

Validating scuba as research methodology

Scuba diving conducted by scientists is an invaluable research tool. Since its advent in the 1950s, placing the trained scientific eye under water on compressed gas has provided research value and flexibility that unmanned systems often could not. One metric substantiating this value is provided by peer-reviewed scientific publications in high-impact journals of research that could not have been performed without the use of scientific diving techniques.

Safety concerns have gradually eroded our depth limit to what has become a 60msw compressed air scuba window for scientific diving in the United States. The U.S. Department of Labor's Occupational Safety and Health Administration does not restrict the scientific diving community with regard to technology, leaving us the operational flexibility to utilize mixed gases, rebreathers, and saturation habitats in our research methodology to meet the Nation's marine science needs. More often than not this research is conducted in challenging and remote environments under polar ice caps, from research vessels at sea, or at atolls far removed from immediate medical assistance. Yet exposure statistics document that these research activities are performed to a remarkable degree of safety and scientific productivity.

Access to the underwater research site is provided by scuba and we are in continuous pursuit of technology to expand our operational window within acceptable safety limits. For example, shallow-water coral reefs are well understood, as are the linkages between adjacent mangroves and sea grass beds and their contributions to the reef ecosystem. Akin to limiting a tropical rainforest

biologist from climbing higher than 10m (thereby missing the majority of biodiversity that resides in the canopy), a scientific diver cannot effectively study the biodiversity and contributions of the deep reef to the shallow-reef system because of current technology and training limitations. Our understanding of the reef ecosystem *in toto* is, therefore, vastly impaired. Advanced tools such as rebreathers are not new technology but, with their surge in popularity in the technical diving community, we are hopeful that engineering solutions will support their increased reliability and reduced maintenance effort.

The Smithsonian Institution, the National Science Foundation, and the Ocean Studies Board of the National Research Council convened a symposium in May 2010 in Washington, DC to celebrate the scientific contributions and value of scuba as research methodology. ***Research and Discoveries: The Revolution of Science through Scuba*** symposium presented research findings by U.S. scholars with particular focus on the scientific contributions accomplished using self-contained underwater breathing apparatus. This symposium was the first major effort to highlight and validate the use of scientific diving techniques by evaluating the scientific output of this research through high-impact journal publications. During the two-day event, fifty scholars discussed their papers on research findings and discoveries from around the world on coral reefs, blue-water environments, under-ice polar habitats, temperate kelp forests and other sites of interest. This effort further supported the integration and validation of



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scientific diving within the overall science domain.

Overarching symposium themes were to celebrate the highlights of past, present and future scientific diving contributions since the introduction of scuba to the science community in 1951, and to evaluate the accomplishments and impact of underwater research in major scientific disciplines to our

overall understanding of nature and its processes. Exemplars of the first generation of scientific diving research include Paul Dayton's groundbreaking ecological work under Antarctic ice sheets, Bill Hamner's pioneering studies of gelatinous zooplankton in blue waters of the open ocean, multidisciplinary long-term phylogenetic studies by Mark and Diane Littler, crustacean behavioral ecology research by Bill Herrnkind, kelp forest ecological work by John Pearse and Mike Foster, and baseline establishing coral reef research by Ian Macintyre, Peter Glynn, and Chuck Birkeland.

Approximately thirty years after the advent of scuba an-

other research tool, molecular techniques, made itself more generally available to marine scientists. Used complementarily these two tools offer broad techniques to further our understanding of biodiversity, systematic and genomics. An increased trend in biopharmaceutical work and understanding chemical defenses of marine organisms, harmful algal bloom outbreaks and invasive species has also urged more scientists to don scuba gear and work under water. In an era of increasing occurrences of multiple stressors on coral reefs, deep-time geological studies show patterns and trends of previous episodic events. Of course, it continues

to be difficult to understand ecological processes and interactions, and the functioning of nature itself in the underwater environment without actually immersing oneself in it to make first-hand observations and data collections.

Symposium results will be disseminated to scholars and the public through publication of the symposium proceedings volume in the *Smithsonian Contributions to the Marine Sciences* series by Smithsonian Institution Scholarly Press. In the mean time, the symposium web site (WWW.SI.EDU/SDS) contains abstracts, speaker bios and presentation video clips.
