VII. TECHNOLOGIES FOR THE FUTURE OF CORAL HEALTH

POTENTIAL TECHNOLOGICAL DEVELOPMENTS FOR CORAL DISEASE MONITORING

Melissa Bos
Hawaii-Pacific Coordinator of the Alliance for Coastal Technologies

The Alliance for Coastal Technologies (ACT) is a NOAA-funded partnership of research institutions, state and regional resource managers, and private sector companies interested in developing and applying technologies for monitoring and studying coastal environments. The long term goal of ACT is to be a national resource for facilitating the transition of sensor technologies to routine use in monitoring and studying coastal environments. ACT was established to serve as a comprehensive information clearinghouse on technology performance, a forum for capacity building, and an unbiased, third-party testbed for evaluating coastal sensor technologies. ACT strives to provide products such that the coastal observing community is able to identify and select technologies that are appropriate for their needs and capacities, technology developers have tools for trend identification and targeted marketing, and that the latest, innovative, and most effective technologies are continuously integrated into observing capabilities.

ACT is organized to ensure geographic and sector involvement. The program is headquartered at the University of Maryland's Chesapeake Biological Laboratory, and there are currently eight ACT Partner institutions around the country with coastal technology expertise that represent a broad range of environmental conditions for testing. The ACT Stakeholder Council is comprised of resource managers and industry representatives who ensure that ACT focuses on service-oriented activities. Regional chapter Alliance Members provide advice to ACT and are kept abreast of ACT activities.

The Hawaii-Pacific Partnership is housed at the University of Hawaii, Hawaii Institute of Marine Biology. This relatively new partnership is striving to assess the needs of the region before full-scale implementation throughout the entire region. More information on current ACT activities throughout the nation can be found at www.act-us.info.

Preliminary ACT assessments revealed that coral disease monitoring is emerging as a critical issue in Hawaii and the broader Pacific. Current monitoring programs are often limited by the number of trained professionals who can do in situ assessments of coral disease status. In situ assessments require skilled personnel and are time consuming.

Technological advancements have allowed many types of coastal monitoring programs to increase precision and efficiency, and to decrease the number of people, training of those people, and overall program expense. Tools can increase the number of lesser-trained personnel who can be involved in a program, often enabling community participation, and can decrease the number of experts who have to be involved in the entire monitoring effort. This is especially true for a parameter like coral disease which requires a very high skill level for in situ determination. Monitoring technologies tend to increase precision, allowing measurements to be taken by multiple individuals with reduced observer error.

Accuracy may be increased or decreased by switching to or adding in technology-based monitoring, so program managers should be aware of the level of accuracy needed to meet their goals, such as to establish a baseline or temporal trend, or to trigger management actions. Program managers should also consider what factors are limiting to them in developing a monitoring program: number of people, training level of people, operating budget, capital expense budget, equipment, analysis abilities, etc. Evaluating these limits can assist in the determination of what tools are best for their situation.

ACT Hawaii-Pacific is not aware of any existing technologies that have been specifically designed for coral disease monitoring. Many tools used in other coastal monitoring programs may be useful to coral disease monitoring, and many existing technologies used in diverse applications may be adapted for specific coral disease use. The best strategy is to build upon existing technologies and identify what adaptations are necessary for coral disease monitoring needs.

The first four things that coral disease experts and managers should work together to identify are 1) the best set of parameters to be measured, 2) sampling frequency, and 3) preferred method of deployment (in-situ mooring, hand-held, etc.), and 4) level of accuracy required. For the parameters that are proxies or indicators for disease, e.g. a water quality parameter, determine if an existing tool is able to sample at your required frequency, deployment type, and accuracy. A comprehensive database of existing sensors can be found at www.act-us.info.

For parameters that do not have adequate existing sensors, the next phase is to determine if any sensors exist that could be easily adapted to coral disease monitoring needs. If a tool already exists for the parameter, but the frequency, deployment type, or accuracy is not satisfactory, scientists and managers can collectively voice their needs to industry and ask for a modification. ACT was created to be a liaison between these communities and can assist in these discussions and negotiations.

If no sensors exist for a chosen parameter, an analysis of tools used in related fields may identify places to start. For example, if a manager needs to be able to spot-check for the presence of a particular bacterium, one can ask, what other fields are interested in spot-checking bacteria levels? Public health and bioterrorism experts come to mind. Perhaps tools that have been developed in those fields could be adapted by changing the bacterium of interest. Once a similar sensor is identified, the process of negotiating with industry begins.

This likelihood of success for convincing a company to modify a tool or create a new one depends on the collective finances available to purchase the tool. If only a few individuals would be able to purchase the tool, it is not likely that industry could justify the expense. This is one key reason that the global coral disease monitoring community would benefit from standardized protocols. If, however, this approach does not work, a researcher may be able to create a tool and produce it on small scale using a federal grant for technology development. Several of these opportunities exist.

Consideration should be given not only to identifying the correct sensors, but also to data analysis protocols/tools and personnel training. ACT Hawaii-Pacific is poised to assist will all of these questions and hopes to facilitate some of the necessary discussions.

LEVERAGING POST-GENOMIC TOOLS AND SYSTEMS BIOLOGY APPROACHES TO ACCELERATE THE UNDERSTANDING OF CORAL DISEASE AND EFFECTIVELY MONITOR THE HEALTH OF TROPICAL REEF ECOSYSTEMS

Eric J. Mathur
Consultant, J Craig Venter Institute & Synthetic Genomics Inc; Delegate, EO Wilson Biodiversity Foundation; Founder, Diversa Corporation

Biotechnology can no longer be considered a new scientific discipline; molecular and genomic innovations have progressed dramatically and continue to advance at unprecedented rates. No longer is there simply the promise of how these new technologies will one day help solve biological problems; already there exists many tangible examples of biotechnological success stories in fields ranging from aquaculture to transgenic plants, from fermentation sciences to animal health, and from biocatalysis to solutions for alternative energy.

Moreover, the development and refinement of molecular methods is beginning to impact our understanding of basic biological processes, including coral bleaching and the health of tropical reef ecosystems. In the context of genomics, DNA sequencing costs have plummeted more than three orders of magnitude resulting in the availability of complete genome sequences for over 300 microorganisms and representative genome sequences available for most eukaryote lineages. Furthermore, the dramatic reduction in sequencing costs has catalyzed the development of a new method which involves direct sequencing of uncultured microbial communities and organismal consortia. This environmental sequencing strategy, also known as metagenomics, utilizes genomic principles to glean information and understanding from such complex biological processes as symbioses and host:pathogen relationships. Metagenomics can also be used to evaluate and quantify the metabolic potential of a given environment and even serve to identify nucleic acid, protein and small molecule-based probes which can monitor spatial and temporal metabolic changes within a defined ecosystem.

In addition and complementary to genomics, improvements and recent progress in proteomics and metabolomics now enable one to pose scientific questions which utilize genomic and metagenomic sequence data sets as reagents to help understand and unravel the physiological and biological consequences of an ecological perturbation, such as coral bleaching. Collectively, these strategies make use of extremely sophisticated molecular tools to revisit the age old concept of *gestalt* biology, which views biological systems as complex, multi-organism, complete ecosystems which respond cooperatively to given environmental circumstances. Improvements and advancements of these genomic and systems biology tools will be reviewed and the ramifications toward understanding of coral disease and monitoring ecosystem health will be discussed.

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