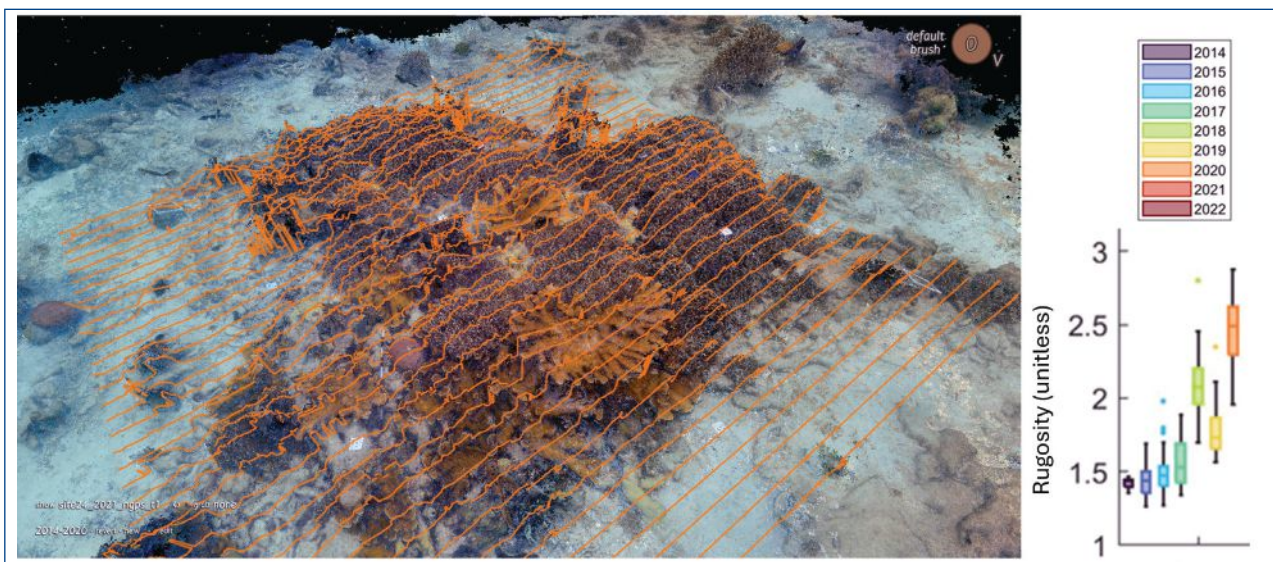
Technological innovation is critical to advancing marine conservation and sustainable resource management. The development of new high-tech tools can improve ocean monitoring, data collection and scientific analyses, efforts that aid in the protection of marine ecosystems through better surveillance, enforcement and

restoration. These advancements can also enhance public engagement and awareness, contributing to better informed and more proactive conservation practices.

Throughout the world, scientists supported by the Pew Fellows Program in Marine Conservation are leveraging groundbreaking technologies to address pressing envi-

A full-page photograph showing a diver in a dark wetsuit and fins swimming horizontally over a vast, textured coral reef. The water is clear and blue, with sunlight filtering down from the surface. The diver is holding a camera, and a small pink buoy is visible in the distance.

Arthur Gleason demonstrates photo acquisition during his underwater photomosaic training class in Belize. (Credit: Ana Giro)



Digital 3D models allow for improved measurements of the seabed. For example, divers traditionally measure rugosity, or roughness, on centimeter-to-meter scales using chain transects or profile gauges. This slow process is time consuming and hard to replicate year to year. With digital models like the one shown here from a coral reef restoration site in Belize, measurements can be precisely replicated over time and spread out over space, thereby estimating not only rugosity but the variance in rugosity across a site. (Credit: Arthur Gleason)

ronmental challenges, from coastal habitat restoration in East Asia to coral reef conservation in the Caribbean to European aquaculture sustainability. With support from this prestigious program, which seeks to improve ocean health through high-quality research, scientists Juan Patino-Martinez, Arthur Gleason, Emi Uchida, Marine Cusa, and James Kar-Hei Fang use cutting-edge tools to drive marine conservation initiatives and address urgent problems plaguing the world's oceans.

Satellite Telemetry and Marine Megafauna Tracking

Cape Verde is home to one of the largest nesting colonies of endangered loggerhead sea turtles. These majestic animals face numerous threats to their survival, including fisheries bycatch, habitat loss and pollution. Tracking the turtles is essential to understanding their migratory patterns, foraging behavior and habitat preferences. It's also important in helping scientists identify areas where the turtles are most likely to face threats from human activities. However, current tracking technologies, such as biologging telemetry instruments that are typically attached to the turtles' shells, remain costly and, as such, are often inaccessible.

Juan Patino-Martinez, a 2023 Pew marine fellow and scientific coordinator at the Maio Biodiversity Foundation in Cape Verde, works to redefine the landscape of marine megafauna tracking through the development of affordable, open-source satellite telemetry devices. With a primary focus on sea turtles, Patino-Martinez's innova-

tive approach uses satellite technology to meticulously monitor the movements and behaviors of these highly mobile marine creatures.

In a 2023 study in the *African Journal of Sea Turtle Biology and Conservation*, Patino-Martinez and fellow researchers explain the advances in technology that have enhanced our understanding of loggerhead turtles. The researchers use small temperature data devices to investigate the effect of temperature variation on turtle eggs in nesting beaches. Infrared night-vision cameras are used to assess the natural behavior of predators, such as ghost crabs. The team also uses drones to monitor turtle nesting activities in remote regions.

These methods are coupled with the scientists' own technological innovations, including integrating video technology with tracking equipment to enhance research on sea turtle habitat use while overlaying turtle movement tracks with data collected from fishing vessels to help determine and reduce the risk of harmful interaction with sea turtles.

"[T]hrough the progressive integration of technological innovations, we have facilitated data acquisition and enhanced data quality, ultimately improving research efficiency and accuracy," Patino-Martinez and his co-researchers wrote in the study. "We have developed more accessible and efficient technological tools for tracking and observing marine migratory species."

"The design, implementation, and widespread dissemination of technological innovations applied to conservation will enable global efforts, promoting collaboration within information networks and effective synergy between conservation and technology experts," the researchers added.

Underwater Landscape Mosaics For Coral Reef Conservation

Caribbean coral reef ecosystems face unprecedented threats, including climate change, overfishing and pollution. Monitoring the health of coral reefs is critical for effective conservation. However, traditional methods, such as line transect surveys—in which divers assess coral

“The underwater landscape mosaics of Arthur Gleason, a 2020 Pew marine fellow and research associate professor at the University of Miami, are a paradigm shift in coral reef monitoring.”

cover along lines across the substrate—lack the precision and scalability needed for comprehensive monitoring.

The underwater landscape mosaics of Arthur Gleason, a 2020 Pew marine fellow and research associate professor at the University of Miami, are a paradigm shift in coral reef monitoring. This emerging technology can measure—in stunning detail—how well various methods to conserve and restore the Caribbean coral reefs are working. The approach uses software and cameras to assemble and analyze large-scale composite images of reefs, enabling scientists to efficiently track the fate of individual coral colonies over time and the composition of entire communities on the ocean floor.

"A major goal of coral reef restoration is the resumption of critical ecosystem services, including shoreline protection, creation of fish habitat and biodiversity maintenance. Hard coral coverage and rugosity [or, roughness] are two key drivers of these ecosystem services," Gleason explained. "The underwater photogrammetric

models that I've been making are wonderful tools for quantifying and monitoring both of these values, among other things."

By precisely monitoring coral reef health, biodiversity and structural integrity, Gleason's research provides crucial data for evidence-based decision making and the formulation of targeted conservation strategies. Scientists who participate in Gleason's training workshops on the use of underwater photogrammetry will also be able to send their images to a digital archive. This collaborative effort will help determine how to best scale active reef restoration initiatives and create conditions favorable for natural coral reef rehabilitation.

Predicting Changes in Coastal Habitats And Designing Proactive Restoration Solutions

Coastal habitats, such as mangroves and seagrasses, in the western Pacific Ocean's Coral Triangle provide numerous ecological and socioeconomic benefits, includ-

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ing coastal protection and carbon sequestration. However, these vital ecosystems are threatened by habitat loss, pollution and climate change.

“To reverse the losses effectively and efficiently, decision makers need reliable predictions of future threats and defensible evidence on the cost effectiveness of management practices,” said 2024 Pew marine fellow Emi Uchida, a professor of environmental and natural resource economics at the University of Rhode Island.

Uchida’s research is a pioneering effort in the application of remote sensing and social experiments to rigorously assess the effectiveness of conservation interventions. She employs remote sensing technologies, coupled with machine learning and econometrics, to identify degradation hotspots and the impact of local policies, and to predict future at-risk areas. Uchida aims to develop models that can forecast future changes in coastal habitats. These predictive models can then be used to design and assess proactive management strategies for the purpose

of reducing the risk of man-made environmental stressors while promoting ecosystem resilience.

Collaborating with local communities when addressing the problem of mangrove and seagrass loss is key to success, Uchida says, since many of the ecosystem services these coastal habitats provide directly affect people’s livelihoods—from fisheries and coastal protection services to beekeeping and other conservation endeavors. Through this approach, Uchida hopes to give local stakeholders and policymakers the knowledge and tools they need to ensure the long-term sustainability of coastal habitats.

“By working with the communities,” Uchida said, “we can better understand the values of these ecosystem services and their variation across and within communities. And by quantifying these values, we can get a [fuller] picture of the benefits of conservation and restoration—and better justify the efforts to reverse the losses of mangrove forests and seagrass meadows.”



(Left to right) Dried fish samples to be analyzed using genetic tools. (Credit: Marine Cusa) Marine Cusa uses genetic tools to evaluate seafood fraud on the European market. (Credit: Charles Baillie) Marine Cusa uses genetic tools to investigate the shark trade in Indonesia. (Credit: Bruno Cusa)

Enhancing Transparency in Aquaculture Through Genetic Tools

The aquaculture industry plays a significant role in global food production but also poses challenges for ocean sustainability. In Europe, most of the finfish aquaculture sector—in which fish are raised in closed pens or other contained areas—is devoted to farming carnivorous fish such as salmon, which are typically fed diets that include some amount of fish meal often from other small wild-caught fish. These small species are the primary prey for many larger marine animals and play a key role in ocean food webs. As such, ensuring the responsible sourcing of these fish feed products and the conservation of forage fish populations is important for ocean health and essential for the long-term sustainability of aquaculture operations.

Marine Cusa, a 2024 Pew marine fellow and policy adviser at Oceana in Denmark, aims to enhance transparency and sustainability in European aquaculture

through the integration of advanced genetic tools. With a specific focus on forage fish populations and the sourcing of fish feed products, Cusa employs state-of-the-art genetic techniques to trace the origins of forage fish used in aquaculture feeds and promote accountability within the sector.

By leveraging DNA-based tools, Cusa works to develop streamlined methods for species identification and traceability, thereby encouraging the responsible management and conservation of marine resources. Through collaborative partnerships with industry stakeholders, regulatory agencies and conservation organizations, Cusa's research seeks to foster a culture of transparency and stewardship in the aquaculture industry.

"I hope this research will provide transparency on the origin of aquafeed products, informing decision making and preventing the entry of unethically sourced fish into the market," Cusa said. "I aim to empower individuals, influence policies and hold the aquafeed industry ac-

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3D Imaging Technologies for Pearl Oyster Restoration

Pearl oyster reefs, once abundant in Hong Kong waters, have declined significantly due to overexploitation and coastal development. The loss of these habitats not only impacts biodiversity, but also undermines the ecological and economic resilience of coastal communities.

James Kar-Hei Fang, a 2024 Pew marine fellow and associate professor at Hong Kong Polytechnic University, focuses on spearheading pearl oyster restoration efforts in Hong Kong, with a dual emphasis on ecological revitalization and economic resilience. Recognizing the ecological significance of pearl oyster reefs as critical habitat for marine biodiversity, Fang employs innovative culture methodologies and advanced 3D imaging to aid in restoring degraded habitats and to help assess how the oysters contribute to ecosystem health by acting as a substrate for other organisms. By engaging with local communities, fishers, students and policymakers, he aims to develop sustainable aquaculture practices that promote the recovery of pearl oyster populations while enhancing ecosystem services and supporting local livelihoods.

“Knowing that this project can provide additional income to local fishermen and inspire conservation awareness among students brings a sense of purpose to my research,” Fang said.

Through his interdisciplinary approach and commitment to conservation-driven innovation, Fang seeks to establish a model for sustainable aquaculture and coastal resource management that can be replicated in other regions facing similar challenges.

Advanced technologies are transforming marine conservation by enabling more precise and effective ways to protect the world’s oceans. Scientists supported by the Pew Fellows Program in Marine Conservation are spearheading this technological innovation, helping to better predict, monitor and address environmental issues, and ensuring that marine ecosystems remain resilient and sustainable for future generations. Through their groundbreaking research and collaborative efforts, these experts are at the forefront of new approaches to ocean conservation, instilling hope for a brighter, more sustainable future for the oceans—and the communities that depend on them. **ST**

Nathan Fedrizzi is a principal associate at the Pew Charitable Trusts. He implements the Pew Fellows Program in Marine Conservation.

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