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Martha's Vineyard Coastal Observatory – Existing Infrastructure for Interdisciplinary Science

Janet J. Fredericks, John H. Trowbridge, Thomas C. Austin, Heidi M. Sosik, Robert J. Olson and Peter A. Traykovski

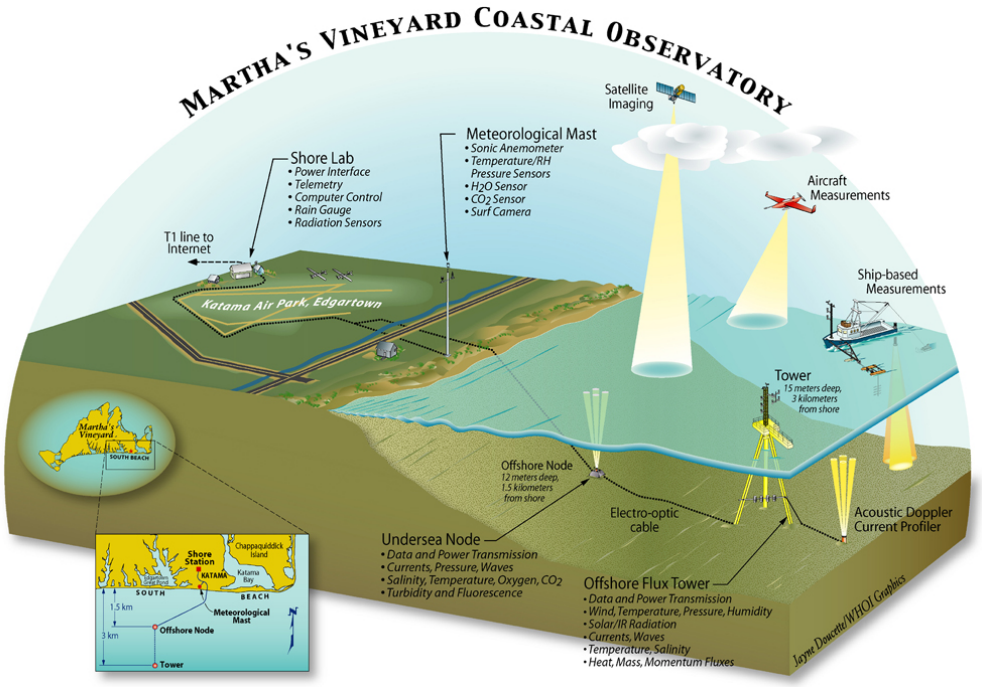

Figure 1.

The Martha's Vineyard Coastal Observatory (MVCO), constructed and operated by the Woods Hole Oceanographic Institution (WHOI), is a meteorological and oceanographic cabled observatory off the coast of Martha's Vineyard, Massachusetts, USA (Figure 1). The facility supports scientific endeavors by providing remote power and high bandwidth communications for instrumentation deployed for specific experiments, as well as providing a set of core meteorological and oceanographic observations. Funding for construction of the facility was provided by the National Science Foundation (NSF), the Office of Naval Research (ONR), WHOI and private donors. The MVCO became operational in the spring of 2001 and the air-sea interaction tower (ASIT) was completed in the fall of 2002.

Infrastructure

The MVCO core facilities consist of a data server situated at WHOI, a shore lab on Martha's Vineyard and three 'nodes', which provide individual, ground-fault protected power and communications for each scientific user. Each node consists of a communications server, an Ethernet switch and a number of guest ports. Each port can provide 12 V and/or 24 V of power with a recommended power draw of 100W and can be configured to communicate via Ethernet or serial (RS232/RS422). The communications server in each node converts serial data to TCP/IP, allowing it to travel kilometers over a GB Ethernet fiber-optic cable to the shore lab and via a T1

line to the world wide web (WWW) or directly with other in-situ instruments in the field (Figure 2).

Communications

The shore lab houses routers, switches, T1 access points, data loggers and control consoles, as well as some of the core meteorological instrumentation. The control consoles allow offshore node power to be remotely controlled by systems support personnel using standard communications protocols. Access to each port is restricted, but can be point-to-point connection can be allowed, allowing access to scientific investigators for control of their assigned ports and in-situ instruments.

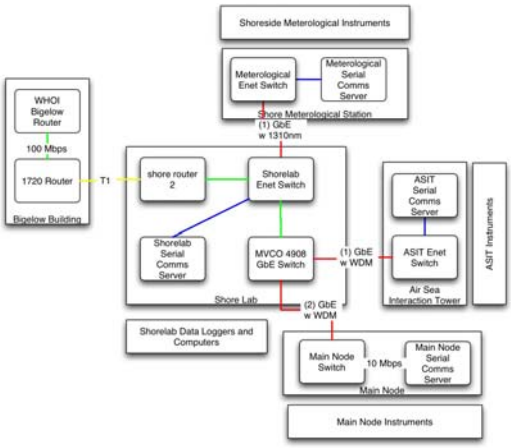

Figure 2. Communications Network for MVCO

Cable Technology

The cable consists of six AWG13 copper power conductors, with high voltage insulation, providing three separate single-phase circuits. Ten single-mode optical fibers are contained in a loose-tube assembly at the center of the cable. The core is jacketed with a polyurethane sheath protected by two layers of cross-laid armor wire and a polyethylene outer jacket. In order to cross the beach area with the least environmental impact, WHOI utilized directional drilling technology. This technology, originally developed for use in oil fields, was only just coming within economic reach of science. The drilling operation, accomplished in May 2000, provided a steel conduit, 626 meters in length, between the airfield and the seafloor (approximately 300 meters from the beach in about 3 meters water depth). A second conduit (206 meters in length) was drilled to provide a cableway to the meteorological sensor mast located on the beachfront. The cable was then pulled back through each conduit and connected to a junction box on the airfield and then to the lab. The offshore cable was laid on the bottom and jetted under the sand using an underwater cable jet-plow to the 12m node. Power was stepped down for the final leg to the air-sea interaction tower, allowing passive burial to be used for the extension. A more detailed description of the installation and issues relating to construction can be found in McElroy, et al.[i]

Power

Power supply is protected by two backup battery systems (UPS) and a propane powered generator at the shore lab. Power is transmitted from the shore lab at 1500 Vrms, using a step-up transformer and single-phase 60 Hz AC. At the 12m node, power is stepped-down using transformers to 240 VAC. Power is stepped up to 1200 VAC to travel the 1.5 km to the ASIT, where it is again stepped down to 240 VAC.

At each of the three nodes, power is transformed to 12 and/or 24 V DC for each guest port. Isolated power supplies and independent ground fault monitoring for each guest port protect users from troubles caused by problems on other

ports. A more detailed description can be found in Austin, et al.[ii]

Nodes are located on South Beach, 1.5 km offshore on the 13-m isobath and on an air-sea interaction tower (ASIT) approximately 3 km offshore on the 16-m isobath. The node at South Beach has 10 guest ports and supports a beach camera and core meteorological instrumentation mounted on a 12.5-m meteorological mast. The node at the 13-m iso-bath can accommodate up to 20 guest ports and hosts three of the core oceanographic instrument packages. The ASIT provides access from the bottom of the ocean through the air-sea interface to the top of a meteorological mast 18 m above the water surface (Figure 3). To support access at the air-sea interface, a beam was installed 4 m below the surface at the ASIT in August, 2003. The node at the ASIT can provide up to 20 guest-ports.

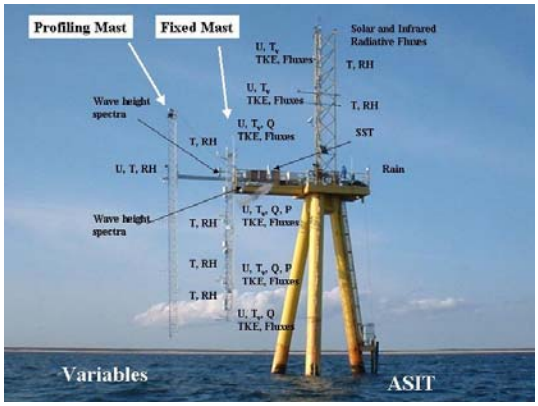

Figure 3. ASIT instrumented for the low-wind component of the ONR-funded Coupled Boundary Layers and Air-Sea Transfer (CBLAST-low) project during summer 2003.

Instrument Control and Data Logging

To support users of MVCO, custom instrument control and data logger units have been developed. These are based on PC104 stacks and support control of instruments (via VNC client/server) and logging of multiple serial and/or Ethernet data. This allows logging close to the source and allows multiple devices to be installed on each guest port. An advantage of the GB Ethernet access it provides the ability to configure and monitor instrumentation in the field prior to investing in long-term observations or responding to changes in environmental conditions. The instrument manufacturer's software packages can used to run diagnostics either from the users' desktop by mapping the IP to a serial port or by installing software on the logging system in the field.

Once data are logged (either in situ or at the shore lab), data are copied via ftp from the loggers and summarized every 20 minutes at the main data serving facility at WHOI. The summaries of all core instrumentation, as well as selected scientific data, are served to the scientific community and the general public. These data are displayed in real-time on the MVCO front page (http://www.whoi.edu/mvco) along with links to graphs of weekly time series. Archived summaries of core data are available via anonymous ftp or the JGOFs[1] web-interface and are updated every 20 minutes.

Enabled Scientific Endeavors

Typically, there are several projects each year, varying in deployment length from a few weeks to year-round. Over the

[1] JGOFs – is a distributed data serving systems that was developed as part of the Joint Global Ocean Flux Study (http://usjgofs.whoi.edu/index.html)

past four years, the MVCO has hosted dozens of projects funded by numerous funding agencies (Table 1). For the purpose of describing what the capabilities of a cabled network can provide, four of the projects are briefly summarized here.

Air-Sea Interaction

Along with the extensive air-side observations during CBLAST-low (Figure 3), oceanographic measurements near the air-sea interface provided 20 Hz velocity and temperature observations. Data were logged on one port connected to a PC104 stack on a 25 meter cable. The power and Ethernet communications allowed the installation of a Labview-CVI application installed on a Windows 2000 server. The PC stack also contained a board to extend the number of serial ports to eight, with individually controlled power for each serial port. An A/D board was also added to provide conversion of custom fast-response thermistor output to digital data, as well as providing the ability to generate 20-millisecond pulse generation for synchronizing instrument sampling. Six acoustic Doppler velocimeters with synchronized thermistors were installed on a beam 4 meters below the surface. Investigators also added an acoustic Doppler profiler on the beam and an infrared radiometer. A second mininode enabled four velocity sensors to be mounted at the base of the ASIT to directly measure bottom shear stress.

Sediment Transport

Abundant power and high bandwidth also provides the opportunity to study sediment transport at sub-second timescales. Several velocity sensors were installed at the seabed along with a rotary scan and rotary pencil-beam sonars to measure seafloor microtopography. These systems provide detailed information on ripple formation and movement along with data documenting simultaneous forcing parameters (Figure 5).

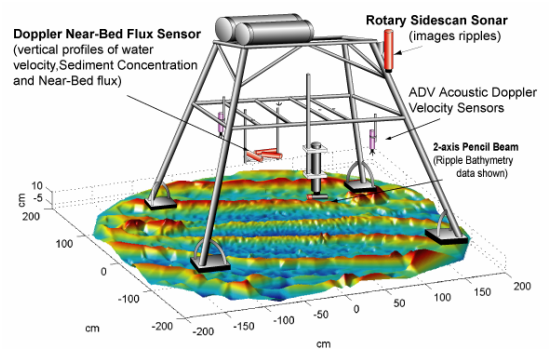

Figure 5. Ripple-scour study at 12m node

Plankton Community Structure

Newly developed submersible flow cytometers provide an unprecedented capability to monitor phytoplankton and other microscopic particles at high temporal resolution (e.g., Olson et al. 2003). MVCO provides an ideal deployment facility because continuous operation of these prototype instruments requires high power (~100 W) and high quality observations can be assured via realtime access to data and instrument control. FlowCytobot, optimized for measurement of pico- and small nanophytoplankton has been operated at the ASIT during spring to late fall for 3 years (Figure 5).

A current project includes side-by-side deployment with the newly developed Imaging FlowCytobot, designed to image individual microplankton and cell chains for identification and enumeration. The long-standing challenge to adequately sample natural plankton communities at the taxonomic

level can only be met with this combination of observatory infrastructure and novel instrumentation.

Conclusion

The scientific community has remained interested in the facility and committed to the concept of obtaining continuous, long-term, real-time data in coastal regions. Access to nearly unlimited power and bandwidth continue to provide unique opportunities for research and exploration. MVCO and WHOI are committed to maintaining the capabilities of the MVCO and to extending its scope as part of the Ocean Observatories Initiative (OOI) (Figure 6) and the Integrated and Sustained Ocean Observing System (IOOS).

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[i] Underwater Observatories: The Challenges and Promises of Offshore Cable Technology to Long-term Environmental Studies, Marguerite K. McElroy, James B. Edson, Thomas C. Austin, Wade R. McGillis, Michael J. Purcell; *Proceedings Under Intervention-2001, MTS/ADC*, Doyle Publishing, Houston, TX, January, 2001.© 2001 IEEE http://www.whoi.edu/mvco/mvco_news/publications.html.

[ii] A Network-Based Telemetry Architecture Developed for the Martha's Vineyard Coastal Observatory, By Thomas C. Austin, James B. Edson, Wade R. McGillis, Michael Purcell, Robert A. Petitt, Jr., Marguerite K. McElroy, Carlton W. Grant, Jonathan Ware, and Sheila K. Hurst; *IEEE Journal of Oceanic Engineering, Vol. 27, No. 2, April 2002*. http://www.whoi.edu/mvco/mvco_news/publications.html

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