Exploring New Technology Horizons

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On April 20, 2010 the Deepwater Horizon drilling rig exploded, killing 11 people and causing 4.9 million barrels of crude oil to be released into the Gulf of Mexico. The Gulf oil spill is the largest marine oil spill in history and will result in long-lasting impacts to the economy and the environment of the Gulf coast. The nation's experts on oceanic and atmospheric science have been on the scene from day one, providing coordinated scientific, weather, and biological information, advice, products, and services when and where they are needed most. Although the well has been capped, efforts to understand and mitigate the full consequences of the spill will require a long-term, sustained, and coordinated effort. Experts must determine how the oil will impact marine and coastal ecosystems; how to ensure seafood safety and the safety of the men and women who make their living on the waters of the Gulf; and how to protect and restore the wildlife and habitats affected by the spill. The use of autonomous underwater vehicles (AUVs) to monitor the spill represents one of the *Deepwater Horizon* spill's many technological firsts for the nation. AUVs, such as ocean gliders, form part of an integrated subsurface monitoring effort. They are used to locate and track oil at various levels in the water column, as well as on the water's surface. Glider technology collects data throughout the water column at relatively low cost and at no risk to human life. The regional partners of the U.S. Integrated Ocean Observing System (IOOS®), for which the National Oceanic and Atmospheric Administration (NOAA) is the lead federal agency, are using AUVs to capture data on temperature, salinity, and additional variables. These data not only indicate the presence of oil, but also assist scientists in predicting the complex Gulf circulation patterns that can affect the movement of subsurface oil. Scientists are analyzing the glider data against water samples in the region. The data and information from the gliders are available from a single website portal operated by Rutgers University (rucool.marine.rutgers.edu/deepwater/).

In 1989 Hank Stommel published an article in which he dreamed of fleets of unmanned gliders.[1] While we have not reached the fleet stage, we have, in fact, embarked on a path that brings us closer to realizing his vision. Today, many of the IOOS regions and academic partners are beginning to make glider operations routine. For example, the Applied Physics Laboratory at the University of Washington has developed long-endurance, autonomous gliders that have seen successful operation in the ice-covered environment of the Davis Strait in winter. In 2009 Rutgers flew a glider across the Atlantic. The mission spent seven months at sea and served as a major advancement for ocean data collection technology because it allowed critical data collection in the middle of the ocean at lower cost and lower risk to human life than ever before. Scientists were able to correlate these data with those from satellite imagery and altimetry. As a result, scientists improved the global oceanographic circulation model by showing that the model was predicting conditions that did not exist. Along the west coast of the United States, IOOS partners in California are using gliders to track spatial and temporal patterns of algal blooms and to forecast La Niña conditions. IOOS gliders have been conducting surveys of the Mid-Atlantic Bight (MAB), a coastal region that runs from Massachusetts to North Carolina. In the past three years the glider fleet has conducted 22 missions spanning 10,867 kilometers and collecting 62,824 vertical profiles of data. During the response to the *Deepwater Horizon* spill, up to nine underwater gliders were routinely providing data about conditions in the water column to 1,000 meters for up to 100 days without interruption. The United States Navy awarded a contract to Teledyne Webb Research in 2009 to purchase 150 gliders which they will begin operating in the upcoming year.

Researchers are also exploring how to use animals as platforms for ocean sensors to help scientists better understand marine organisms and the ocean environment. Animals can travel to regions and depths of the oceans we can't necessarily get to, either physically or with equipment. By using animals to collect data, we can see their habitats through their eyes and get a more accurate picture of animal behavior, foraging "hotspots," key migration routes, and the interaction between organisms and their ocean habitat. Moreover, animals are "smart" platforms that not only deliver biological information, but can also relay physical ocean data from the areas they inhabit. The type of animals typically tagged—charismatic, ocean megafauna such as sharks, whales, sea turtles, and large pelagic fish—tend to inhabit oceanographically interesting places, including upwelling zones, seamounts, canyons, and shelf edges. Breakthroughs in the use of animal-borne sensors (ABS) began in the 1990s with the Tagging of Pacific Pelagics (TOPP) program and its development of a Conductivity Temperature Depth (CTD) tag. Those breakthroughs were "supported by advances in computer and satellite technology that increased the amount of data a tag could hold and made data accessible remotely."[2] This progress in tagging and computer and satellite technology has resulted in ABS becoming a powerful and efficient tool for collecting oceanographic data. When attached to animals, the electronic tags transmit their locations and coincident oceanographic data to satellites or bottom-mounted stations in near-real time. The tagged animals retain these inexpensive sensors for months or, even years as they carry out their life cycles. The sensors can be deployed and tracked in large numbers. ABS is particularly effective at providing insight into remote and difficult conditions where conventional oceanographic sensing techniques are technologically or economically unfeasible. For instance, the Southern Elephant Seals as Oceanographic Samplers (SEaOS) project in the Southern Ocean around Antarctica collected more than 24,000 temperature profiles at depths of up to 2,000 meters.[3] This approach can provide a thirty-fold increase in the availability of temperature and salinity profiles from the sea-ice zone,[4] critical information in a changing ocean.

A whole new class of wave gliders uses waves to power across the ocean's surface. Along with the new classes of unmanned vehicles, this technology leaves us at the water's edge of realizing Hank Stommel's vision. At the same time, innovation in animal-borne sensors will allow us to see through the eyes of some of the ocean's most interesting creatures.

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