Supplementary Materials

Index:

1) Technical details of time-lapse apparatus

The time-lapse apparatus used in this experiment was composed by the following components (Fig. 1):

- one go-pro housing with a BackPack Backdoor for external battery or LCD
- one action-cam GoPro Hero3+B (Black)
- one modified CamDo time-lapse intervalometer controller (placed inside the GoPro housing in the lodgement for the GoPro supplementary battery) (http://cam-do.com)
- one modified underwater Light&Motion SOLA 2000 flood light (http://www.lightandmotion.com/).
- one Sea&Sea fiber-optic cable (http://www.seaandsea.jp/products/strobe/accessory/020.htmland). The two ends of the Sea&Sea fiber optic cable were attached to the rear outside of the camera housing and to the front glass of the lamp using the dedicated adhesive-velcro kit.

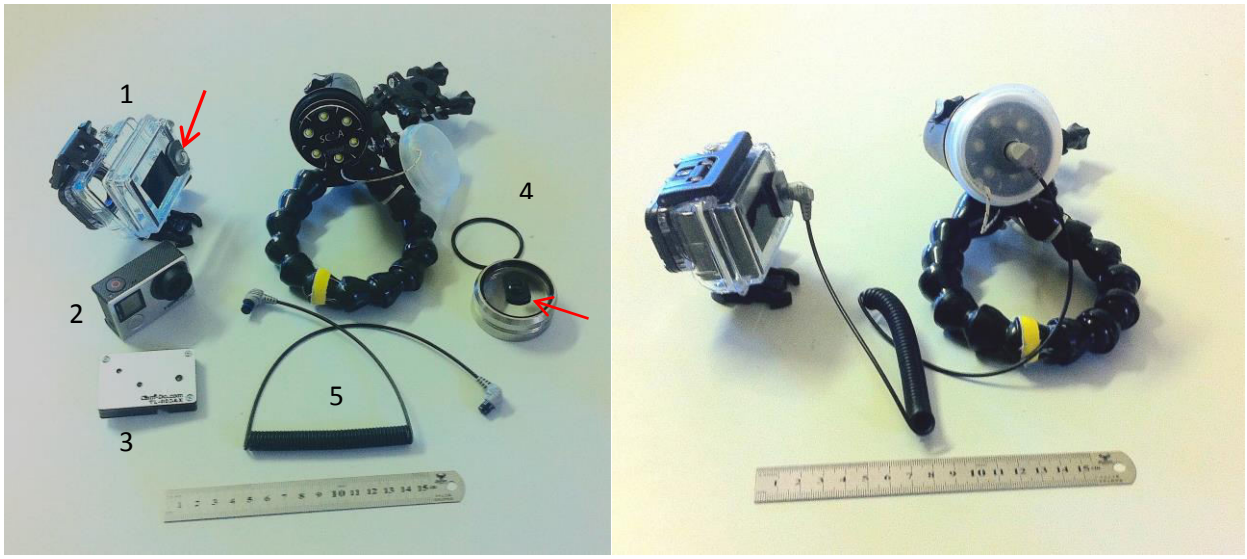


Fig. 1. The time-lapse system array. On the left: the components (1- GoPro housing; 2- GoPro Hero3+Black; 3- CamDo intervalometer; 4- Sola 2000 light disassembled. The red arrows indicated the two velcro-adesive kit to connect the camera to the light. On the right: the system ready to work with a diffuser mounted on the light front glass.

2. Electronic boards hacking

Purpose of the electronic hacking of circuits is the triggering of the SOLA light by the Cam-Do intervalometer through a Sea&Sea optical fiber link.
SOLA light originally has a magnetic slide switch that turns on the lamp if pushed forward and turns off the lamp if pushed backward for about 2 seconds. The magnet was removed from the switch as showed in Fig.2 not to interfere with the electronic hacking. The switch components must be reassembled in their original position paying attention to block the overpressure valve in the rear part of the switch.

Fig. 2: The switch of the Sola 2000 light disassembled. The black arrow indicates the magnetic switch. The red arrow indicates the position of the overpressure valve.

Both the CamDo intervalometer and the SOLA lamp were modified in their electronic boards as follow:

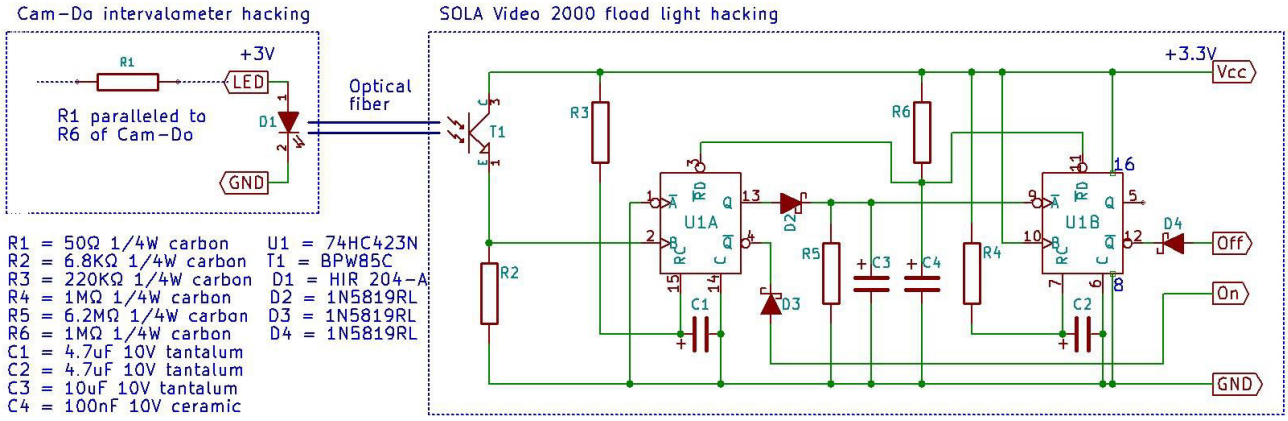
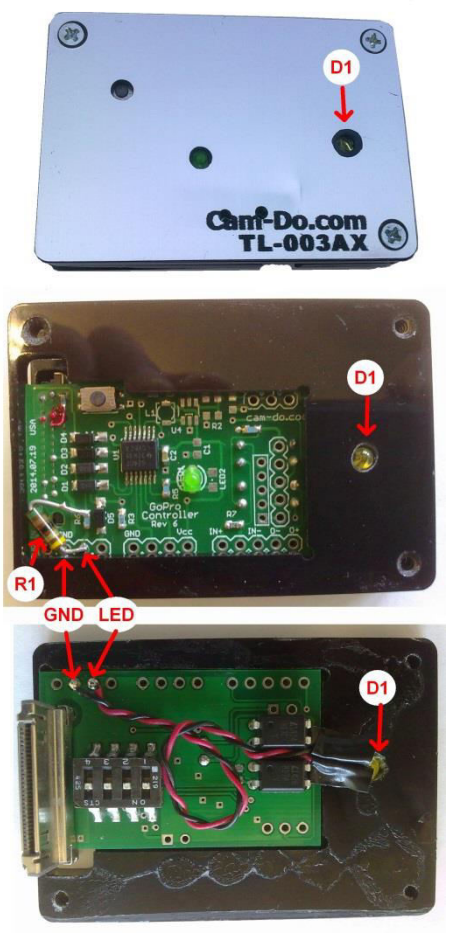


Fig. 3. Electrical scheme for CamDo intervalometer and Light&Motion Sola 2000 lamp hacking.

2.1 Cam-Do intervalometer hacking (Figs 3 and 4)



The Cam-Do intervalometer turns ON the GoPro action camera at predefined intervals and indicates this status by the high-level (3V) of the "LED" output placed on the Cam-Do board. The Cam-Do hacking consists to put an infrared LED (D1) on the "LED" output and to increase the "LED" output current to 30mA by putting a 50Ω resistor (R1) in parallel of the R6 resistor placed on the original Cam-Do board. Mechanically, the D1 infrared LED is placed on the right side of the Cam-Do intervalometer through the implementation of a 3mm drill hole.

Fig. 4. CamDo intervalometer (top), its internal electronic cardboard in rear view (middle) and its front view (bottom).

2.2 SOLA light hacking (Figs 3 and 5)

The positions of the magnetic slide switch are sensed by the three hall-effect sensors mounted on the original SOLA flood light board named U4, U2 and U8.
Our hacking consists to short circuit to ground (GND) the hall-effect sensor U4 output for 0.5 seconds to turn ON the lamp and to short circuit to ground (GND) the hall-effect sensor U8 output for 2.5 seconds to turn OFF the lamp. The infrared trigger coming from the Cam-Do intervalometer by the optical fiber reaches the infrared phototransistor (T1) that triggers the first timer (U1A) whose Q- output (pin 4) goes immediately low turning ON the Sola light. The first timer (U1A) stay ON for about 0.5 seconds (Time=0.55*R3*C1) emulating the manual forward pushing of the original magnetic slide switch and producing the turn ON of the lamp.
While the ON statement of the first timer, a second timer has triggered (R5 and C3) by the Q+ output (pin 13) of U1A. The second timer (R5 and C3) has been dimensioned for a time constant of about 10 seconds, after that, it triggers the third timer (U1B) that stay ON (pin 12) for about 2.5 seconds (Time=0.55*R4*C2) emulating the manual backward pushing of the original magnetic slide switch and producing the turn OFF of the lamp. The R2 resistor value defines the sensitivity to the infrared optical trigger and the immunity to the ambient background light that filters into the optical link so, special care must be taken in the lightshielding at the two leads of the optical fiber. Mechanically, the hacking circuit has been developed with no board because of the limited space available between the SOLA flood light original board and the battery pack. The hacking circuit connects to the original board by the use of four wires welded on some pins of the U4 and U8 hall-effect sensors. The infrared phototransistor (T1) has been stucked in an implemented 3mm drill hole placed in the center of the front Cree LEDs board of the SOLA flood light.

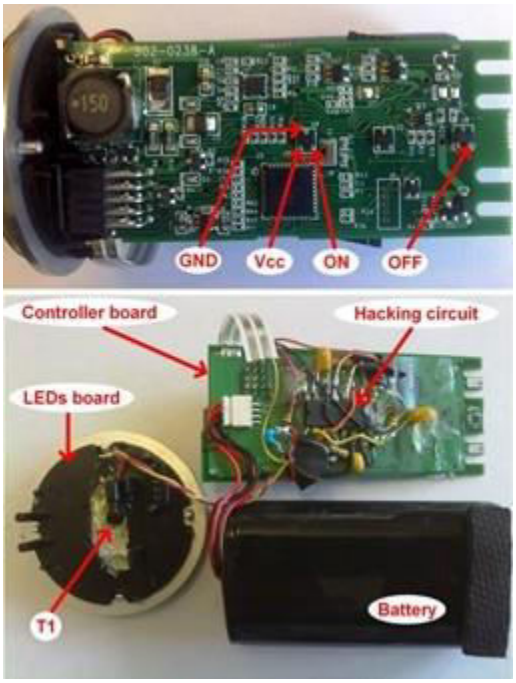


Fig. 5. Sola 2000 light controller board in front view (top) and light components and additional circuits (bottom).

3. How the hacked system works

Every 6 minutes the Cam-Do intervalometer turns ON both, the GoPro action camera and the infrared LED D1. The infrared light emitted from D1 has taken to the infrared phototransistor T1 located on the Sola light through the multimodal optical fiber Sea&Sea. T1 starts a 0.5 seconds timer to turn ON the Sola light and, concurrently, starts a 10 seconds timer (the amount of time the Sola light illuminates the scene). In the meantime the GoPro action camera boot-up, takes the picture an then turns OFF itself. When the 10 seconds timer reaches the end, the 2.5 seconds timer starts to turn OFF the Sola light.

N.B: Although an infrared optical coupling has been used (850nm), the receiving phototransistor (T1) can be turned ON by the infrared part of the ambient background light. For this reason the Sola light should be adequately shielded from ambient light before the dive.

4. Field tests

GoPro3B+ model: underwater test for field view and light adjustments (automatic ISO)

Fig. 6. Test I: photographs shot with light

Camera: GoPro3+ Black Edition
Date: 2/12/2015
Hour: 16:18
TV: 1/30
AV: 2.8
ISO: 200

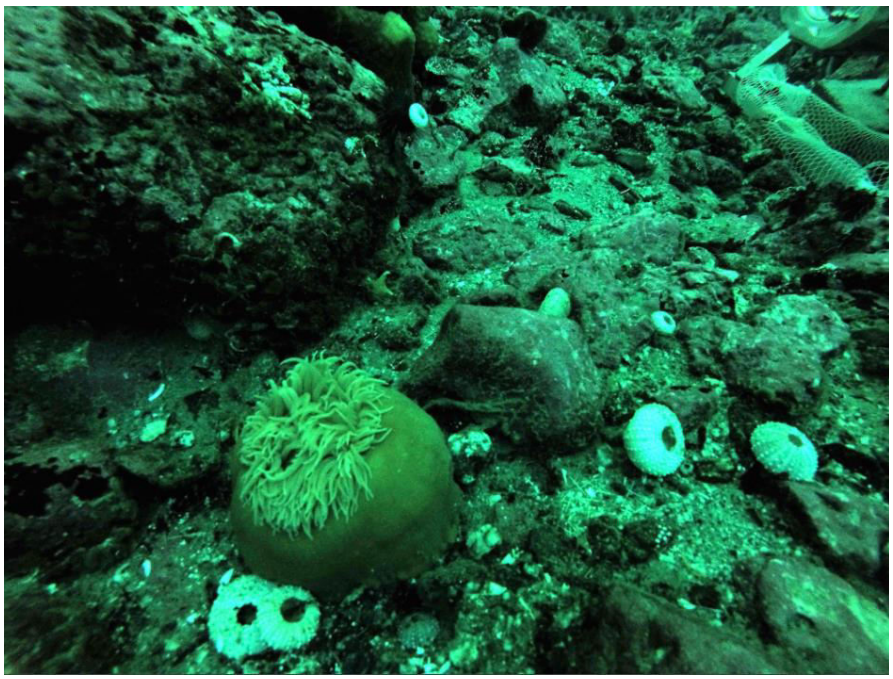


Fig. 7. Test II: photographs shot without light

Camera: GoPro3+ Black Edition
Date: 2/12/2015
Hour: 16:24
TV: 0.5
AV: 2.8
ISO: 400

5. Example of a time-lapse experiment

The video ‘Antarctica-Thethys Bay 14-15 dec2015.m4v’ shows a two days time-lapse experiment. It can be seen and downloaded in the Supplementary Materials section of the journal.