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2008 Annual Report: WHOI Partnership with King Abdullah University of Science and Technology (KAUST)

The shore of Thuwal, Saudi Arabia, a small fishing village north of Jeddah, is also the location of King Abdullah University of Science and Technology (KAUST), a new, international graduate-level research university providing opportunities for study and research in engineering, marine science and in chemical, material and mathematical sciences.

Even before the foundation for the University was poured in Thuwal, SA, KAUST established its first scientific partnership, funding a range of projects with WHOI as part of its Special Academic Partnership program, which is part of KAUST's Global Collaborative Research initiative . The objective of the partnership was for WHOI scientists to begin research projects in the Red Sea that would result in sharing scientific knowledge and the research experience between scientists, technicians, engineers and students of the two institutions.

The ensuing 14 multi-year projects include studies on the ecology and chemistry of coral reefs and fishes, coral health and growth, nutrient and carbonate chemistry of the Red Sea, air-sea dynamics, currents, large-scale circulation in the Red Sea and the development of a bio-economic model for Red Sea fisheries. As KAUST buildings emerged on shoreline, the breadth of expertise amongst WHOI's scientific and technical staffs, and the strength of WHOI's research infrastructure (ship operations and shipping) allowed researchers to start fieldwork quickly, with an impressive suite of modern oceanographic tools to study the Red Sea firsthand.

Enlarge Image

Through a research agreement with King Abdullah University of Science and Technology, WHOI scientists are studying coral reef ecosystems, fisheries, and water circulation along Saudi Arabia's Red Sea coast. WHOI scientists – including MIT-WHOI Joint Program student Jessie Kneeland, shown measuring a large coral – are assessing the health of extensive coral reefs and identifying environmental factors affecting them. (Photo by Konrad Hughen, Woods Hole Oceanographic Institution)

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WHOI News Release

» Agreement Opens Door to Red Sea Research
from *Oceanus* magazine

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» The KAUST Red Sea Marine Sanctuary
Promotional video

Hydrography

Heat exchange between the air and the ocean is an important component of atmospheric and oceanic dynamics. To measure heat exchange in the Red Sea, Tom Farrar led the first WHOI KAUST Red Sea cruise on the R/V *Oceanus* in October 2008, accompanied by Susan Avery, Larry Madin, other scientists, technicians and engineers and KAUST staff. About 55 km (34 miles) offshore of the KAUST campus, Farrar and the engineering team deployed a metrological mooring carrying instruments that send real time measurements of surface meteorology, radiation, surface waves and ocean temperature, and salinity. Results thus far indicate that the strong land-sea breeze may contribute to the large evaporation rate (1.3 m or 4.3 feet of water in 6 months) near the coast. Larry Pratt, Houshuo Jiang and collaborators at UMass Dartmouth have created high-resolution atmospheric simulation models for environmental prediction. Houshuo's model identifies two types of coastal mountain-gap wind jets. A daily summer wind jet blows eastward from the Tokar Gap on the Sudanese Red Sea coast, and in winter, every 10-20 days for several days, wind jet bands blow along the northwestern Saudi Arabian coast. These wind jets may generate unusual coastal circulation patterns.

Hydrographic and modeling efforts incorporate data from pressure, temperature and salinity gauges that record sea height differences over seasons, placed by Richard Limeburner in shallow water in Rabigh, Thuwal and Jeddah. Measured differences in sea surface elevation across and along the Red Sea can help explain the movement of wind driven currents and regional water circulation. To examine water flow from the shelf onto the reefs, Steve Lentz and Jim Churchill deployed instruments on moorings across the shelf during the first leg of the *Oceanus* cruise, and on and around coral reefs.

Physical oceanographer Amy Bower led the second leg of the R/V *Oceanus* Red Sea research cruise with WHOI engineers and technicians, KAUST partner scientists from Hong Kong and Cairo, and observers from KAUST, to the "Atlantis II Deep Brine pool," an unusual type of deep water formation in the Red Sea. The first water temperature measurements of the brine pool in 10 years indicate that temperature continues to increase (now at 68.3^{o} C, or 155° F), but the rate of temperature rise over the past 20 years seems to be slowing. In addition to sampling temperature and salinity of the waters around the brine pools, samples were taken for nutrient and carbonate chemistry analysis for Dan McCorkle's project, and cores were taken for biological and geological analysis.

KAUST also sponsored a research cruise led by Dave Fratantoni in the Caribbean test the *towfish*, a multi-sensor instrument that

measures physical variables while taking plankton images with a laser video recorder. Scientists hope to characterize the circulation, water temperature, salinity and chlorophyll variability from the continental shelf to the deep basin on future Red Sea cruises.

Coral Reefs

Coral reefs are ecologically sensitive habitats that undoubtedly will be affected by global climate change. KAUST offers WHOI researchers a chance to study Red Sea corals, fish, and reef hydrography with the overall goal of having a better understanding of reef ecosystems. In the first of two field surveys of diverse fish and coral communities, Simon Thorrold, Konrad Hughen, postdoctoral scholar Michael Berumen (now at KAUST) and at team of coral and fish experts from Australia found 269 reef fish species, 158 scleratinian (hard) coral species, and 14 soft coral genera. Scarcity of a commercially important fish, nagil, and the reduced abundances of grouper and snapper near Jeddah and fishing areas suggests that reefs may be experiencing fishing pressure. Using isotopic chemistry of fish "otoliths" (ear bone), which reveal the fish's lifetime movements, WHOI/MIT graduate student Kelton McMahon has found that snapper utilize mangroves, patch reefs and mains reefs at different times in their life cycle, so all habitats are important to preservation of coral reef fish diversity.

The distribution and movements of large fishes are not well documented for the Red Sea. As a first step, Simon Thorrold and Michael Berumen successfully tagged 4 whale sharks with data-recording archiving tags, and more tagging is planned. In six months, tags will send back data on the depth, temperature and movements of the sharks.

Anne Cohen, Ann Tarrant and WHOI postdoctoral investigator Neal Cantin are using computed tomography (CT) scans of coral cores to study annual growth bands to document the response of historical calcification rates to periods of high seawater temperature stress. Seasonal patterns in lipid energy stores and photosynthetic pigments within coral tissues are being measured to investigate the link between colony energetic reserves and coral calcification. Dan McCorkle is determining nutrient and carbonate seawater chemistry at reefs where carbonate production rates are being monitored in two species of dominant massive reef building coral.

Konrad Hughen and his students have collected coral samples from 100s of miles of coastline north and south of KAUST to examine large-scale sources of stress to corals. Using trace elements and organic molecular markers in coral tissues and skeleton, they are looking for evidence of stress due to factors such as high temperature, salinity, pollution and disease. They have successfully obtained long coral cores to reconstruct environmental stress and coral health over the past several centuries.

Data collected at several reefs by Steve Lentz and Jim Churchill and by Jesús Pineda indicate that shallow platforms of coral reefs experience large water temperature fluctuations over a 24-hour cycle. In a field experiment to transplant of colonies of the common coral *Sylophora pistillata* from the exposed (seaward) side to the protected side of a reef, Jesús Pineda is determining the impact on corals of small-scale water movement and temperature differences over reef platforms. Molecular analysis in Ann Tarrant's laboratory of transplanted coral will tell us if coral's symbiotic algae – which corals need to grow – respond to these different environmental conditions.

Fisheries stock assessment and bioeconomic models

Hauke Kite-Powell, Porter Hoagland, Andy Solow and Michael Neubert are investigating the health of fish stocks along the Red Sea using historical data from the Saudi Fisheries Department. They have estimated the degree of overfishing and changes in fish stock size from data provided on the amount of fish and species caught, number of fishermen, boats, and fishing trips. Working together with Saudi authorities, they hope to protect the Red Sea fish stocks and coral reefs so that these resources are available for future generations.

KAUST

The inauguration of KAUST will be September 23, 2009. At this time, WHOI and KAUST will share results from ocean and atmosphere models, corals and fish studies, water chemistry analyses, and hydrography measurements from the shoreline, in various coral reefs, out to the continental shelf, and from the deep-sea brines. The KAUST-WHOI partnership is creating a valuable database of information on the Red Sea that will be used by scientists at KAUST and elsewhere for years to come to develop new questions and experiments about the Red Sea.

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Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.
E-Contact: info@whoi.edu; press relations: media@whoi.edu, tel. (508) 457-2000
Problems or questions about the site, please contact webdev@whoi.edu