Long-Term Test of a New Conductivity and Temperature Sensor

VENUS Cabled Observatory Provides Real-Time Feedback on Performance

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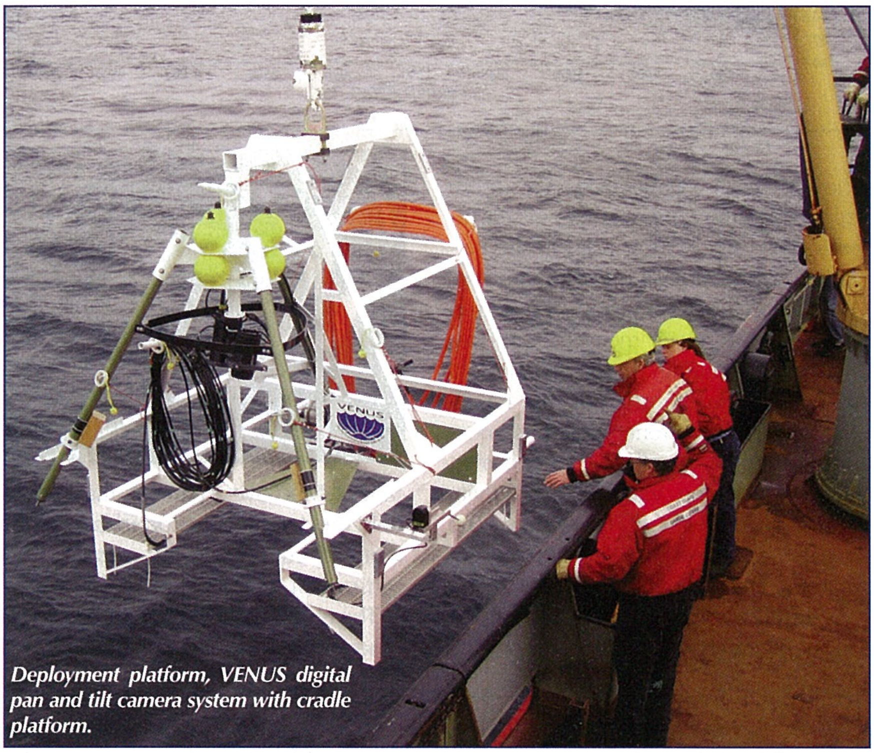


Deployment platform, VENUS digital pan and tilt camera system with cradle platform.

A real-time ocean seabed facility was utilized in the testing and development of a long-term deployable conductivity and temperature sensor, the Infinity CTW, made by JFE ALEC Co. Ltd. (Kobe, Japan). This instrument employs a novel wiper technology to ensure that the conductivity cell remains free and clear of biological growth, thereby ensuring good long-term measurement stability.

The Victoria Experimental Network Under the Sea (VENUS) is a cabled ocean observatory located at the southern end of Vancouver Island, Canada. The observatory is an undersea laboratory that provides ocean researchers with live data streams from three permanent seabed locations. Each location is powered from shore and linked to the Internet through an underwater fiber optic cable. Several platforms reside at each location and support a host of sensors and instruments. The data streams from these instruments are available online.

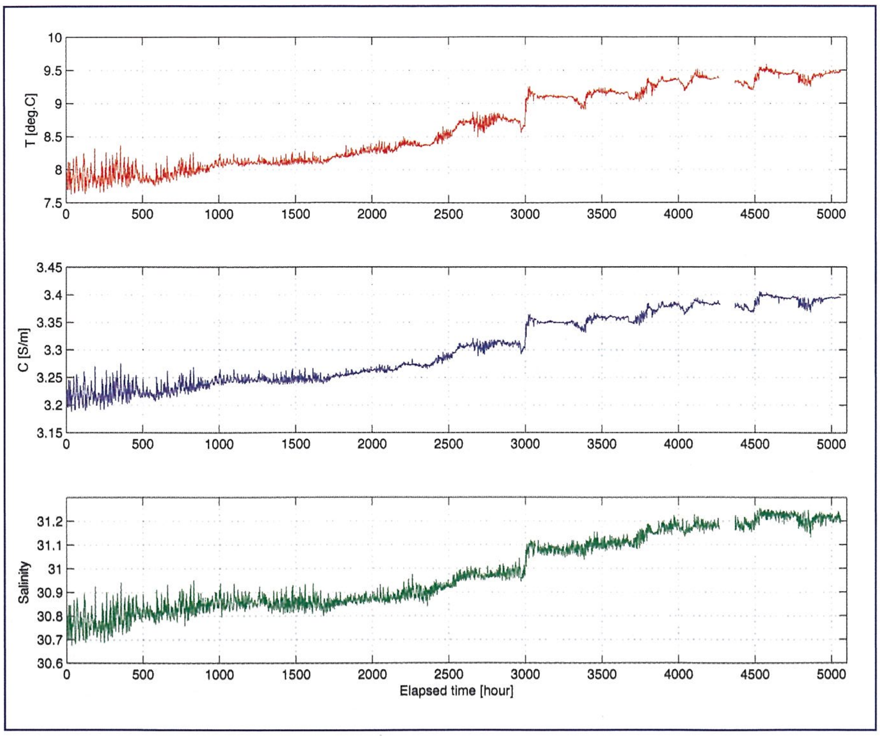
The CTW has been installed on VENUS for a 10-month period starting last March. For the long-term monitoring of salinity on a mooring, the stability of the conductivity sensor is a key consideration, because the conductivity measurement is very sensitive to biofouling on the sensing surfaces. To reduce calibration drift over time, it is necessary to keep the sensor free of biological growth.

In some cases, chemicals are used. The toxic chemical tributyltin slows down biofouling by poisoning the fluid surrounding the sensor. However, this technique is often not effective enough to protect the conductivity sensor in regions of high biological activity, and it cannot be used in environmentally sensitive areas (e.g., near coral reefs). As a result, regular maintenance to remove biofouling from a sensor protected in this manner is required. In extreme cases, the instrument has to be replaced.

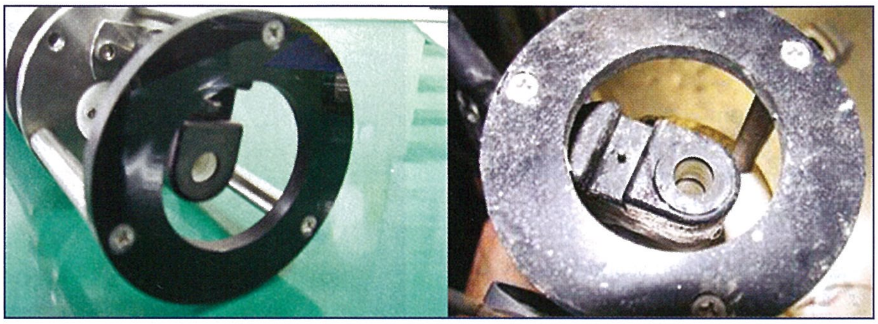
The CTW, on the other hand, has an integrated mechanical piston wiper that periodically sweeps the internal cavity of the conductivity cell. As reported in *Sea Technology*'s February 2005 issue, preliminary testing confirmed that the wiper is effective in keeping the sensor free of biological growth for monthlong deployment periods without requiring chemicals or manual cleaning of the sensor.

Influence of Biofouling on Sensors

Inductive and electrode-cell-type sensors are used extensively to measure



(Left) Time-series data of temperature, conductivity and salinity from the digital camera study site of the VENUS cabled observatory from March 2009.



(Below) A pristine conductivity sensor (left) and recovered sensor (right) after a six-month deployment.

the electrical conductivity (or, more accurately, the conductance) of seawater—which is, in turn, used in the calculation of salinity—but they are susceptible to biofouling inside the sensor. An inductive sensor measures conductivity by inducing an electrical field with a toroidal transformer. The resulting electrical current, which is measured with another transformer, depends on the water's conductivity and the geometry of the sensor. The highest density of the electrical current is in the center of the toroid, where the accumulation of marine organisms strongly affects the measured conductance. Moreover, part of the electric field is external to the toroid, and so any material buildup on the outside of the sensor will also affect the calibration.

The electrode-cell-type sensor, on the other hand, measures conductivity with metallic electrodes in direct contact with the seawater. Typically, electrodes are mounted on the inner wall of a glass tube, ideally in a configuration that confines the electric field to the inside of the tube.

Biological growth inside the tube changes both the geometry and the electrical contact between the electrodes and seawater. These combine to compromise the original sensor calibration.

How the CTW Works

The CTW is an electrode-cell-type sensor. A pair of electrodes of equal polarity (–) are located at the ends of the cavity and share a common electrode (+) in the center of the cell. The oppos-

"Field testing on the VENUS cabled observatory shows that the wiper function prevented biofouling and maintained the stability of conductivity and salinity measurements throughout a 10-month period in a highly productive coastal environment."

ing electrodes drive a current that is completely contained in the inner cavity of the sensor.

In this arrangement, the measurements are not affected by any growth on the outside walls of the sensor. A pair of pickup electrodes measures the potentials (voltages) created by the drive electrodes (which are in the fluid contained in the cavity), and this potential is a function of the fluid's conductivity.

Pressure effects cause no significant variation of the distance between the electrodes or cross-sectional area, so the sensor only measures changes in the seawater conductivity.

A simple and effective solution for maintaining a pristine sensing surface is to mechanically clean the cell at regular intervals. Numerous instrument manufacturers use this concept for keeping optical sensing surfaces clean.

JFE ALEC's CTW has an integrated mechanical piston wiper. The wiper consists of a circular silicone blade mounted on the end of a traveling rod. Periodically, the rod extends out from the instrument and the silicon blade gently wipes against the electrodes inside the conductivity sensor. The wiping process also exchanges the water inside the cavity with new seawater. This wiping motion helps to maintain an accurate measurement of conductivity.

The endurance of the silicone blade depends on the biological activity and the wiping frequency, but is normally more than one year.

The performance of the CTW on moorings in coastal regions was recently evaluated by the Alliance for Coastal Technologies (ACT).

The CTW was deployed in various coastal locations for durations between four and eight weeks, while reference water samplings were conducted daily to monitor the salinity at the deployment site.

Comparison with the reference samples showed that the wiper enabled the CTW to maintain its calibration, even in biologically highly active waters. The full report is available on the ACT Web site.

CTW on VENUS

In March 2009, the CTW was deployed on the VENUS observatory in Saanich Inlet, northwest of Victoria.

This platform also supports an Aanderaa Data Instruments (Bergen, Norway) Optode 4175, a Nortek (Rud, Norway) acoustic current meter, a Satlantic (Halifax, Canada) ISUS-X optical nitrate sensor and a camera system.

The VENUS Science Instrument Interface Module (SIIM) on the platform provides power (360 or 24 volts direct current) and real-time communications (100/10 Base T or RS-232/422/485) to connected instruments. The SIIM is linked to the VENUS Node via a 70-meter, oil-filled hose cable and a Teledyne RD Instruments (Poway, California) wet-pluggable connector.

The CTW utilizes 24 volts direct current for power and a link to a serial-Ethernet server for two-way communications between the shore and the instrument.

Through a custom software "driver" developed by the VENUS data management group, the instrument is initialized and then routinely polled for conductivity and temperature data. A separate command is periodically sent to actuate the wiper system. The instrument produces measurements once a minute, 24 hours a day, and the wiper actuates every 10 minutes in between data records.

The CTW outputs digital data with temperature and conductivity in physical units.

These data are time stamped and briefly buffered at the VENUS observatory shore station before being sent via fiber optic backhaul to the data management and archive system (DMAS) at the University of Victoria. DMAS stores the data and makes them freely available through a data download tool on the VENUS Web site.

Field Tests

As of January 1, the CTW has been on the seabed in Saanich for 10 months.

Variability of the conductivity measured by the CTW is highly correlated with the coincident temperature during the deployment period, an indication of minimal biofouling.

For the first 1,000 hours there were significant fluctuations in both conductivity and temperature. Other conductivity, temperature and depth sensors at a nearby station observed similar trends. A jump in the C and T time-series at about 3,000 hours was a universally observed environmental shift in the region.

A regular, biannual maintenance servicing of the observatory and its integrated instruments was carried out at the end of September, which is shown as a period of no data between 4,250 and 4,300 hours. After recovery, the conductivity sensor was found to be in pristine condition.

Without any cleaning and/or component replacement, the CTW was redeployed and has continued to perform well.

Conclusions

Biofouling is a key consideration for long-term deployments of instruments on moorings and observatories. Field testing of JFE ALEC's CTW conductivity and temperature instrument with a mechanical wiper on the VENUS cable observatory shows that the wiper function prevented biofouling and maintained the stability of conductivity and salinity measurements throughout a 10-month period in a highly productive coastal environment.

The test further indicates the CTW is a useful tool in monitoring conductivity and salinity on fixed autonomous platforms. Currently, the authors are planning to recover the CTW and determine the stability of the conductivity with a pre- and post-calibration comparison. ■

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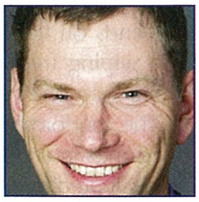
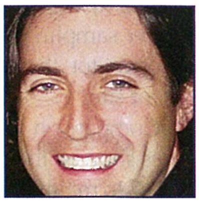


Fabian Wolk is the owner and president of Rockland Oceanographic Services Inc. (ROS). Fabian has been working with JFE ALEC Co. Ltd. since 1999, and ROS is the North American sales and technical support center for JFE ALEC products.



Paul Macoun is the VENUS facility engineer and is responsible for the integration of instrumentation with the subsea network.