Results From an Integrated Optical/Acoustic Communication System Installed at CORK 857D: Implications for Future Observatories

Maurice Tivey, Norman Farr, Jonathan Ware and Clifford Pontbriand • Woods Hole Oceanographic Institution, Woods Hole, MA 02543

Overview

A CORK (Circulation Obviation Retrofit Kit) borehole represents all of the basic components required for a seafloor observatory, a stable environment for long-term continuous measurements of earth and ocean phenomena, access to a unique environment below the seafloor under controlled conditions (e.g. hydrologically sealed), and a standard interface for communication. For full seismic wave sampling, 1 Hz sampling is better is required. While some CORK systems are now being connected to an underwater cable to provide continuous power and real-time data (e.g. Neptune network in the Northeast Pacific), there will be locations where cabled observatories are not viable. Another mode of communication is required to enable both high data rate communication and access for data offload via autonomous vehicles and not limited to those with ROV or submersibles. We have report on technology to enable high data rate downloading and transfer of data and information using underwater optical communications, which can be accomplished from a surface vessel of opportunity or, in the future, by autonomous underwater vehicles. In 2010, we successfully deployed and tested an underwater optical communication system that provides high data rate communication over a range of 100 meters from a deep sea CORK borehole observatory located in the northeast Pacific. The Sea floor Optical Telemetry System (OTS) was plugged into the CORK's existing underwater-mateable connector to provide an optical and acoustic communication interface and additional data storage and battery power for the CORK to sample at 1 Hz, store data, and transmit it to the surface. A CTD-based lowered telemetry system is the Sea floor system connects to the previously installed CORK data logger via an underwater-mateable connector. This is the same connector used to offload data from the CORK to a submersible. An optical receiver/ controller is installed on the lander frame, as well as an acoustic modem, optical emitter, and a battery housing.

CORK visit and OTS recovery

Upon arrival after over a year’s deployment, we were unable to acoustically ping the CORK OTS / data logger lander from the ROV Jason. The 857 D CORK site was dove on with the Jason ROV to visually inspect the lander, finding little biofouling, but signs of corrosion on the lander frame and housing connectors. Water was observed inside one of the emitter housings through its glass dome end cap. Suspecting a leak in our battery housing, the entire lander was recovered. All four of pressure vessels were found to be flooded with brown sludge inside the housings. The problem was traced to anodic corrosion (galvanic) corrosion of the stainless steel connector, and subsequent bacterial cultures revealed sulfite reducing bacteria.

Data was recovered from the CORK using Jason through an ROV-mate-able connector, finding that the CORK collected data at a 1 Hz rate for the life of the supplemental battery. In the event of the failure of the supplemental battery, the data record was unaffected by the flooding event. The OTS logger survived long enough to run down the supplemental battery, therefore the flooding happened sometime after the 7th week of the deployment.

Equipment / Hardware

CTD-Based lowered telemetry system

The lowered system consists of an optical receiver / controller, an acoustic modem for command and control, an Avtrak USBL transponder for navigation, a transmissometer to ascertain water clarity, a depth sensor, a camera and batteries. An SDSL modem was used for communications up the copper CTD cable to the surface ship.

OTS / Seafloor system

The Sea floor system connects to the previously installed CORK data logger via an underwater-mateable connector. This is the same connector used to offload data from the CORK to a submersible. An optical receiver / controller are installed on the lander frame, as well as an acoustic modem, optical emitter, and a battery housing.

Optical link capabilities

Optical transmission testing ROV JASON with test lander

A test lander was deployed from the ROV JASON to test different wave- lengths and radiance patterns. Five emitter colors, 405nm, 450nm, 505nm, 532nm, and white were used, and the extent of communication range was measured. The image to the left of JASON on deck during a pre-dive check of the test lander lights. A camera was also on the lander to test the ability to send video data over the optical link.

Video transmission was verified on subsequent JASON dives from the lander to an optical receiver mounted on JASON’s (Juke).

A plot of optical communications extent, lower left, shows an example of one wavelength (Haliotis pattern). Red on the plot represents high bit errors and no data link. The maximum range achieved for 1 Mbps data rate was 180 meters using a blue (450nm) emitter. This is typical of all wavelengths tested.

Future opportunities

Planned testing August 2012

Technical team: Ed Hobart, Steve Lerner, Steve Faluotico, Terry Hammar, Jason Kapit, Alex Franks

Dr. Keir Becker and Katherine Inderbitsen of the University of Miami

Acknowledgments

Technical staff: John Miller, Kristen Dennett, Jennifer Roberts, Todd Cramer, Jason Kapit, Alex Franks, R. J. Barnes, Eric and Anne Gary, Dr. Jill Davis and Ray Phillips of Pacific Geoscience Centre, Canada, Dr. Ray Phillips and Ralph Phillips of the University of Victoria, Canada.

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