TNA PROJECT REPORT

1. Project Information

Proposal reference number	JN_CALL_2_12
Project Acronym (ID)	FOULSTOP
Title of the project	Fouling Protection for Marine Optical Systems
Host Research Infrastructure	Expandable Seafloor Observatory (OBSEA)
Starting date - End date	09/11/2018 - 21/05/2019
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2. Project objectives

This project consist to test in the Mediterranean sea environment an innovative technique to protect optical windows that are part of optical oceanographic sensors or more generally part of optical devices like underwater cameras and lights. The biofouling protection is achieved by a conductive layer that coats the optical window and is used to generate very low quantity of hypochlorous acid by controlled *in situ* chlorination of seawater.

3. Main achievements and difficulties encountered

The FOULSTOP antifouling station equipped with 2 protected fluorometers, 1 unprotected fluorometer and a protected camera was deployed on the OBSEA seabed observatory from 5th of December 2018 to 21st of May 2019. During this deployment the station was recovered on the 15th of February and deployed back to sea on the 12th of April. During this recovery the real time data transfer system and the fluorometers were checked.

The biofouling protection of the optics of the 2 fluorometers and of the camera is achieved by a conductive layer that coats the optical window and is used to generate very low quantity of hypochlorous acid by controlled in situ chlorination of seawater.

This innovative low power demand and very efficient biofouling protection technique was controlled by a loop system based on a biofilm sensor that can trigger the active biofouling protection device only when biofilm formation is detected.

Before shipping the station to OBSEA we were not sure that the biofilm sensor was working properly. We could not postpone anymore the shipping and consequently it was decided to cancel the antifouling loop system in order to ensure that the antifouling protection was applied at its maximum rate. The maximum rate for fluorescence sensors was a periodic cycle made with 10mn with protection ON and

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then 10mn with protection OFF. For the camera, since there is no possible adverse effect on the images due to the protection, the maximum rate was a continuous protection ON. The loop system based on the biofilm sensor was first demonstrated during the NeXOS project (*NeXOS Project, D3.4 – Biofouling protection control system, Test and Sites Dependence Report*) during a one month deployment, and showed that a sensor protection controlled by the biofilm sensor is perfectly protected with SnO_2 conductive layer technology with a ratio of 1/6 compared to a protected sensor that is blindly actively protected by the same technology and on half time period (e.g. 10mn ON, 10mn OFF).

After nearly 5 months of deployment in the Mediterranean Sea the biofouling protection shows a good protection efficiency that was clearly showed for example by the images (camera) that remained perfectly unblurred during the whole period. And, the fluorescence measurements produced by the two protected fluorometers didn't show drift that could be caused by biofilm development and the unprotected one showed a suspicious drift.

4. Dissemination of the results

Social media, and photos of the deployments:

JERICO-NEXT Web site: http://www.jerico-ri.eu/2019/01/29/fouling-protection-for-marine-optical-systems/

The live video was displayed during the whole deployment on the OBSEA web site:
https://obsea.es/data/live_video.php#loaded

https://twitter.com/Jerico_NEXT/status/1090929807041486848

https://photos.app.goo.gl/vUuV77BxA9gTkpb19.

https://photos.app.goo.gl/VK4dwUKAqJ55EeSi8

https://photos.app.goo.gl/8k97H6UEXRRZWNm47
https://photos.app.goo.gl/mXUYVPDTHqVFPtXs7.

The FOULSTOP TNA results will be presented during the final JERICO-NEXT general assembly in Brest from the 2nd of July to the 5th of July.

The Ifremer is presently studying how to collaborate with private companies specialized in oceanographic instrumentation and underwater cameras.

5. Technical and Scientific preliminary Outcomes

The FOULSTOP antifouling station equipped with 2 protected fluorometers, 1 unprotected fluorometer and a protected camera was deployed on the OBSEA seabed observatory from 5th of December 2018 to 21st of May 2019. The FOULSTOP station was immersed at 20m depth in the Mediterranean Sea and during a period where fouling pressure is from medium to high.

The biofouling protection technology has been fully integrated to two TriOS commercial optical sensors and an HD camera. The deployment at sea is performed on an underwater-cabled structure equipped with an EMSO COSTOF II junction box. As show on the photo below, the camera is placed faced to the three fluorometers and connected to the OBSEA observatory by a specific junction box that allowed for example to view the camera online in real time on the OBSEA website.

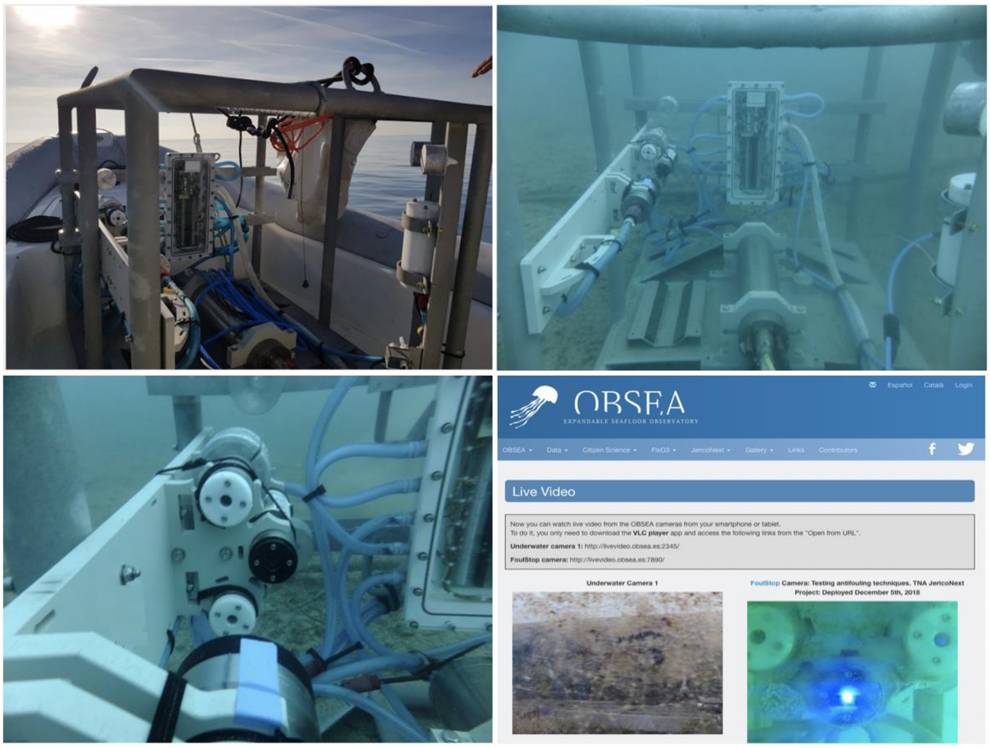

Fig 1: The FOULSTOP station deployment and online camera stream on the OBSEA website

To evaluate the efficiency of the biofouling protection, 2 indicators was used. The first one consists to compare the fluorescence measurement produced by the protected fluorometer in comparison to the one that is unprotected. If a fluorometer is affected by a biofilm, the fluorescence measurement should rise little by little as the biofilm is developing. The second indicator is to examine the images produced by the camera as the experimentation runs and monitor whether the images become fuzzy or not.

The figure below shows the fluorescence signal produced by the unprotected fluorometer (top) and the protected fluorometer (below).

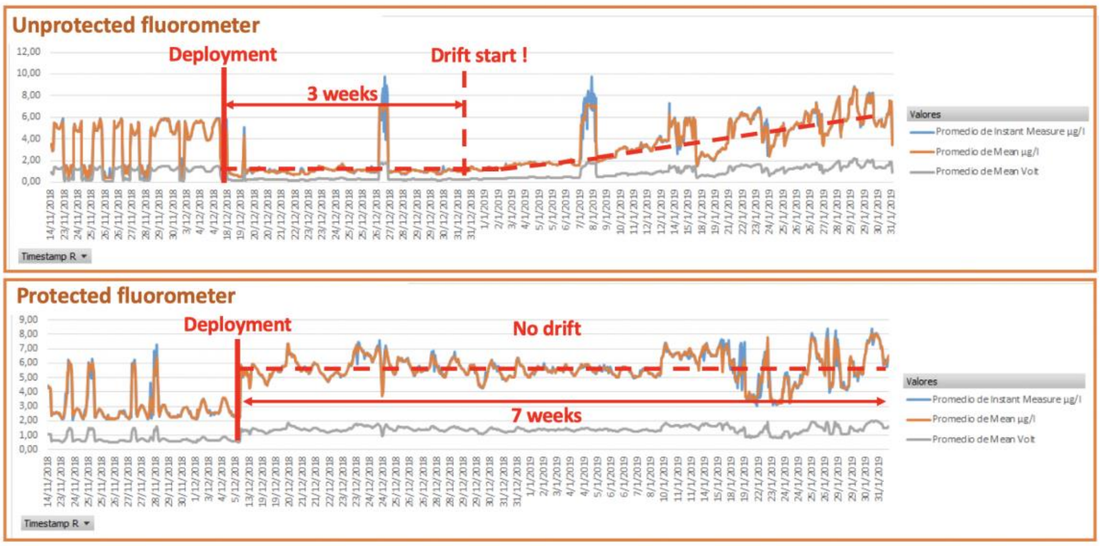

Fig 2: Fluorometers, 2 first months of deployment.
Top: Unprotected fluorometer – Below: Protected fluorometer

The important information shown by these data (Fig 2) is the regular increase of the value produced by the unprotected fluorometer after 3 weeks of deployment and during the remaining 4 weeks of data recording. And at the same time the protected fluorometer shows fluorescence variations but not a continuous increase during the 7 weeks of continuous recording. This indicates that a biofilm has developed on the optics of the unprotected fluorometer while on the protected instrument no biofilm happened.

Indicator #2 is shown below (Fig3).

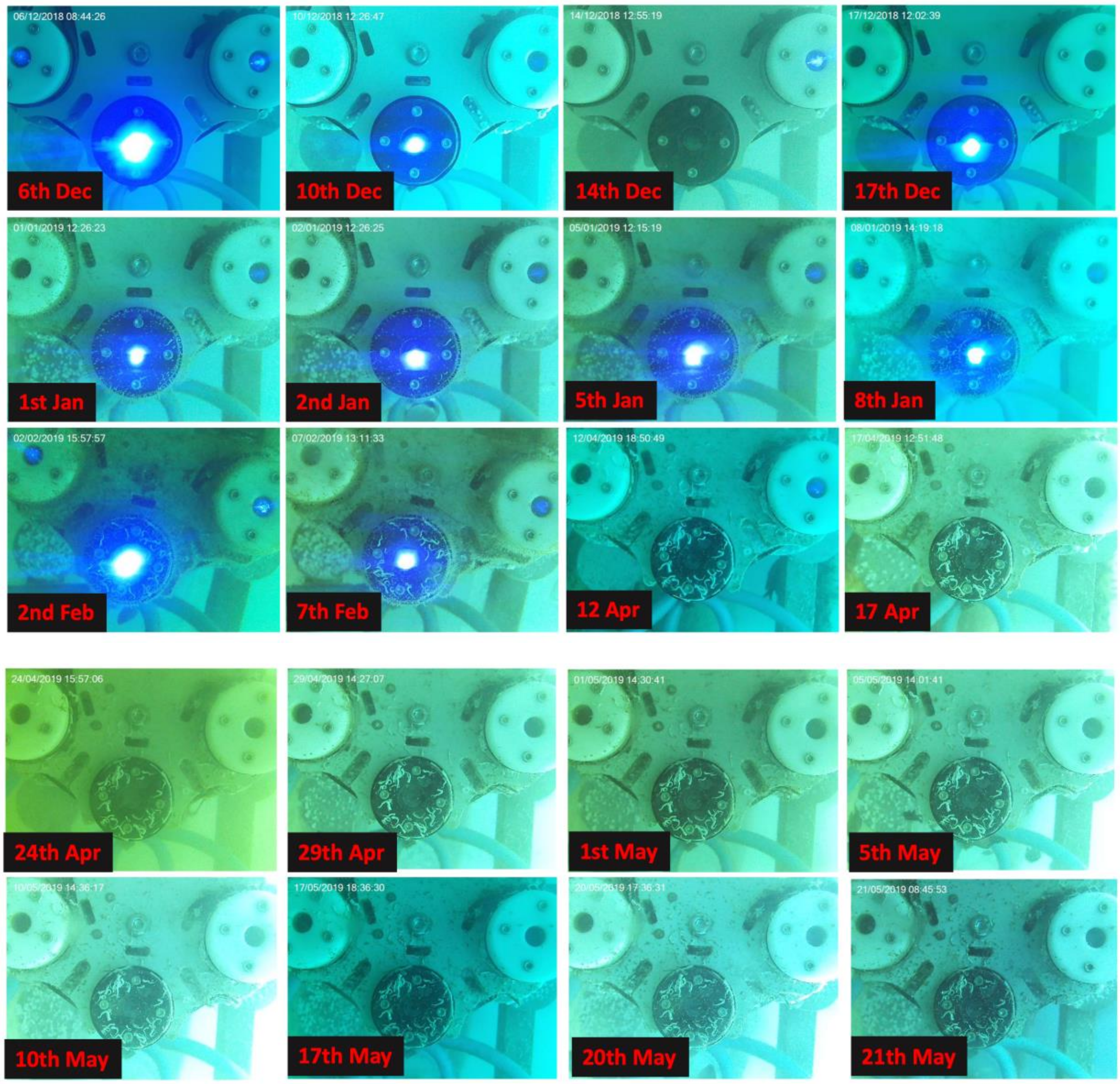

Fig 3: Protected camera snapshots over the full deployment duration (from December 2018 to May 2019)

Fig 3 is showing snapshots produced by the protected camera over the full deployment duration, from December 2018 up to May 2019. The snapshots show clearly the very neat images obtained days after days regardless of deployment duration thanks to the biofouling protection used on the optics of the camera. We can see on the pictures the unprotected fluorometer in the center with a black optic holder getting little by little colonized by biofouling.

As a general conclusion, we can consider that this experiment clearly demonstrated that the biofouling protection for optical instruments based on a polarized conductive layer is efficient enough to protect camera or fluorometer in Mediterranean Sea conditions. This experiment has been a very useful complement to the previous test performed in Atlantic condition during the NeXOS project.

To complete the Atlantic and Mediterranean tests, it would be desirable to be able to deploy this technology in North Sea conditions, for example on the LoVE observatory in Norway or the Utö observatory in Finland.

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