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

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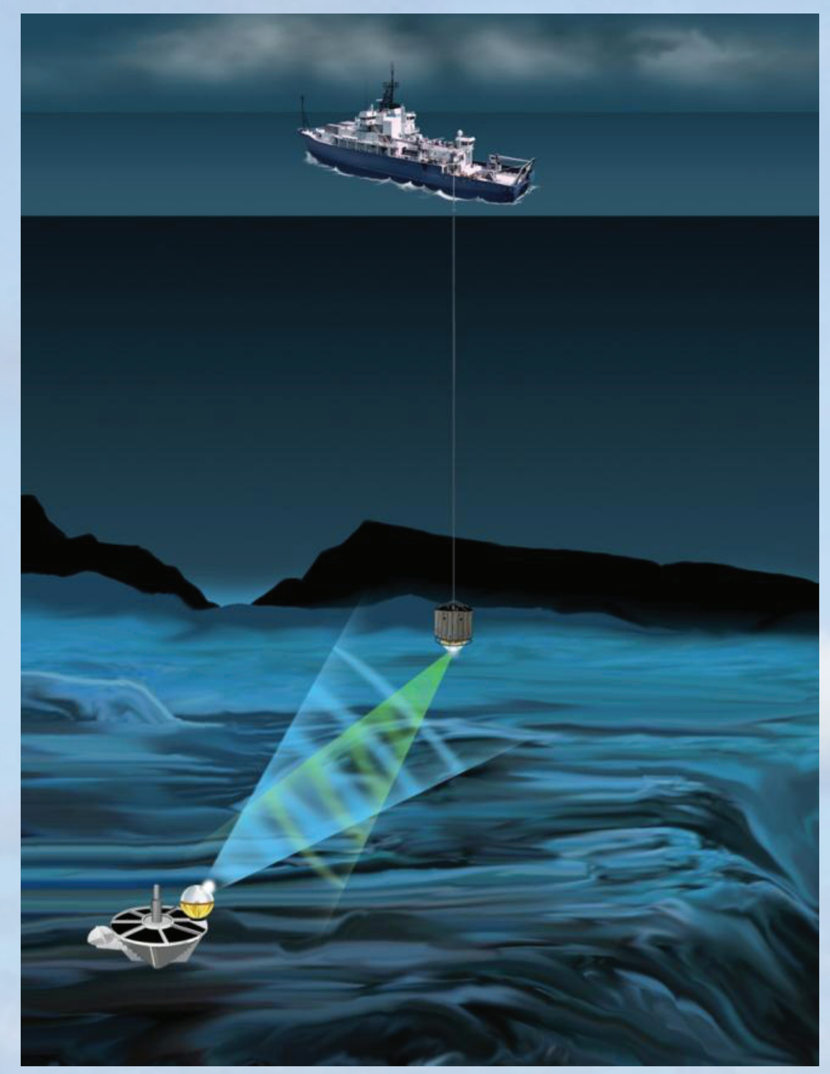
Overview



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 or better is required. While some CORK systems are now being connected to an underwater cable to provide continuous power and real-time data (cf. 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 download via more conventional vessels and not limited to those with ROV or submersibles. We here report on technology to enable high data rate download 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 vehicle. In 2010, we successfully deployed and tested an underwater optical communication system that provides high data rate communications over a range of 100 meters from a deep sea CORK borehole observatory located in the northeast Pacific at IODP Hole 857D. The seafloor 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 data-rate, an increase over the normal 15 sec data sample period. A CTD-mounted OTS, lowered by wire from a surface ship, established an optical communication link at 100 meters range at rates of 1, 5 and 10 Mbps with no bit errors. This mode of communication demonstrates the effectiveness of using a ship-based system to interrogate the system remotely. The OTS was designed to be installed at the seafloor CORK for a year. In 2011, we revisited the CORK and OTS using the ROV Jason to test the system, download the data collected during this period and to refurbish the batteries for a further year-long deployment.

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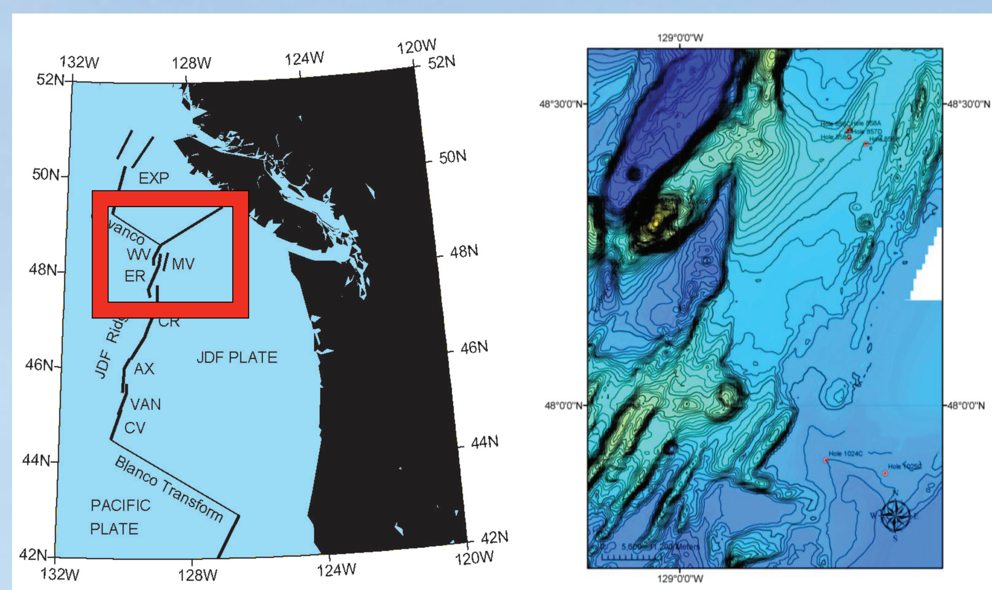
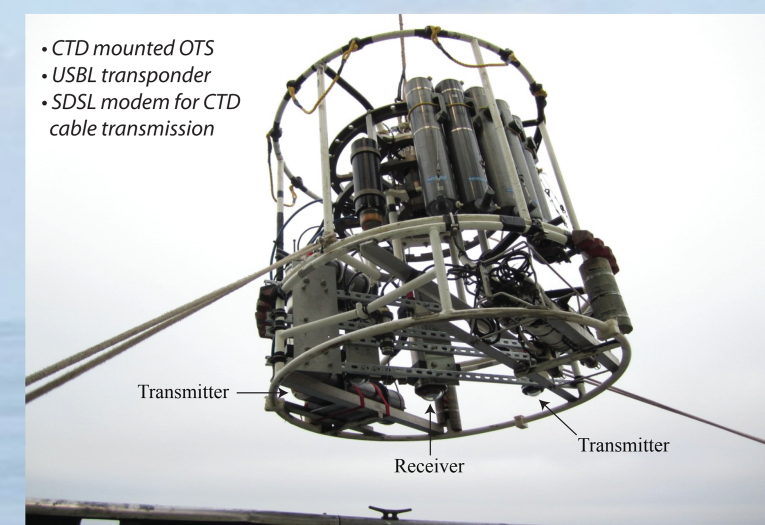
Location (857D)



Equipment / Hardware

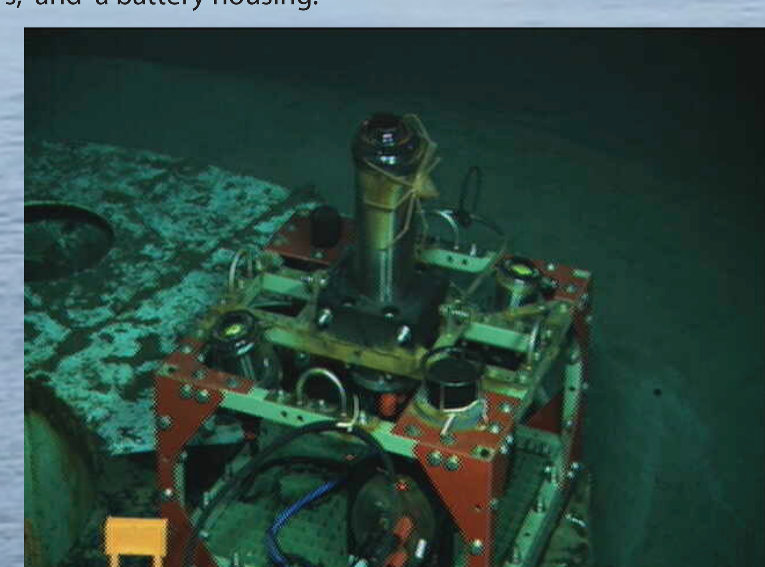
CTD-Based lowered telemetry system

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 Seafloor 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 emitters, and a battery housing.

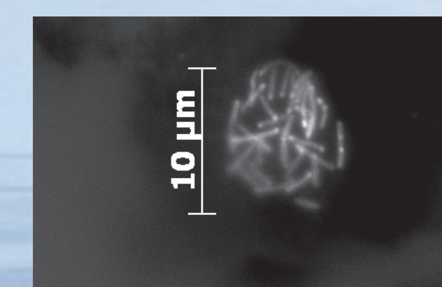


CORK visit and OTS recovery

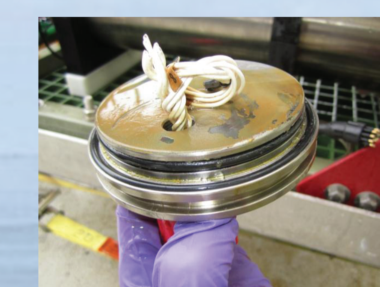
Upon arrival after over a year's deployment, we were unable to acoustically wake or ping the CORK OTS / data logger lander from the lowered OTS. The 857 D CORK site was dove on with the Jason ROV to visually inspected the lander, finding little biofouling, but signs of corrosion on the lander frame and 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 anoxic crevice (pitting) corrosion of the stainless steel connectors, and subsequent bacterial cultures revealed sulfate reducing bacteria.

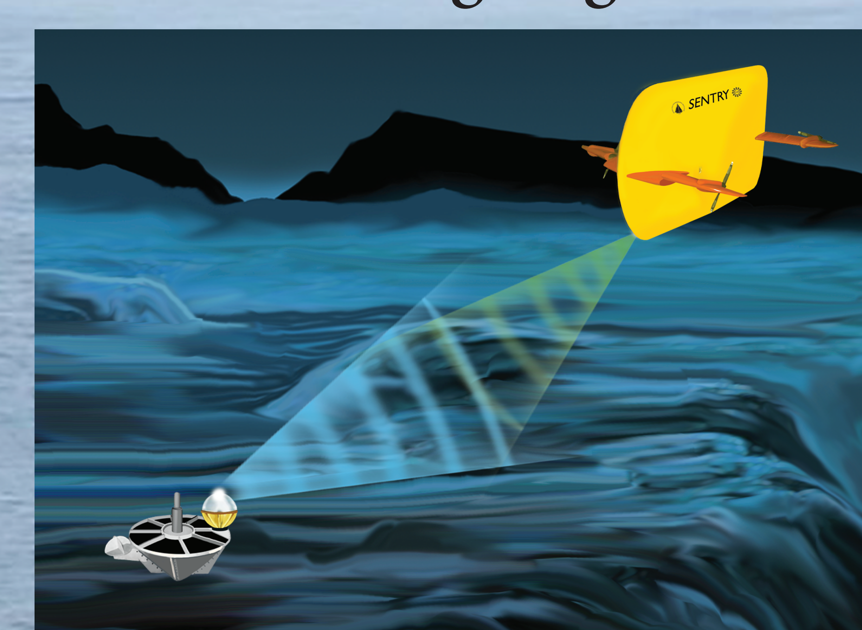
Data was recovered from the CORK using Jason through an ROV-mateable connector, finding that the CORK collected data at a 1 Hz rate for the life of the supplemental battery provided: the data record was unaffected by the flooding event. The OTS logger survived long enough to run down the supplemental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



DAPI staining results (Edgcomb lab)



Planned testing August 2012

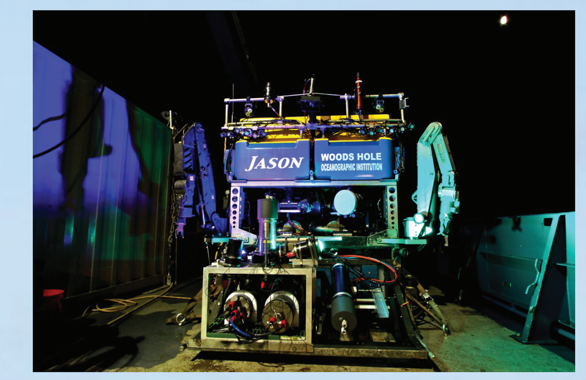


Optical link capabilities

Optical transmission testing

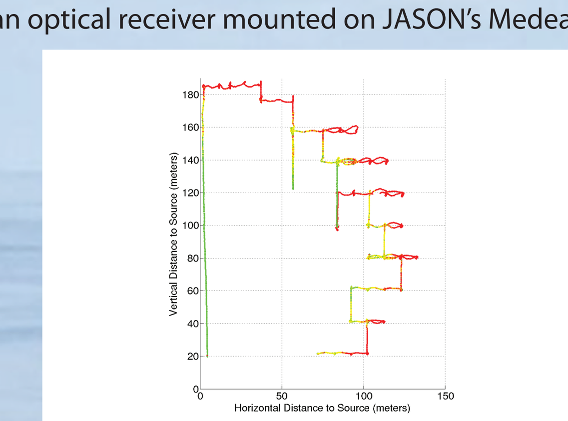
ROV JASON with test lander

A test lander was deployed from the ROV JASON to test different wavelengths 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.



A plot of optical communications extent, lower left, shows an example of one wavelength /radiance 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.

Video transmission was verified on subsequent JASON dives from the lander to an optical receiver mounted on JASON's Medea.



Future opportunities

Acknowledgements

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