TEMPO-Mini: a custom-designed instrument for real-time monitoring of hydrothermal vent ecosystems

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Abstract : *TEMPO-Mini is a new custom-designed instrument package created by IFREMER for real-time monitoring of hydrothermal faunal assemblages and their ecosystems [2].*
TEMPO-Mini integrates a 2 megapixel streaming video camera with embedded event detection, 4 LED lights, an Aanderaa oxygen sensor, and a 10m-long, 10-sensor temperature probe. An efficient and innovative biofouling protection system is set on the camera porthole, on the lights as well as on the optical oxygen sensor [4].
IFREMER collaborated with NEPTUNE Canada and VENUS Canada networks to acquire live data from the seafloor in Saanich Inlet near Sidney, British Columbia (BC), Canada (Figs 1,2). In May 2010, a reconfigured version of TEMPO-Mini, will be connected to the NEPTUNE Canada network on the Endeavour vent field junction box in the North-East Pacific Ocean.
In this paper, we present the architecture and functionality of the system and zoom into the operational perspectives.

Keywords – Undersea cabled networks, sea bottom observatories, hydrothermal vent ecosystems, video camera, event detection, and real time data transmission

INTRODUCTION

There is worldwide recognition for the need of long term in situ monitoring of the marine environment. Particularly lacking in the study of abyssal benthic communities are time-series data. Time-series studies provide a means of studying organism growth, faunal succession, biological interactions as well as the response of species and communities to environmental changes [2][3].
Understanding community dynamics is also an important prerequisite for management, conservation and protection of natural ecosystems. A great effort is now being invested by the international scientific community into developing new ways to study the temporal aspect of both environmental and biotic factors in abyssal zones.

The goal of networked seafloor observatories (c.f. ESONET, MoMAR, EMSO, NEPTUNE, VENUS) is to develop multidisciplinary long-term experiments for observations and monitoring of seafloor active processes.

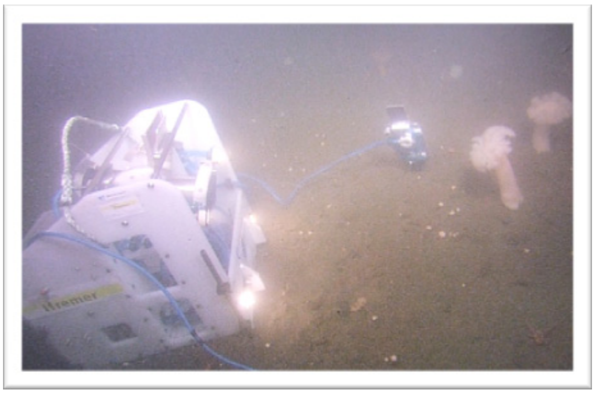

Fig. 1: TEMPO-Mini during the test deployment in Saanich Inlet, British Columbia,, Canada

The development of new scientific tools, suited for long-term deployment, is an essential step to ensure the success of these future observatories.

The major goal of this project was to design an integrated instrument module for studying deep-sea community dynamics at hydrothermal vents over a long period of time.

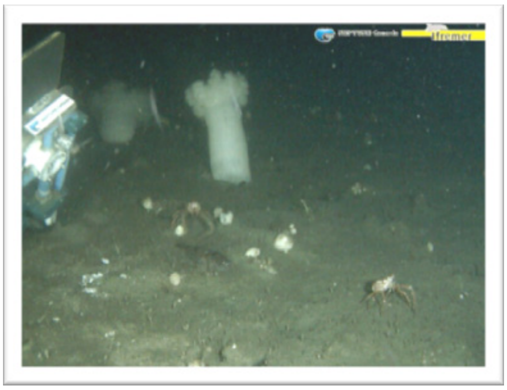

Fig. 2: A view of the benthic community at 100m depth in Saanich Inlet, British Columbia, Canada

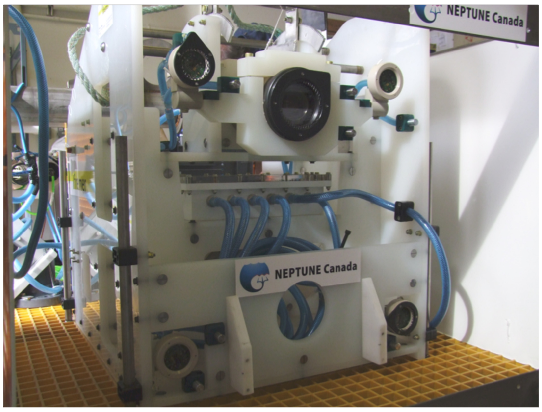

Fig. 3: TEMPO-Mini before the test deployment in Saanich Inlet, BC, Canada

TEMPO-Mini is a cabled version of TEMPO (Figs. 1-3). The TEMPO ecological module was developed by IFREMER for non-cabled long-term deep-sea observatories [1].

Multidisciplinary observatories, based on cabled networks, offer new opportunities for science and also for the electronic engineering. Indeed, a permanent power supply and an Ethernet link are a major breakthrough in the design of instruments. TEMPO-Mini is mainly designed from commercial off-the-shelf elements: Ethernet switch, Ethernet to serial bridge, Ethernet to 1-wire bridge, Ethernet to general purpose I/O, Ethernet video camera... This facilitates the design and the future add-ons and extensions while reducing the global cost of the instrument.

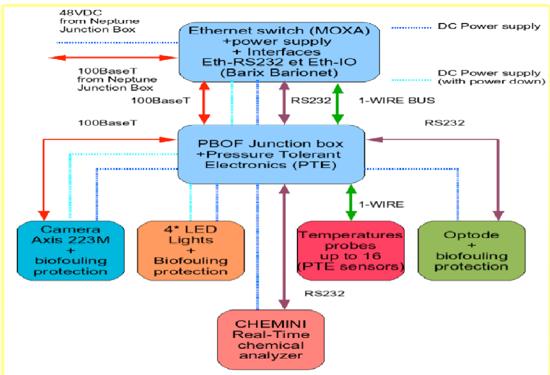

Fig. 4: TEMPO-Mini architecture, block diagram

RESULTS AND DISCUSSION

The TEMPO-Mini module (Fig. 4) is built around a compact polyethylene structure assembled by titanium rods and bolts to save weight and to prevent corrosion during long-term deployments. The dimensions of this module are approximately 110*60*80 cm. The total weight of TEMPO-Mini in seawater is approximately 35Kg to be handled with a Remote Operated Vehicle (ROV) or a submersible.

<u>Cable between TEMPO-Mini and the junction box</u>

The main cable between the NEPTUNE junction box and TEMPO-Mini is based on a 70 meter long Pressure Balanced Oil Filled (PBOF) cable that include an Ethernet 100BaseT cable and a 48 VDC power supply cable. The maximum power consumption of TEMPO-Mini is 120 watts during data acquisition, when the lights are switched on.

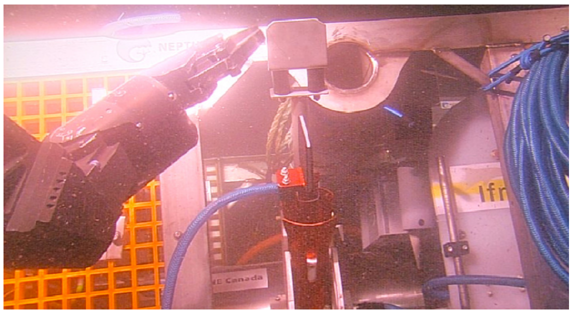
Fig. 5: CDC Wet mate connector in action allowing connection and disconnection on the seafloor.

A wet mate connector called CDC (designed at IFREMER) allows connection and disconnection on the seafloor between the junction box and TEMPO-Mini, which are necessary during maintenance operations (Fig. 5). This custom-designed connector is a low cost wet mate electrical connector that will be available in the market soon.

<u>Video camera</u>

TEMPO-Mini uses an Axis 223M network camera, a commercial off-the-shelf high-resolution video Ethernet camera with embedded motion detection. This 2.0 Megapixel high-performance camera is integrated inside a titanium housing rated up to 6000-meter water depth. This video camera allows continuous streaming up to 1600x1200 with a MJPEG video compression.

<u>LED lights</u>

The light is provided by four 20W LEDs projectors (designed at IFREMER) inside a PBOF housing for optimizing the size and improving the heat transfer.

<u>Oxygen and temperature sensors</u>

An Optode from Aanderaa (Norway) was used for oxygen measurements.

A 10m-long temperature probe includes ten 1-wire digital thermometers 18B20 from Maxim/Dallas (USA), which have a wide operating temperature range and an accuracy up to ±0.5°C over the range of -10°C to +85°C.

<u>Power and controls</u>

TEMPO-Mini is directly powered and remotely controlled over a cabled network. A software instrument driver at the shore station performs the measurement sequencing and data acquisition. During its first test deployment on VENUS Canada network, the instrument driver for the video acquisition and the lighting was located at IFREMER through a VPN connection over Internet. All the other instruments were directly controlled by the Data

Management and Acquisition System (DMAS) at NEPTUNE and VENUS networks in Canada.

Biofouling issue

Biofouling can be a major issue in marine ecosystems. Tempo-Mini is thus equipped with an innovative system that uses localized microchlorination to prevent biofouling [4]. An external metallic mesh (Fig. 6) or a thin conductive and transparent film of metallic oxide (Fig. 7) protects the portholes of the video camera, LED lights and optode oxygen sensor. The application of a defined potential allows seawater electrolysis to generate hypochlorite on the protected surfaces. This method does not modify the image and the concentrations of chemicals released are negligible.

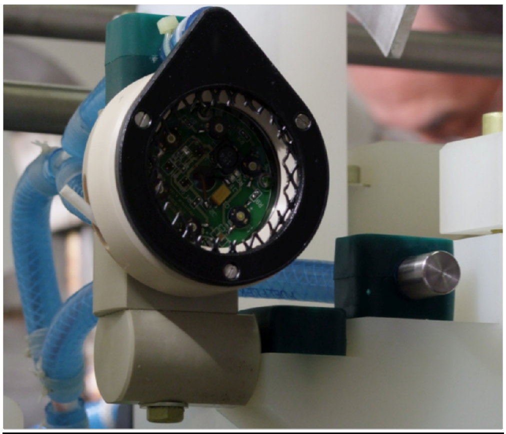

Fig. 6: LED light protected against biofouling with a metallic mesh

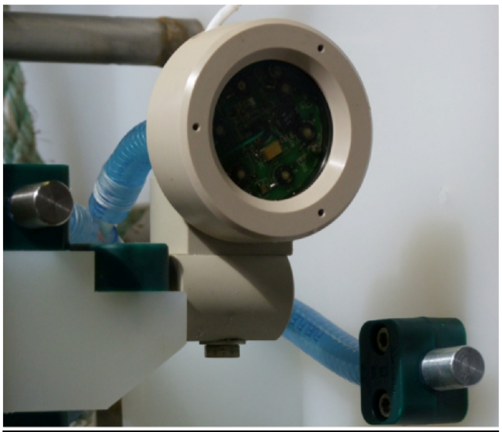

Fig. 7: LED light protected against biofouling with a coated with a thin conductive and transparent film of metallic oxide

CONCLUSION

IFREMER collaborated with NEPTUNE Canada and VENUS Canada networks to acquire live data from the seafloor in Saanich Inlet near Sidney, British Columbia (BC), Canada (Figs 1,2). After this 5-month test in relatively shallow water (100m) TEMPO-Mini has been recovered in February 2009.

In May 2010, TEMPO-Mini, up-dated with a CHEMINI Fe, a new generation of in-situ chemical analyzer of iron using flow injection analysis and colorimetric detection [5], will descend to 2300 m. Linked to the NEPTUNE network, the camera, lights, sensors and probes will help scientists to study the dynamics of deep-sea hydrothermal ecosystems of the Endeavour vent field in the North-East Pacific Ocean.

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