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Underwater and Undercover with Bluefin's Modular AUV Fleet

First Mid-East Cabled Seabed Observatory

Lighthouse R & D Enterprises

For over four decades, Lighthouse R&D Enterprises founder, Lou Tapscott, has been mystified by the ocean. From diver to CEO, Mr. Tapscott has been involved with, and intrigued by, the great mysteries of the sea. His thirst for knowledge has forged a quest to better understand current direction, eddies and earthquakes and the potential impact of such ocean phenomena on communities.

From tsunamis to ocean currents Mr. Tapscott has explored the very depths of our biggest mystery, the ocean. Many do not realize that we have a greater understanding of outer space than the movement and mysteries of our ocean. As we gain oceanographic knowledge, we continually improve our ability to predict and proactively respond to opportunities and challenges presented by ocean phenomena. For instance, the oil & gas industry will have a better understanding of its offshore environment, potentially leading to higher returns on its investment. As well, the data Lighthouse gathers and documents, contributes to a better understanding in general of the eco system of our ocean community, including impact on ocean wildlife, natural cyclical marine changes, and mapping of patterns to help predict likely pollution migration. Lighthouse's commitment to advance oceanographic understanding that will positively impact residential and commercial ocean communities is what fuels its determination to unlock these mysteries.

Lighthouse's flagship project is L.O.R.I. (Lighthouse Oceans Research Initiative), which has its primary installation off the coast of Oman. Through his earlier work in the Gulf of Mexico with one of Deep Star's projects, Met Ocean, Mr. Tapscott became aware of the importance of loop currents in the Gulf of Mexico. With a vision of the potential impact globally of such patterns in deeper water, Mr. Tapscott continued research in this field. The Gulf of Oman is one area that revealed a major loop current. With the interest and crucial support of Oman's Ministry of Fisheries and Agriculture, in 2005, Lighthouse completed Phases I and II of the L.O.R.I. program in Oman

As a result of its position at the northern margin of the Arabian Sea, the Gulf of Oman is a dynamic marine environment driven by the seasonal extremes of regional monsoon events. Aside from environmental perturbations, the Arabian Gulf is subject to real and potential pollution from the heavy traffic of large oil tankers entering and leaving the Arabian Gulf (Figure 1). Ballast water discharges, spills, and other effluents associated with such traffic are a continuing concern of Oman, whose pristine Batinah coast is under development as a national resource for underutilized fisheries and an emerging recreational industry exploiting sport fishing, diving, and other tourist attractions. The Sultanate of Oman has a vital interest in preserving and protecting the Coast. A recent deployment of oceanographic sensors is providing essential data necessary for monitoring existing conditions, as well as providing the basis for prediction of environmental impacts in the event of an accidental release of substances, which might threaten the coastal habitat.

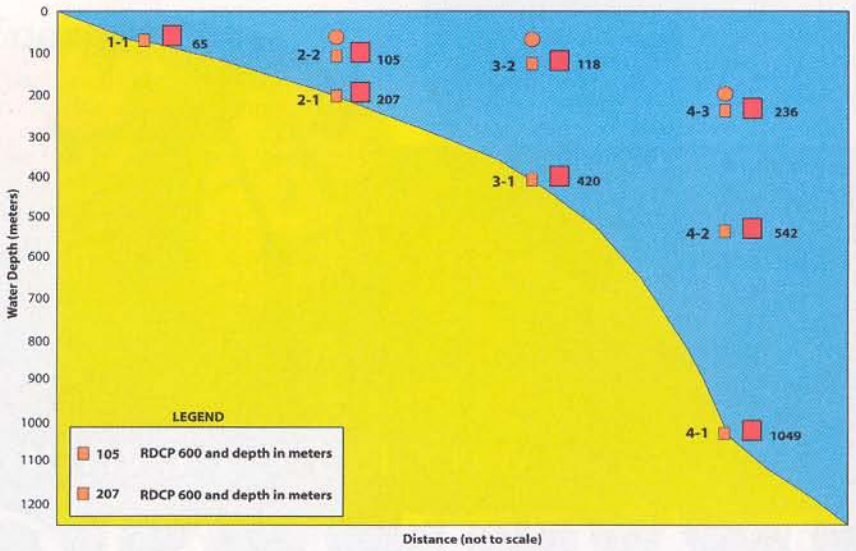

Figure 2. *Schematic profile of deployment elements. Red boxes are insonified layers of the water column yielding current speed and direction data (see text under "Seabed Deployment").*

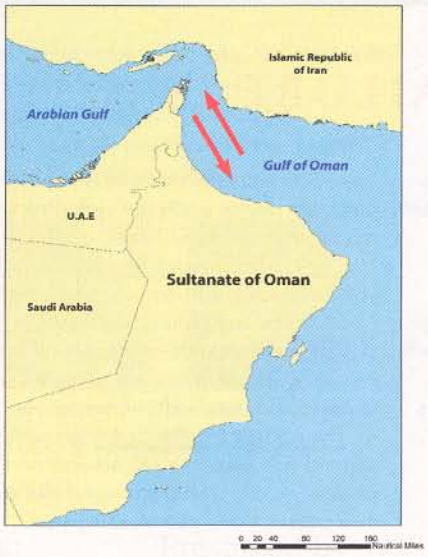

Figure 1. *Gulf of Oman, Strait of Hormuz and Arabian Gulf commercial traffic pattern. The Strait and the Gulf exhibit one of the highest densities of oil and gas shipping in the world. South-bound traffic exiting the Arabian Gulf oil fields pass near the cabled seabed array.*

The global oceanographic community is mobilizing and planning instrumented seabed arrays to monitor ocean parameters through cabled instrument strings reporting to a coastal station where data are fed to researchers. Several such links are in place in Canada, the Pacific (Hawaii), Japan, the east coast of the United Sates, and elsewhere. The European community plans for extensive observatories under the "ESONET" program where over eleven countries will share marine data.

In the past year, the Sultanate of Oman's Ministry of Agriculture and Fisheries has fielded an array of instruments to record current speed and direction, temperature, salinity, oxygen, and turbidity (Figure 2), leading the way to a Middle-Eastern data collection system in a vital region not yet studied in detail. The Sultanate of Oman's Marine Science and Fisheries Center has emerged as the leader in oceanographic studies of the northern Arabian Sea through its four offshore sites, which record on an hourly basis. Data are collected onshore and forwarded to the Oman Marine Science and Fisheries Center (OMSFC). These data form the basis for environmental assessments to measure seasonal varia-

tions associated with monsoon perturbation. The array was positioned to intercept signals from any release from the Arabian Gulf shipping traffic, as well as to monitor parameters essential to water quality assessments meaningful to fisheries (salinity, temperature, oxygen, etc.). It provides detailed information on water motion and density; both are critical to the modeling and prediction of spill behavior.

Four seabed nodes are connected to base arrays containing the full suite of sensors mentioned above. A fiber optic cable connects the nodes, and it leaves the water at Abu Bakara, where the data collection, storage, and early analyses on the health and performance of the system is constantly monitored. The cabled observatory thus extends about 60 km northeast across the Al Batinah coastal shelf, providing real-time ocean data, which monitors the health and potential threats from natural and possible anthropogenic causes. Closest to shore, designated 1-1, is a stand-alone seabed measurement system sited at a depth of about 65 meters. Since the current speed and direction are acoustically measured in thin (2 meters thick) "layers" (cells, or "bins") to a height of 50 meters above each sensor, 1-1 is monitoring currents in nearly all the water column. The other seven sensor packages are shown in the profile of deployments in Figure 2, and the 50-meter layer shown in the water column above each package is sampled for current speed and direction in the red box positioned above the meters (see Figure 3 for an example of current velocity data). Thus array 4-1 and its moored instruments at two levels above the seabed (and likewise the single moorings above 2-1 and 3-1) provide a real-time snapshot of water motion in the overlying shelf waters.

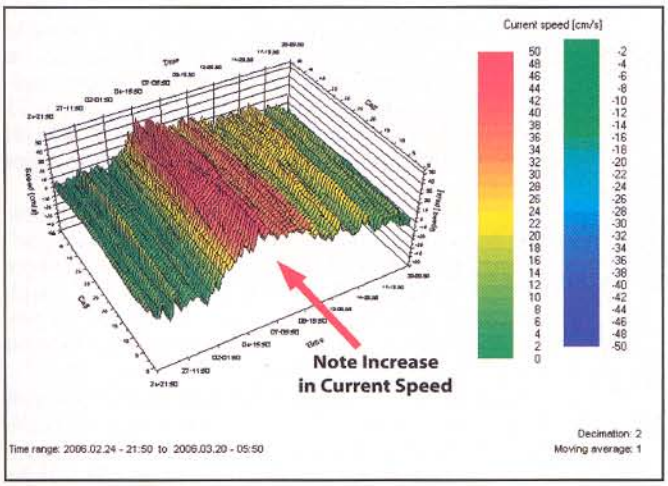

Figure 3. *RDCP Studio example of current strength data from mooring 3-2 (see Figure 2 for location and depth of sensor 3-2).*

The base of each array is housed in a trawl-proof cage, which protects all sensors from fishing damage while acting as an instrumented tether for the deeper buoyed arrays. They weigh about 37,000 pounds (~17,000 kilos) and are designed to withstand any dragging or other displacement of observatory components.

To increase the accuracy of numeric modeling, three autonomous moorings were set 60 nm off of Oman's Cape Ras Al Hadd. These arrays are positioned to monitor the currents coming out of the Arabian Gulf, currents coming up the coast from the Red Sea, and within the convergence area off the Cape. Another stand-alone array is set off the South Eastern Margin of the Murray Ridge in the Northern Arabian Sea. Data from all four autonomous moorings are retrieved annually.

Cabled seabed observatories are generally considered prototype installations and as such they have not been without problems. The Al Batinah deployment has been no exception. Electronic systems in the sea are always subject to numerous hazards, and the Batinah systems have seen sensor failures, power interruptions and mechanical problems related to complex instruments operating continuously hundreds of feet below the surface. The cabled observatory is a prototype, which through troubleshooting, analyses and repair provide confidence in continued and improved data collection.

Continuing interest in the Sultanate of Oman for ocean measurements and monitoring for public safety is leading to its critical role in developing the ongoing Indian Ocean Tsunami Warning System (IOTWS). As a result of the tragic December 2004 tsunami, twenty-seven nations have joined the IOTWS under a multinational program being directed by the Intergovernmental Oceanographic Commission under the United Nations Education, Science and Cultural Organization.

The IOTWS effort has been launched through at least sixteen international coordination meetings in which a team of experts representing the IOC/UNESCO-led meetings in many of the coastal states who participate in IOTWS. The Oman meeting was held in Muscat 7-9 June 2005 (See UNESCO Mission Report No. 21), which was coordinated by Dr. Ahmed H.M. Al-Harthi, acting Director of Meteorology, Ministry of Transport and Telecommunications. The purpose of each national assessment is to help coastal states establish and operate a tsunami warning and mitigation system, assess available organizational resources, and identify capacity building needs. Dr. Al-Harthi (a.alharthi@met.gov.om) is the designated official Omani contact for receiving instant transmissions of both Pacific Tsunami Warning Center and Japan Meteorological Agency bulletins, which provide warnings of possible tsunami threat (See IOC/UNESCO Communications Plan Report by Hagenmeyer, 2006). Dr. Al-Harthi was encouraged by the Omani participation which included fifty-two representatives from eleven agencies of ministries during the three-day meeting.

The IOC/UNESCO Communications Plan regarding early warning and public awareness mentions the need for monitoring the Makran tectonic zone of eastern Iran/western Pakistan. This active zone produced a tsunami in 1945, which reached the Omani coast within 30-60 minutes. It suggests a tripartite cooperative venture in the installation of a real-time warning system around the Makran region.

By applying lessons learned in the current cabled seabed observatory experience Lighthouse R & D Enterprises, Inc. is developing a seismic / tsunami system and hopes to field the first prototype system in the Gulf of Oman in December of 2006. The development of this program will be reported in a forthcoming paper.

Beginning in a youthful fascination with the coastal waters of California, Lou Tapscott's focused work and creative vision have culminated in a dream made reality – L.O.R.I. – understanding of ocean phenomena that benefits commercial and residential ocean communities.