Hurricanes Katrina and Rita
AND THEIR IMPACT ON THE OCEAN SCIENCE COMMUNITY

AS THIS ISSUE of *Oceanography* was being finalized, the ocean delivered two catastrophic punches to the United States Gulf Coast. Within a three-week period, two major hurricanes, Katrina and Rita, slammed ashore with 100+ mile an hour winds and unprecedented tidal surges. For those of us watching the disaster and aftermath unfold through the news media and through accounts from friends and relatives, the scope of the damage and the socioeconomic impacts are impossible to comprehend. Like everyone else, the oceanographic community was heavily impacted. Several coastal marine laboratories and field stations were destroyed or heavily damaged; aquariums and other educational facilities are total losses. It has been reported that about 40 percent of the Naval Oceanographic Office/Naval Research Laboratory employees located at Stennis Space Center (in Mississippi, approximately 45 miles from New Orleans) either lost their houses or are facing many months of reconstruction before they are habitable. Many of our colleagues have been dispersed across the country with family or friends or remain in hotels. As a consequence, concern has been expressed that expertise may be lost if employees decide to move elsewhere permanently. Time will tell what the long-term social and economic impacts will be and what the human and natural systems recovery will look like.

As devastating as these storms were, the Katrina and Rita events highlight several aspects of modern oceanographic research and provide some unique opportunities for future studies. Although the initial genesis of the two storms in the Atlantic Ocean was somewhat unpredicted, their movement through the Gulf of Mexico and eventual landfall was predicted with amazing accuracy by the National Hurricane Center. Whatever the response in the coastal communities may or may not have been, the hurricanes' arrival was not a surprise. Taxpayer investments in basic oceanographic research, in satellite and remote observational systems, and in mathematical modeling certainly paid off in the ability of forecasters to predict the path of these monster storms.

However, there is still much to be learned about the processes that lead to hurricane generation and intensification. In the past few years, new instrumentation (e.g., neutrally buoyant and profiling floats with additional mixing and shear sensors, acoustic rain gauges, oxygen probes) has been developed for deployment in the forecast path of hurricanes to quantify the exchange of heat, momentum, and gases between the ocean and atmosphere. Because these platforms observe from beneath the ocean surface, they have a much higher survival rate than surface buoys and will enable researchers to observe the before, during, and after phases of hurricanes passing through warm water masses. Being better able to quantify air-sea exchanges in hurricanes using these new technologies will lead to further improvements in our ability to predict hurricane intensity.

Within a few days of when Hurricane Katrina struck, the oceanographic community started work to identify areas of research to study the aftermath of the storms. Several U.S. agencies, including the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the U.S. Geological Survey (USGS), the Office of Naval Research (ONR), and others, set in motion activities to conduct assessments of environmental impacts and monitoring. The hurricanes represented a major disruption to natural, or at least stable, environmental systems. The response of those systems and their recovery represent opportunities for interdisciplinary oceanographic research. Several broad topical areas come to mind:

1. How do major hurricanes impact the resuspension and redistribution of nearshore sediments, both mineral and organic matter?
2. What is the impact on benthic shellfish and demersal finfish populations, and how is the survival of recently settled larvae and juveniles affected?
3. To what extent and by what pathways are chemical and biological contaminants from urban environments, industrial complexes, water and sewage treatment facilities, and previously buried nearshore sediments released and redistributed onshore and offshore.
4. When human enteropathogens are released into marine waters following a major storm, are they still viable infectious agents? How do environmental factors, both storm-generated as well as quiescent, impact the open environment ecology of these pathogens? What are the potential open environment reservoirs in which infectious agents are most likely to survive for an extended period of time?
5. Under what circumstances do major storms and flooding promote harmful coastal algal blooms and proliferation of infectious agents (e.g., Vibrios) nearshore? How is human exposure and the incidence of disease impacted?
6. What new chemical or biological tracers might be used to quantify the extent to which municipal water, sewage, and open coastal waters have infiltrated one another?
7. In terms of historical and present-day land-use patterns, how do channel (canal) construction and wetland state relate to the dynamics of flooding and regional erosion?

Another potential area of research involves barrier islands and wetlands. The coastal marshes of Louisiana, Mississippi, and Alabama provide many natural services. They buffer the coastal communities from modest storm surges associated with typical non-tropical storms, serve as nursery grounds for extensive fisheries, both commercial and sport, and provide the habitat for other important species, such as oysters. These marshes have been severely degraded by Hurricanes Katrina and Rita. Added to this direct impact are the loss of barrier island protection from future wave erosion and long-term reduced resiliency because of previous manmade alterations to the local hydrology from levee building and canals. A natural experiment created by the hurricanes offers the opportunity to quantify and understand both the importance of these marsh services and to study the adjustment of the coastal ecosystems to a significant episodic change.

Looking toward the future, the devastation wrought by Hurricanes Katrina and Rita suggests some opportunities to conduct multidisciplinary oceanographic research. This type of research is The Oceanography Society's primary interest. Future issues of *Oceanography* will inform the community about hurricane-related research findings. Results of these studies, and the increased understanding that accompanies them, can be used to better inform decision-makers.

As interesting as they may be scientifically, I do not wish any more of these major storms on anyone. We have had quite enough for now!

LARRY CLARK, TOS PRESIDENT