M4 PRELIMINARY RESULTS ON AUTOMATED VIDEO-IMAGING FOR THE STUDY OF BEHAVIOURAL RHYTHMS OF TUBEWORMS FROM THE TEMPO-MINI ECOLOGICAL MODULE (NEPTUNE, CANADA)

Aron M.[81], Cuvelier D.[82], Aguzzi J.[83], Costa C.[84], Doya C.[85], Sarrazin J.[86], Sarradin P.M.[87]

Abstract

The presence of behavioural rhythms has been studied in organisms of coastal areas in relation to circadian and tidal cycles, but their presence in benthic fauna inhabiting dark deep-sea regions remains largely unknown. Cabled video-observatories allow the study of these activity rhythms via the acquisition of pictures or footages over extended periods of time. In this work, we present the preliminary steps in the automation of biological data extraction for the determination of deep-sea fauna activity rhythms with TEMPO-mini (NEPTUNE; Canada). Automated analyses of tube worm behaviour were carried out with the Hough transform algorithm. Some different testing parameters were applied to the same image with siboglinid tubes. Tube openings identifications showed to be difficult, since circle placing was in some cases attributed to animals. The future step of automation will be to run the Hough transform algorithm within sub Region of Interests were tube identifications is the most efficient as we identified with this preliminary screening. Then, we will focus on each singe individual producing time series in terms of opening identification (as marker of moments of animals' retractions) per unit of time (e.g. 10 min).

Key words: Cabled observatories, TEMPO-mini, NEPTUNE, time lapse photography, Automated video imaging, tube worms rhythms.

INTRODUCTION

The presence of behavioural rhythms has been studied in organisms of coastal areas in relation to circadian and tidal cycles, but their presence in benthic fauna inhabiting dark deep-sea regions remains largely unknown (Aguzzi and Company, 2010; Aguzzi et al., 2011). This is particularly true for the deep-sea as a whole and more specifically for the hydrothermal vent ecosystems as these are often characterized by their remoteness, both in depth as from land. Moreover, hydrothermal habitats are characterized by a huge variability and steep gradients of environmental conditions in which vent organisms tend to survive.

Cabled video-observatories allow the study of these activity rhythms via the acquisition of pictures or footages over extended periods of time (Aguzzi et al., 2012). The TEMPO-mini ecological module was implemented on the NEPTUNE observatory (www.neptunecanada.ca), focusing on a hydrothermal edifice of the Main Endeavour Field. This module has provided us with a huge amount of continuous imagery data along with environmental data (e.g. temperature, iron and oxygen concentrations).

Various temporal studies have already been carried out at hydrothermal vents, however, these are at best based on yearly visits and thus assessing pluri- and/or inter-annual variability (see Cuvelier et al. 2011 for an overview). The use of time lapse cameras already emphasized the importance of sub-annual processes, such as diurnal and semi-diurnal periodicities, in shaping the hydrothermal vent communities (Tunnicliffe et al. 1990). Here, we have a unique opportunity to see what actually happens at a deep-sea hydrothermal vent. In this work, we present the preliminary steps in the automation of biological data extraction for the determination of deep-sea fauna activity rhythms. We focused on the behavioral rhythms of plume (i.e. branchial apparatus) emergence and retraction of the siboglinid tube worm (Ridgeia piscesae), a typical vent species, using time-lapse imagery.

METHODS

TEMPO-mini isa deep-sea ecological observatory module developed by IFREMER to study the dynamics of hydrothermal communities (Auffretet al. 2009). It has been deployed in 2011 at the base of the Grotto edifice, located at 2186 m depth on the Main Endeavour Field as part of the NEPTUNE cabled observatory (off the coast of British Columbia, Canada) (Figure 1).

23 days (7/10/2011 – 30/10/2011) of continuously video recordings are available, saved at a frequency of 5 minutes (adding up to a total of 6480 sequences available, ~540 hrs) (Figure 2). Images were stored in a .mp4 file and were compressed using the H264 codec under a resolution of 1440x1080 pixels.

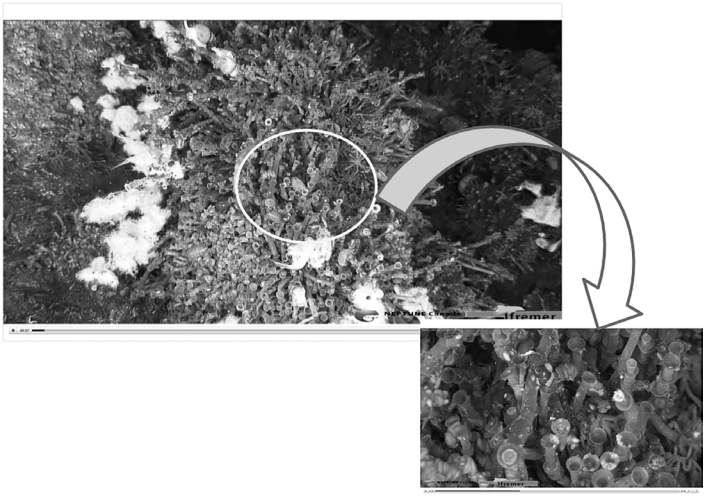

Fig. 2. The TEMPO-mini observatory module records imagery data from an assemblage visually dominated by Ridgeia piscesae tubeworms. Large: A screen shot of the 23 day continuously recorded Region Of Interest. Small: a zoom-in of the faunal assemblage, dominated by R. piscesae, polynoid polychaetes, Buccinum snails, pycnogonids, and microbial mats.

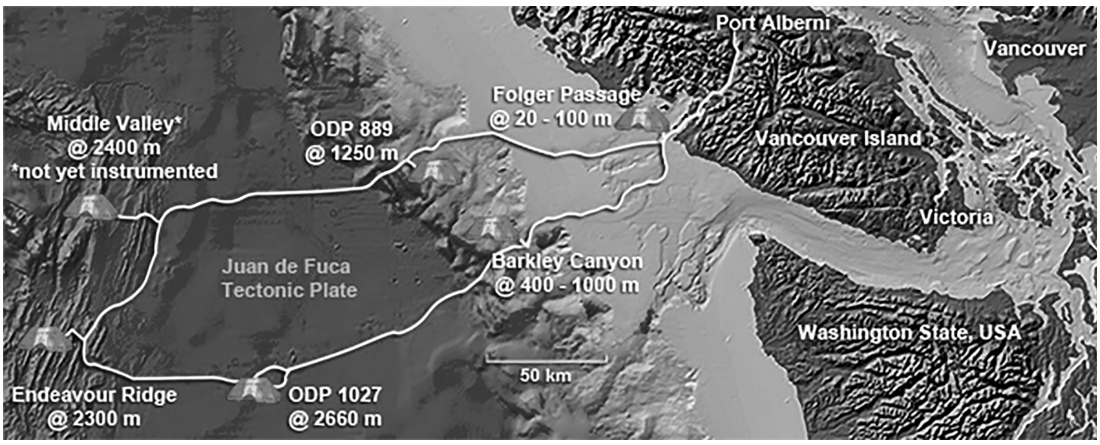

Fig. 1. Area map off the coast of British Columbia (Canada) featuring the NEPTUNE cabled observatory. The Tempo-mini module is connected to the Endeavour Ridge node.

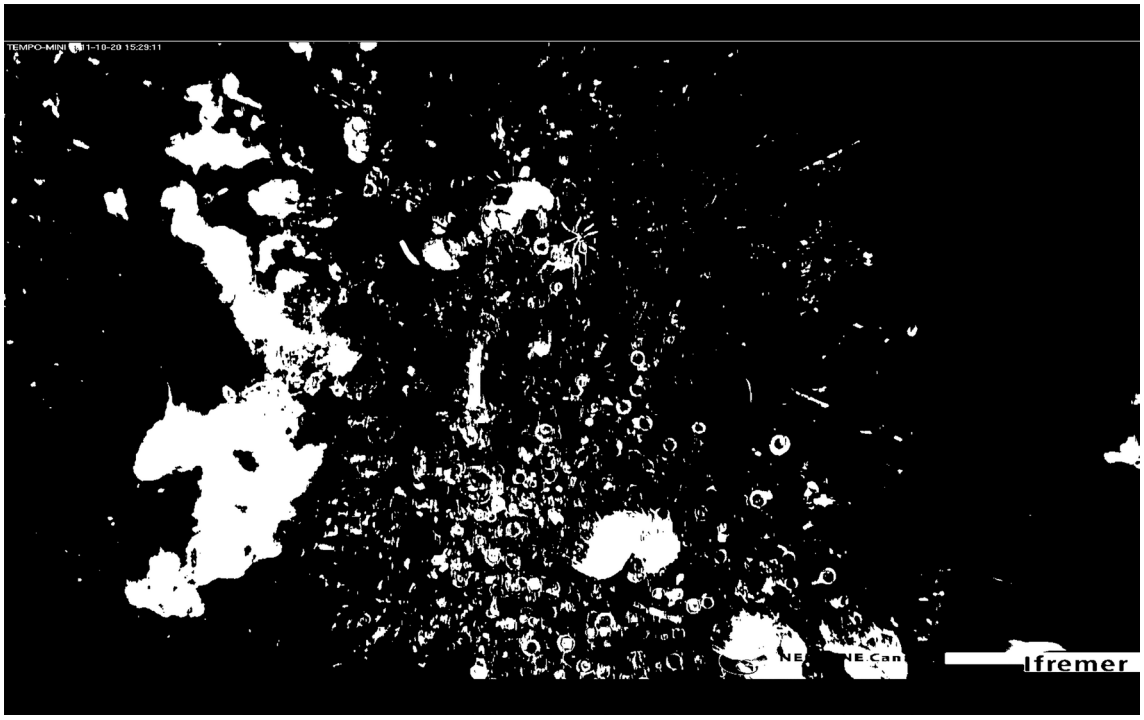

Figure 3. Black and white binarized output of image in Figure 2, as carried out in order to enhance tube warm tube openings prior the processing with the Hough transform algorithm.

Automated analyses of tube worm behaviour were carried out with the Hough transform algorithm [1]. This is an image processing method used to segment defined shapes such as lines and circles. Our tests were performed with the Hough algorithm defined in [2] and implemented in the OpenCV library [3]. Several parameters had to be fixed by the user in order to efficiently use the algorithm: the minimum (minr) and maximum (maxr) radius in pixels of detected circles, a threshold parameter (p1) to perform an edge detection on the image on which the Hough transform is applied, the minimum distance (md) in pixels between detected circles and another threshold (p2) corresponding to the Hough method itself ("accumulator threshold" - the smaller it is, the more "false circles" may be detected). Before using this method, a thresholding of the image was applied, in order to enhance tube openings reducing the background noise (Figure 3).

RESULTS

Here, we presented the outputs of automated processing of acquired images, as an example of difficulties in identification and counting of tube openings by the Hough transform algorithm (Figure 4). Some different testing parameters were applied to the same image with siboglinid tubes. The images were named according to the values of applied parameters (i.e. md, Minimum Distance; minr, Minimum Radius; and finally maxr, Maximum Radius), as follow:

A-Image "Neptune_md10_at_17_minr1_maxr20.png"
B-Image "Neptune_md1_at_17_minr1_maxr20.png"
C-Image "Neptune_md10_at_17_minr1_maxr40.png"
D-Image "Neptune_md10_at_10_minr1_maxr20.png"
E-Image "Neptune_md10_at_17_minr10_maxr20.png"

A-image showed the "best" results, while the B one evidenced that md between detected circles should be higher to 1 unit in order to avoid multiple circle detection for one tube. Image C showed the influence of the maxr parameters for detected circles. A too high value of it provided results without any biological meaning. Differently, in D the influence of the accumulator threshold is evident. A high amount of "bad" circles are detected with a low threshold.

Tube openings identifications showed to be difficult, since circle placing was in some cases attributed to animals (e.g. the misclassification of the pycnogonid in Figure 4D; i.e. in the upper centre). Outputs in openings automated counting are presented in Table 1. and indicated for the same image

DISCUSSION

In this work we presented the results of a preliminary testing we performed in order to set the best parameters for TEMPO-mini automated image processing. We used one single image and subsequently, we tested the capability of the Hough transform algorithm in counting tube warms openings. Based on the results presented in Figure 3, difficulties still exists after image binarization, and a different parameter setting of algorithm produce too highly variables results, being only one condition the best.

The future step of automation will be to run the Hough transform algorithm within sub Region of Interests were tube identifications is the most efficient as we identified with this preliminary screening. Then, we will focus on each singe individual producing time series in terms of opening identification (as marker of moments of animals' retractions) per unit of time (e.g. 10 min). As terminal step, we are now validating our results by comparing them with a manual counts, in order to be able to quantify the error provided by the automatic processing method.

N	Image A	Image B	Image C	Image D	Image E
Detected circles	25	58	192	572	5
True openings	23	23	23	23	5

Table 1. Outputs of automated identification of tube warms openings by the Hough transform algorithm.

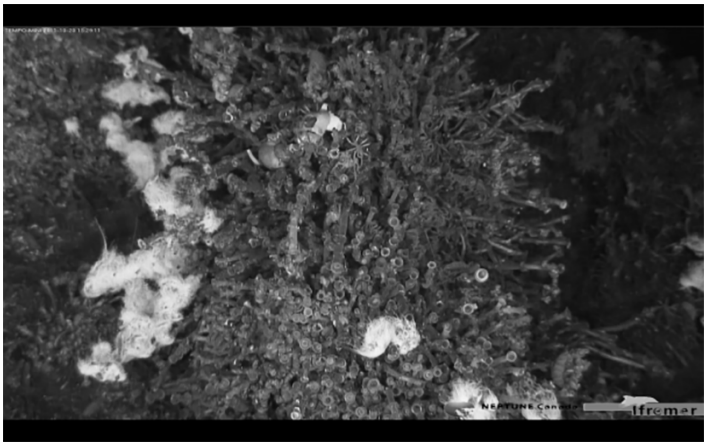

IMAGE A

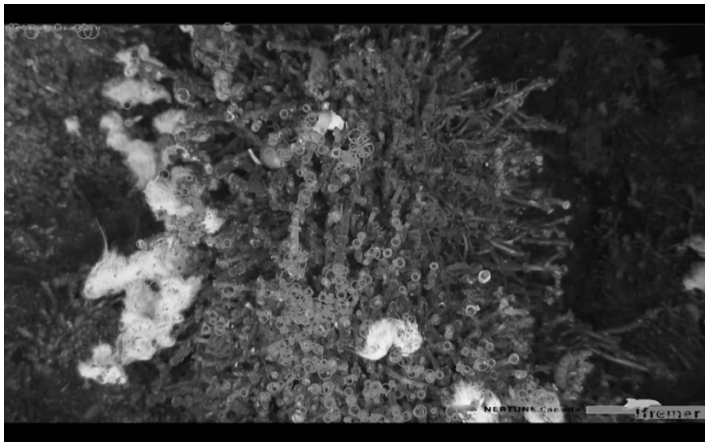

IMAGE D

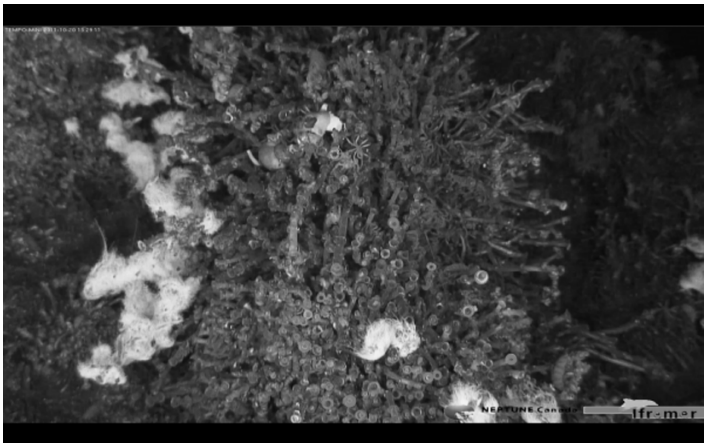

IMAGE B

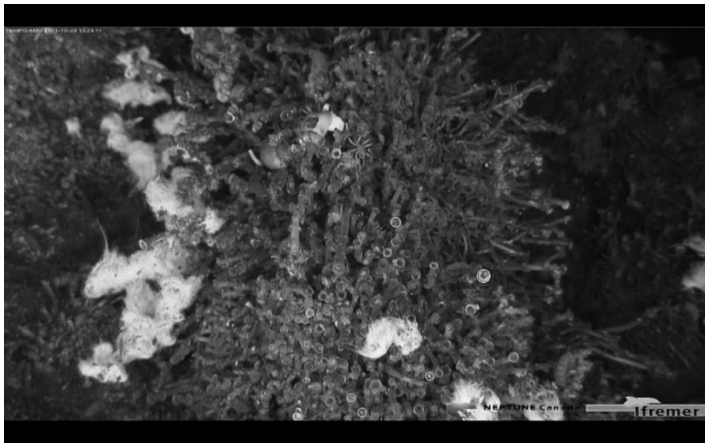

IMAGE E

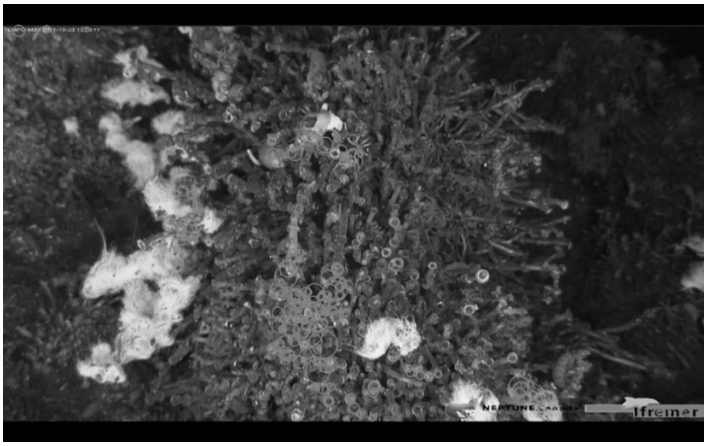

IMAGE C

In the course of the next year, present results will be associated to the habitat multiparameter also measured by TEMPO-mini, specially focusing on water speed increases and decreased and associated temperature changes. We will then evaluate the linkage between animals' rhythms of fan activity and internal tidal motions.

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