Innovation in underwater science – how a simple camera transformed the scientific diving community

Shortly after the advent of commercially available SCUBA diving equipment in the 1960s, scientists took a giant stride forward in our understanding of ocean environments. Before SCUBA diving, we could only get a glimpse the underwater world via organisms and habitats that were brought to the surface. After the creation of SCUBA diving equipment, we could now enter this world and see these environments first-hand. In a matter of years, science was transformed by the ability to directly observe and manipulate marine habitats, allowing our knowledge of these systems to grow exponentially. Fast forward 30 years, and SCUBA-equipped scientists are still largely using the same tools for data collection – SCUBA equipment, waterproof paper, a pencil, and our eyeballs.

The invention of small, affordable digital cameras in the early 2000s marked a second wave of scientific advancement for diving researchers. Prior to this, scientists attempted to use underwater housings for film cameras. Unfortunately, these film-based cameras were limited to 24 photos, meaning you had to be very selective in what you photographed, and crossed your fingers that the subjects were in focus! The creation of digital cameras has afforded researchers the ability to more freely, and frequently, document the underwater world for later analysis back on land. While such a seemingly simple advancement, this innovation has revolutionized the underwater sciences.

The greatest limitation to scientific divers is how long we can remain underwater – at best, an hour or two per dive, and usually no more than 3-4 dives a day due to safety constraints. When you only have a fixed amount of time, efficiency becomes one of the highest commodities – how can you do more in the same amount of time? Digital cameras pushed that efficiency needle into overdrive. Now, we can take hundreds or even thousands of photos and hours of high-resolution video in that limited time, then spend hours or weeks analyzing them once back at the surface.

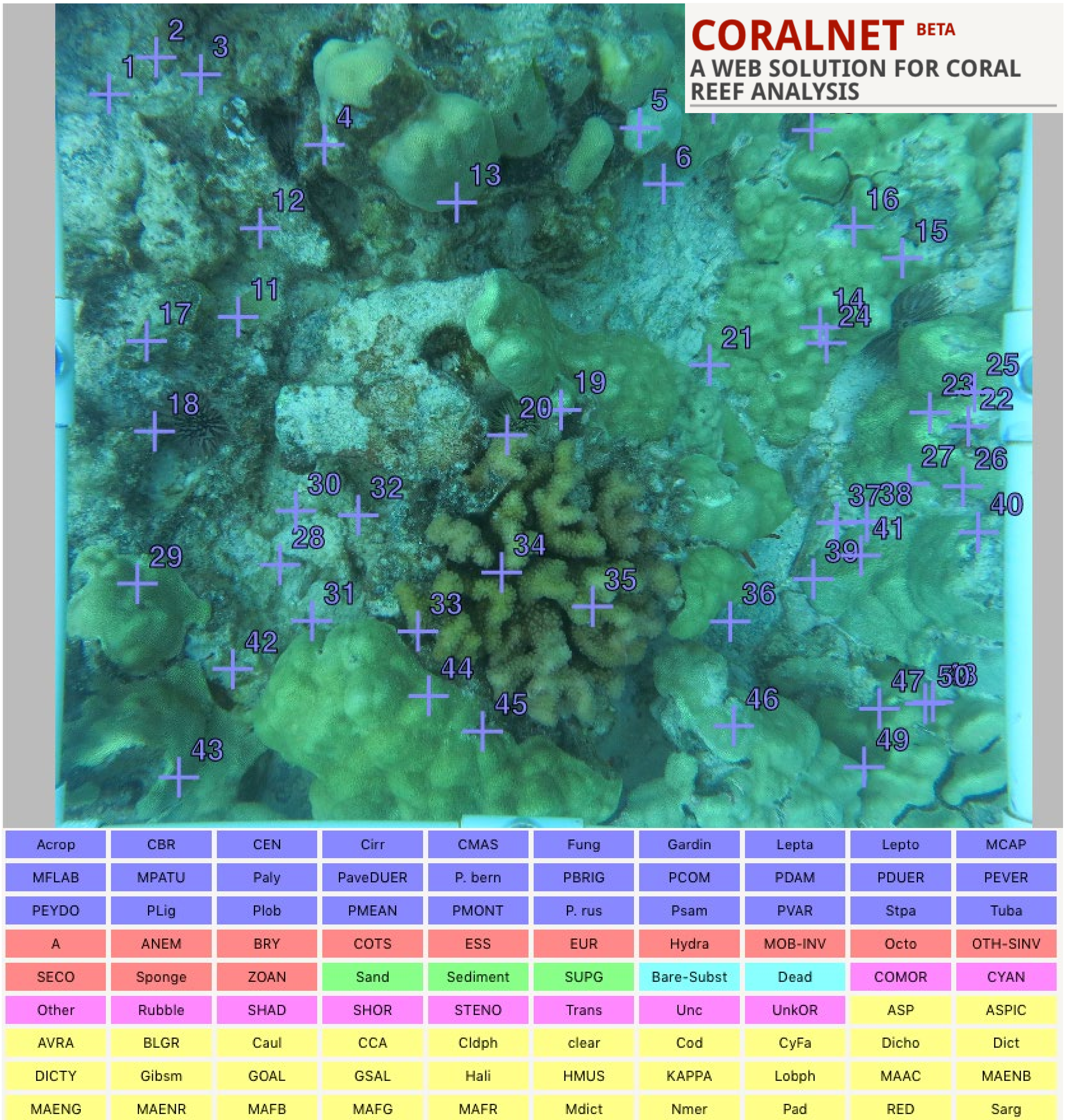
But you may still be thinking - how does a simple digital camera revolutionize science? This simple technological advancement has unleashed a slurry of innovation by bringing together underwater scientists with computer scientists – two facets of research that up to now, have never really had a reason to collaborate. The ability to generate lots of data requires new ways to look at and analyze systems, allowing scientists to think bigger, dream bigger. This simple innovation has inspired entire new fields of underwater science, merging once disparate disciplines into creative collaborations. For example, marine ecologists and archaeologists are now able to create 3-D maps of the seafloor or shipwrecks using a new technology called structure from motion (SfM) photogrammetry, all created using simple digital cameras. OSU's Marine Mammal Institute is even employing 3-D photogrammetry to non-invasively study sea lion morphometrics such as body mass index.

Marine scientists are also utilizing machine learning and artificial intelligence to recognize algae, invertebrates, corals, and even fish from photographs to enable analysis of thousands of photos/videos in a very short period of time. By pairing two digital cameras together, researchers have developed ways to create stereoscopic (3-D) video footage that can accurately record and measure underwater organisms in 3-dimensional space.

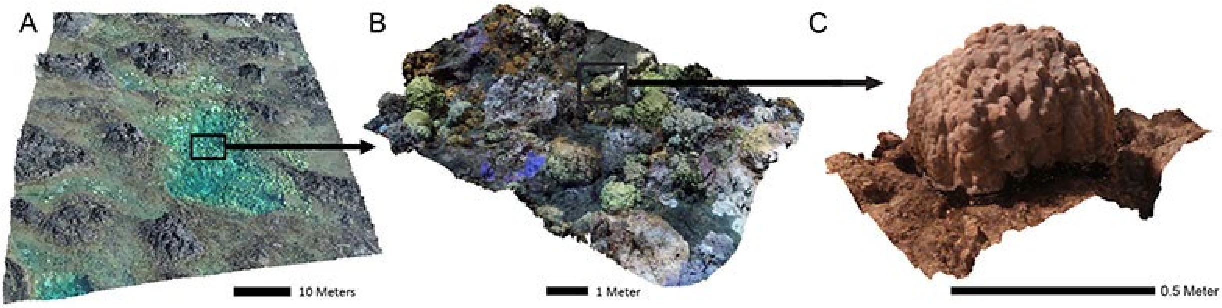
How is this innovation used in our "backyard"? The Oregon Marine Reserves ecological research program conducts extensive subtidal monitoring along the Oregon coast and uses digital cameras in nearly every facet of their scientific efforts. A long-term collaboration between OSU researchers, OSU's scientific diving program, Oregon Coast Aquarium, and the Oregon Department of Fish and Wildlife's (ODFW) Marine Reserves team has resulted in robust SCUBA-based monitoring efforts. Through this collaboration, we have designed a deployable camera system (video lander) that can take high-definition video footage to monitor fish and habitats, collecting useful information on species-habitat relationships and often times, providing excellent outreach video when charismatic critters come to check out the cameras. We have also designed a stereoscopic camera system (3-D video) to accurately measure the size of fish encountered during our survey dives. The Marine Reserves longline fishing surveys employ a digital camera to track and record fish caught and provide a timestamp to which we can then match with GPS data to accurately record when and where fish are caught. And perhaps the most technologically advanced camera system is employed by the ODFW habitat team via the use of a remotely operated vehicle (ROV). The ROV contains multiple high definition digital cameras as well as a stereo camera system that have the ability to record hours of high-resolution video from habitats too deep for SCUBA divers to safely access. The combination of high definition cameras and a dual laser system allows scientists to accurately identify, count, and measure the size of organisms. In short, these small digital cameras enable us to maintain a robust scientific monitoring program for Oregon's nearshore habitats.

To take a quick look at the Marine Reserve tools in action and see the excellent video they provide, check out these links:
https://www.youtube.com/watch?v=qVNEoRRqOEo&feature=youtu.be&t=42
https://oregonmarinereserves.com/2016/03/30/lander-pilot/
https://oregonmarinereserves.com/2016/06/30/stereo/
https://youtu.be/jYuDzwCJfeQ
https://oregonmarinereserves.com/2019/07/10/rov/
https://youtu.be/dgDEtGmiC20
https://oregonmarinereserves.com/2016/08/12/lens/

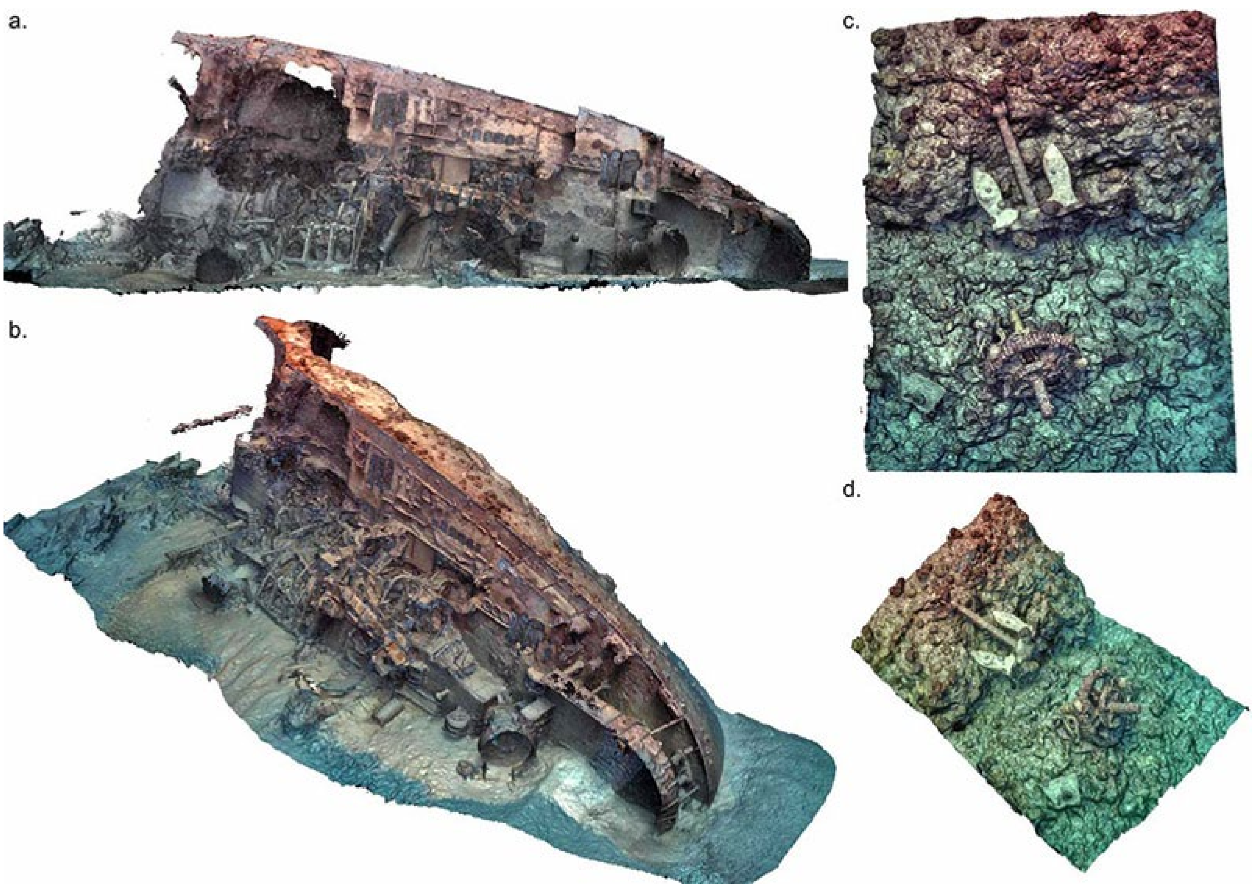
If you are curious to learn more about Oregon's Marine Reserves, visit oregonmarinereserves.com.



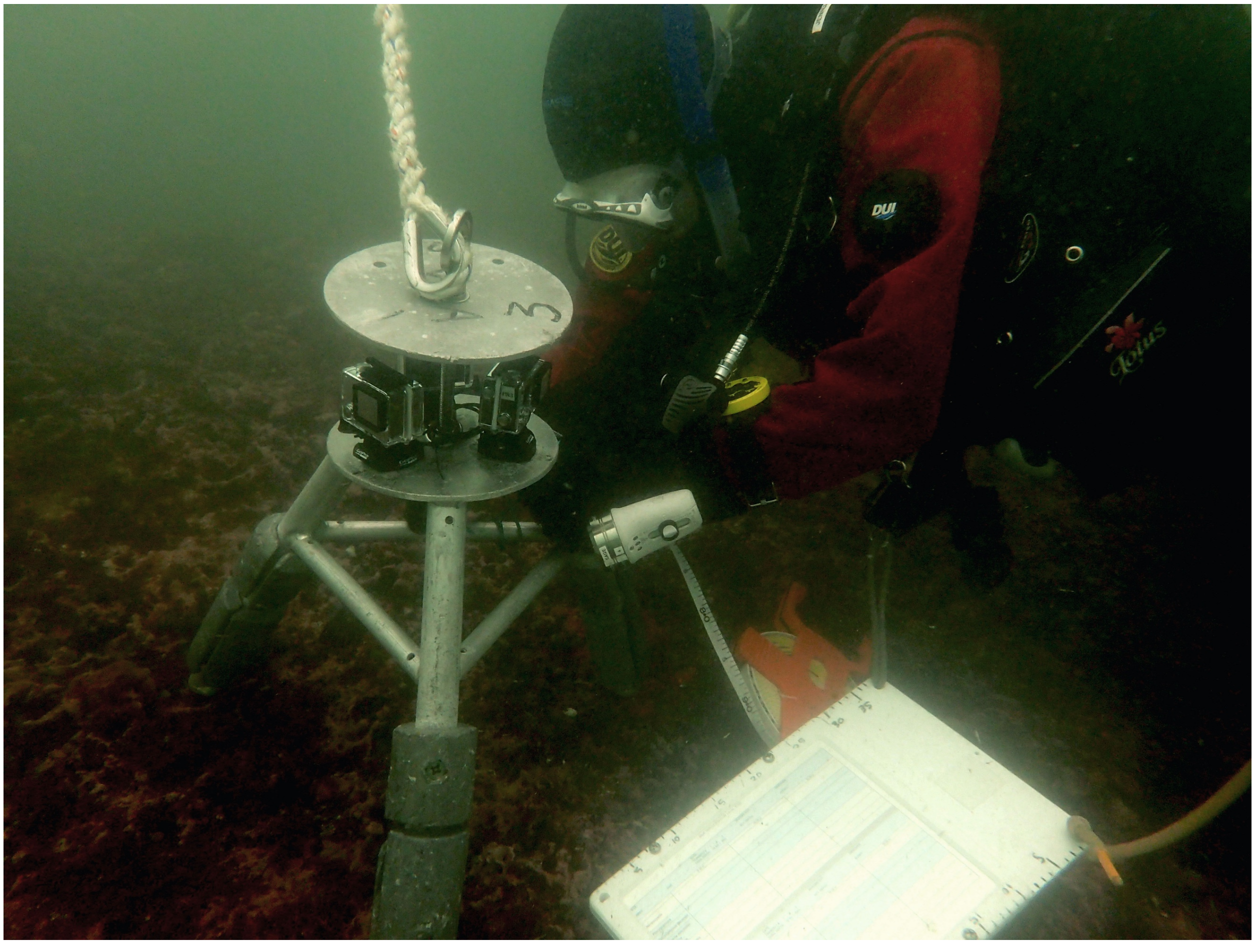
Machine learning algorithms such as CoralNet are used to automatically identify individual coral and algal species, as well as multiple habitat parameters via a randomized series of points overlaid onto a photograph. Colored boxes indicate species identified underneath each point in the photo.



Structure from Motion (SfM) photogrammetry allows scientists to stitch together digital photos/video to produce high-resolution 3-D imagery. Above, a digital representation of a coral reef in the Hawaiian Islands at multiple scales; a) 10 meter section, b) 1 meter section, c) 0.5 meter section (compliments of J. Burns, University of Hawaii Hilo).



Structure from Motion (SfM) photogrammetry allows scientists to stitch together digital photos/video to produce high-resolution 3-D imagery. Above, a digital representation of components of USNS Mission San Miguel, which sank in the Northwestern Hawaiian Islands (adapted from Price et al. 2016).



An Oregon Marine Reserves research diver utilizing the video lander system. Note the old-fashioned underwater paper and pencil still being employed by scientific divers. Photo courtesy of Oregon Marine Reserves.