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Celebrating more than 56 years of serving the global ocean community - Since 1963 -

editorial

Mark Stoeckle and Jesse Ausubel, *The Rockefeller University*

The eDNA Revolution

Marine environmental DNA (eDNA) promises a widely applicable method for monitoring ocean animal life. Results demonstrate loose DNA in small volumes of saltwater suffices to identify reliably the species nearby and to provide an index of their abundance. eDNA is easy and cheap to collect and costs little to analyze, and collection does not harm animals or their environment.

The first steps are collection of water (typically 1 liter), filtration to concentrate particulate matter, and extraction of DNA. DNA can then be analyzed by a "metabarcoding" approach that targets all species in a taxonomic group (such as vertebrates), or by assays that target single species. Typical cost is $20 to $50 per sample, and turnaround time is days to weeks for metabarcoding and hours to days for single-species assays. Hundreds of experiments have now proven the method, and all steps will improve. Kits will become smaller and software for analysis more user-friendly. Within a few years, devices on underwater instruments could filter and sequence "on board."

eDNA will help meet demand for environmental assessment associated with increases in aquaculture, oil extraction, wind energy and shipping, for example. We expect eDNA will be a routine component of fish stock assessment, detection of invasive species, and monitoring effects of coastal storms and climate change. The method will facilitate a shift from episodic surveys to ongoing monitoring, a future with eDNA "weather stations" reporting daily on local marine fauna. It revolutionizes the ability for people to know, affordably, what lives in the waters near them.

Limits include absence of information on individuals, for example, size, weight and age. More work is also needed on how presence of eDNA relates to nearness and abundance of organisms, and differences among species, by season, local weather and DNA dispersal and degradation in different environments. Other factors possibly modifying eDNA signals are: presence of eggs, sperm or larval forms; dead or injured individuals; substances that interfere with DNA analysis; extraneous DNA from wastewater; and potential deliberate contamination.

Integrating eDNA into existing marine surveys can efficiently lift understanding and identify study priorities. Ongoing research is examining whether quantifying eDNA is better done by precisely measuring the DNA in a single sample or by analyzing presence/absence in multiple samples; the choice may differ by environment and species.

The method is as good as existing genetic reference libraries. For scale, consider that for nearshore fishes in northern temperate regions, 90 percent of species have reference sequences in GenBank. Pelagic, deepwater and tropical fishes are less well represented. Some closely related species cannot be distinguished by the short (100 to 200 base pair) mitochondrial DNA segments typically analyzed in eDNA studies. The enormous diversity of marine invertebrates challenges broad approaches.

About 100 American ocean scientists and associated stakeholders assembled in New York City for a conference (bit.ly/2HR4xTI) sponsored by the Monmouth University-Rockefeller University (MURU) Marine Science and Policy Initiative in November 2018. Participants came from academe, government, nongovernmental organizations and the private sector. Discussions proved the maturation of the U.S. marine eDNA community, revealed fast-increasing applications, and called for a national marine eDNA program sparked by the National Ocean Partnership Program, which embraces the many federal agencies for which eDNA will become indispensable.

For 30 years, genomics has been a sea technology on the horizon. eDNA is now rushing into our pipes, channels and ducts. It excites the marine science community and public with the capacity for current information on what lives where and could greatly improve operational decision making and regulation. For the marine eDNA community and stakeholders, the message is clear: Get going. **ST**