

## 2009 Annual Report: WHOI Partnership with King Abdullah University of Science and Technology (KAUST)

After just two years, the collaboration of WHOI and King Abdullah University of Science and Technology (KAUST) is already reaping scientific benefits. The past two years of research have increased our understanding of the hydrography of the Red Sea and its influence on the chemistry, biology and fisheries of coral reefs.

The second year of the WHOI-KAUST collaboration has included scientific advances in the 13 research projects and the inauguration of the University by King Abdullah in October 2009. WHOI President and Director Susan Avery and Jesús Pineda represented WHOI at the inauguration and symposium. They were joined by thousands of other Saudi and international guests. The opening of the University has accelerated the collaboration and transfer of scientific expertise between WHOI and KAUST scientists.

Tom Farrar has collected one full year of hydrographic and meteorological data from the WHOI-KAUST onshore meteorological tower and the offshore mooring, and collection of a second year of data is underway. These data and those from near-shore pressure gauges deployed by Richard Limeburner are being used to look at seasonal wind patterns over the Red Sea and how they affect seasonal along-shore and cross-shelf currents. The meteorological data are being used by Ru Chen, WHOI graduate student, to study the influence of wind jets on the general circulation and currents in the Red Sea. Data from the deployed instruments are also being incorporated into a circulation model and a high-resolution tidal model developed by Larry Pratt and colleagues. The models are being transferred to KAUST in collaboration with KAUST postdoctoral researchers.

The role of hydrodynamics on reefs and coral biology is being investigated in several studies. On the central Saudi coast near KAUST, the coral reef crests are shallow, relatively narrow and are aligned parallel to the shore. Waves and the dominant wind push water from the exposed side of the reef, over the top of the crests, to the protected shoreward side. WHOI postdoctoral scholar Kristen Davis is investigating the influence of wind and waves on the currents that move water over the reef. She is working with Steve Lentz and Jim Churchill, who are measuring cross-shelf hydrodynamic forces that affect currents and heat flux on reefs. They have found that offshore water is on the reef crests for about one hour, and there are diurnal differences in temperature on the reefs. Pineda and Davis are also investigating diurnal and seasonal small-scale temperature differences on the reef crests and on offshore and near shore reefs.

Pineda and Vicke Starczak have conducted a field experiment to investigate the response of coral to these temperature changes. Ann Tarrant and post-doctoral investigator Adam Reitzel have analyzed coral samples from different locations on reefs and from this experiment, and preliminary results indicate that symbiont diversity differs among reef sites that are exposed to different temperature regimes.

Water sampling and analysis by Dan McCorkle has provided a picture of the immediate chemical environment of the corals, and the influence of the reefs on seawater chemistry. Nutrient availability and seawater carbonate chemistry help explain patterns of coral calcification and growth. Analysis of water samples shows that the surface waters of the Red Sea are strongly supersaturated with respect to the calcium carbonate mineral aragonite, a situation that promotes coral calcification.

Anne Cohen, WHOI postdoctoral investigator Neal Cantin, and Tarrant are developing and applying new tools to quantify the impacts of climate change and direct anthropogenic activity on the health of coral reefs in the central Red Sea. Reef-building corals and calcifying algae contribute up to 90% of the reef's calcium carbonate budget through the process of skeletal building. Their project addresses the impact of rising sea-surface temperatures, ocean acidification and nutrient loading on the ability of regionally important reef-building coral species to build skeletons. Results from their coral samples link changes in coral growth over the past decade to rising sea-surface temperatures, which suggests that CO<sub>2</sub>-induced climate changes have begun to negatively impact coral reef health in this region. Using their data in the Intergovernmental Panel on Climate Change (IPCC) model projections of future climate changes, they hope to predict changes in the Red Sea coral reef ecosystem over the coming century.

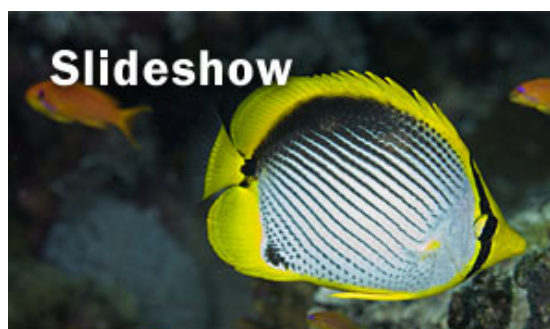
Konrad Huguen and colleagues have been conducting molecular analysis of lipids in coral zooxanthellae, symbiotic algae that live within coral hosts, to develop novel indicators of coral health. They have been studying the relative abundance of healthy and diseased corals in



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Many corals and other marine animals contain dinoflagellate symbionts that provide nutrition to the host from photosynthesis. These symbionts can be expelled from the host following exposure to elevated temperature or other stressors, resulting in a pale appearance or "bleaching." This partially bleached soft coral was observed in relatively deep waters (50 ft) during an August trip to the Red Sea. (Photo by Ann Tarrant, Woods Hole Oceanographic Institution)

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the Red Sea in order to relate stress factors such as temperature, turbidity and pollution to the distribution patterns of coral Yellow Band Disease. They are also analyzing trace metals in long drill cores obtained from massive coral colonies to reconstruct sea surface temperatures back more than 400 years.

Rapid ecological surveys of coral-reef ecosystems in Saudi waters were conducted to broaden coverage to include the Farasan Bank region of the southern Red Sea. The survey team was led by Simon Thorrold and KAUST scientist Michael Berumen, and included an international team of coral reef experts. They documented an abundant and diverse assemblage of corals and fishes. As part of Thorrold's study of fish connectivity, Kelton McMahon, an MIT/WHOI Joint Program student, is analyzing stable isotopes in fish otoliths (ear bones) to determine movement patterns of snapper among mangrove, seagrass and coral-reef habitats in the Red Sea. He finds that seagrass beds may be more important than mangroves in fueling productivity in coastal ecosystems of the southern Red Sea. Thorrold and collaborators are also tracking movements of large fish: They have successfully tagged seven whale sharks. The tags are due to report in the spring of 2010, and will provide the first glimpses of whale-shark movements in the Red Sea.

Hauke Kite-Powell, Porter Hoagland, Di Jin, Andy Solow, and Michael Neubert are working with officials of the Saudi Arabian Ministry of Agriculture to assemble a detailed data set on fishing effort and catch along the Saudi Red Sea coast, and are incorporating these data into a bio-economic model of the Saudi Red Sea traditional fishery. Their preliminary results suggest that the present fishing fleet and fishing activities may be too large to sustain fish stocks at optimal levels. This work will expand to include additional data on the southern (Jizan) region traditional and industrial fisheries. The team will also assist Saudi Ministry of Agriculture officials in their efforts to improve collection of data on commercial and recreational fishing, provide advice on the design of management measures for protected areas in the Farasan Islands and provide input to design of research studies and management measures for a proposed reef protected area near KAUST.

The success of the research collaboration will continue into next year, with greater opportunities for interactions between WHOI and KAUST scientists, postdoctoral researchers and students.

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