ALOHA Cabled Observatory Will Monitor Ocean in Real Time

First Use of a Retired Commercial Electro-Optical Submarine Cable for a Scientific Observatory

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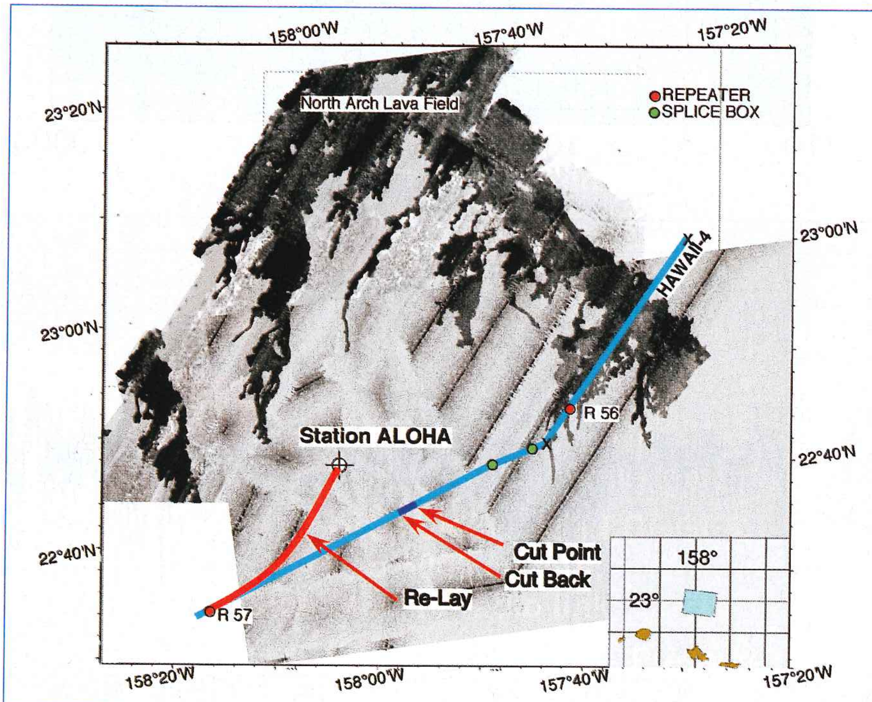
On February 16, 2007, an acoustic release fired from a U.S. Navy cable repair ship allowed the ALOHA (A Long-Term Oligotrophic Habitat Assessment) Cabled Observatory (ACO) cable termination to settle on the ocean floor 4.7 kilometers below, completing the first phase of the observatory's installation.

The ACO is located at Station ALOHA, about 60 miles north of Oahu, Hawaii—an important site for long-term monitoring of the ocean. Data have been collected here on monthly cruises for the past 19 years by the Hawaii Ocean Time-Series Program.[1,2]

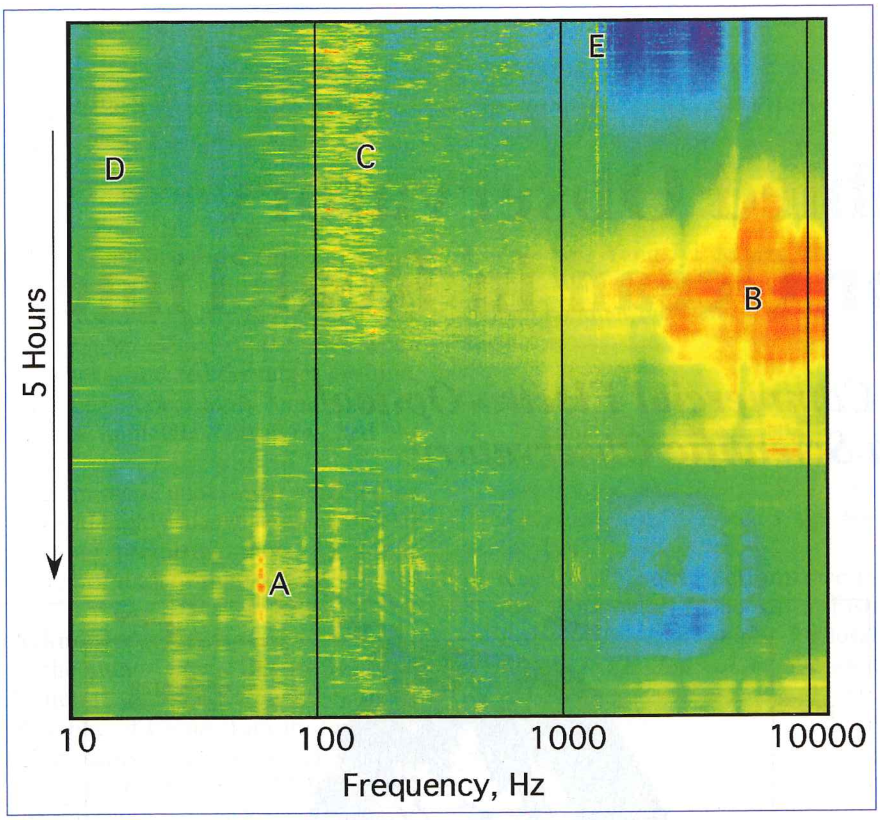
The ACO will provide continuous power for sensors that will monitor ocean variables in real time at data rates that are orders of magnitude higher than would be practical using internal storage or satellite data transmission. Rare and episodic events at Station ALOHA can be better observed with these new capabilities, because sustained real-time detection of events will support adaptive sampling within and around the observatory.[3,4]



ACO installation. The blue line shows the original cable route, and the red line shows the relaid cable path. The background is side scan swath data.

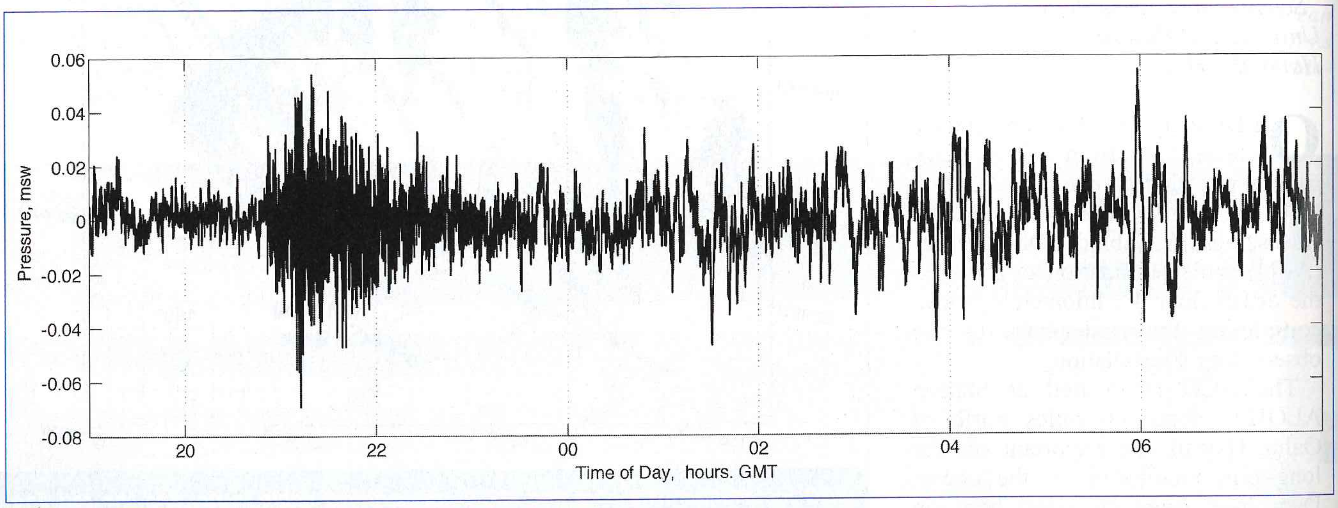
The ACO is the first reuse of a retired commercial electro-optical telecommunications cable for a deep-ocean scientific observatory. It utilizes the HAW-4 cable that was decommissioned by AT&T Labs (Morristown, New Jersey) in 2004, after 15 years of commercial service between California and Hawaii. The system was retired because newer systems provide much more communication bandwidth, using optical amplifiers rather than electrical repeaters. However, the robust first-generation optical cable technology is ideal for observatory use, since the available power and bandwidth are more than sufficient for most ocean sensor systems. A new data transmission algorithm, developed for this project by former AT&T Labs submarine cable systems technology consultant Mark Tremblay, has made it possible to utilize these first-generation systems at relatively low cost.[5] More than 35,000 kilometers of first-generation optical cables were installed in the Pacific Ocean basin alone, comprising a huge potential resource for future scientific use.

During installation of the ACO, the cable was cut, the Oahu-end recovered and 22 kilometers of cable were hauled onto the ship from the ocean floor before turning and relaying the cable to Station ALOHA. The cable was spliced to the ACO termination



(Left) Spectrogram of ACO hydrophone data. Red colors signify more energy than blue colors. (A) A ship passage, (B) a rainstorm, (C) humpback whales, (D) fin whales and (E) Minke whales.

(Below) Pressure recording of an April 1, 2007, earthquake. Fluctuations of plus or minus four centimeters were observed when a tsunami would arrive, between 4:00 and 7:00 a.m. Greenwich Mean Time on April 2. Pressure units are meters of seawater.



frame, tested from the AT&T Makaha Cable Station and lowered to the ocean floor with the Proof Module, a minimal observatory designed to prove the concept of the design and its ability to supply high-quality data to users. Data from the ACO are transmitted to the AT&T Makaha Cable Station, where they are transmitted over a T-1 data link to the University of Hawaii for distribution and archiving.

The Proof Module, floating about four meters above the ocean floor, is plugged into the cable termination frame with an Ocean Design Inc. (Daytona Beach, Florida) electro-optical hybrid wet-mate connector connecting two fiber pairs to the observatory. The Proof Module contains a small power supply, an ocean ground, an optical regenerator, a hydrophone and a Paroscientific (Redmond, Washington) Digiquartz® absolute pressure sensor. The hydrophone is sampled at up to 96,000 samples per second with 24-bit resolution, resolving signals from 0.01 hertz to 40 kilohertz; the pressure sensor is sampled at up to 15 hertz with a resolution of approximately four millimeters of ocean depth. Together, these two sensors utilize less than one-tenth of the currently available bandwidth.

During the first eight months of observations, several types of signals were recorded. Vocalizations from humpback, sperm, fin and Minke whales are easily identified in the data, as are ships, tides, ocean waves, wind, acoustic pingers, rainfall and earthquake body waves, surface waves and T-phases.

The April 1, 2007, Solomon Islands earthquake and aftershocks were well recorded by both the hydrophone and the pressure sensor.

The second phase of the installation will occur in October 2008, when the JASON II remotely operated vehicle will install the observatory infrastructure on the ocean floor at a depth of 4.7 kilometers. This second phase of the ACO will supply up to 1,000 watts of electrical power and a 100-megabyte Ethernet link for servicing up to eight experiment ports. Users will also have the capability of reprogramming their experiments *in-situ* to modify sampling strategies. As future demand for power and bandwidth increases, the system can be augmented with at least three more 100-megabyte channels and an additional one kilowatt or more of power. During the second phase of installation, the Proof Module will be reconfigured as an experiment and plugged into the observatory.

"The ACO will provide continuous power for sensors that will monitor ocean variables in real time..."

Initially, six of the eight experiment ports will be supplied with 48-volts of direct current power systems designed for low-power users, and two ports designed for more distant or high-power users will be supplied with 400 volts of direct current power. Each user will have their own Ethernet address, allowing direct communication from their laboratories. An external science and technology advisory committee has been set up to help guide the development of the ACO so that it becomes a valuable asset for the entire ocean research community.

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References

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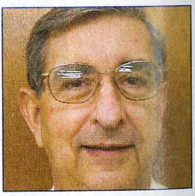

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