Biofouling protection for marine sensors

JERICO - 1[ST] March 2012

Laurent Delauney – RDT/EIM

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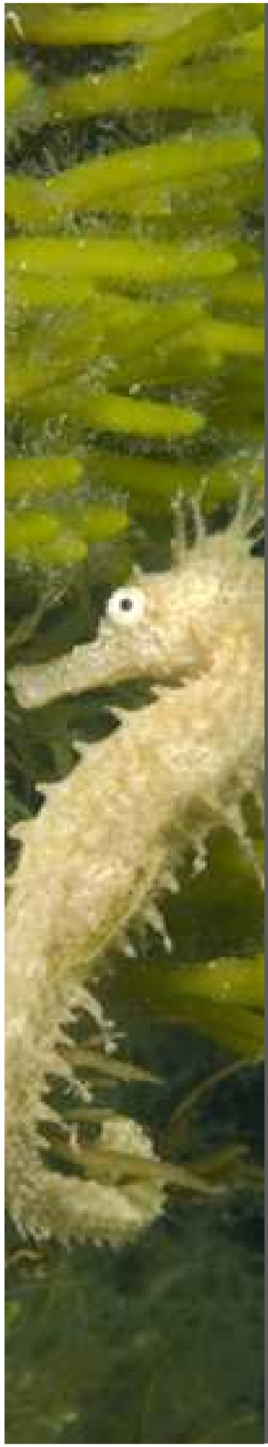
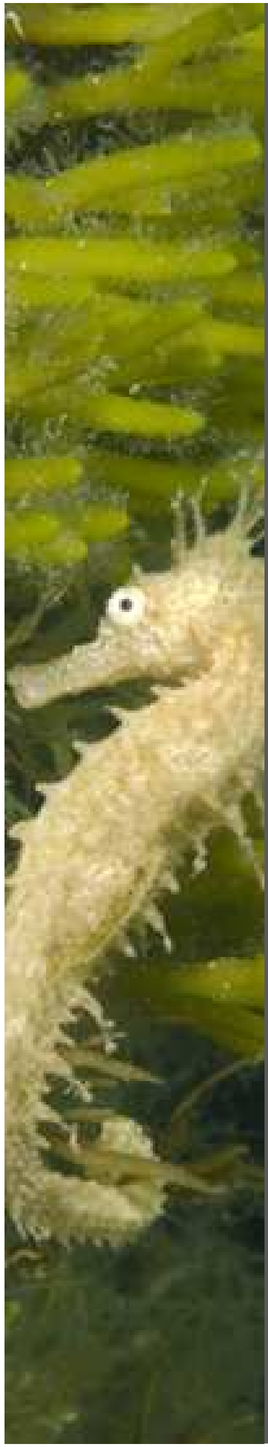
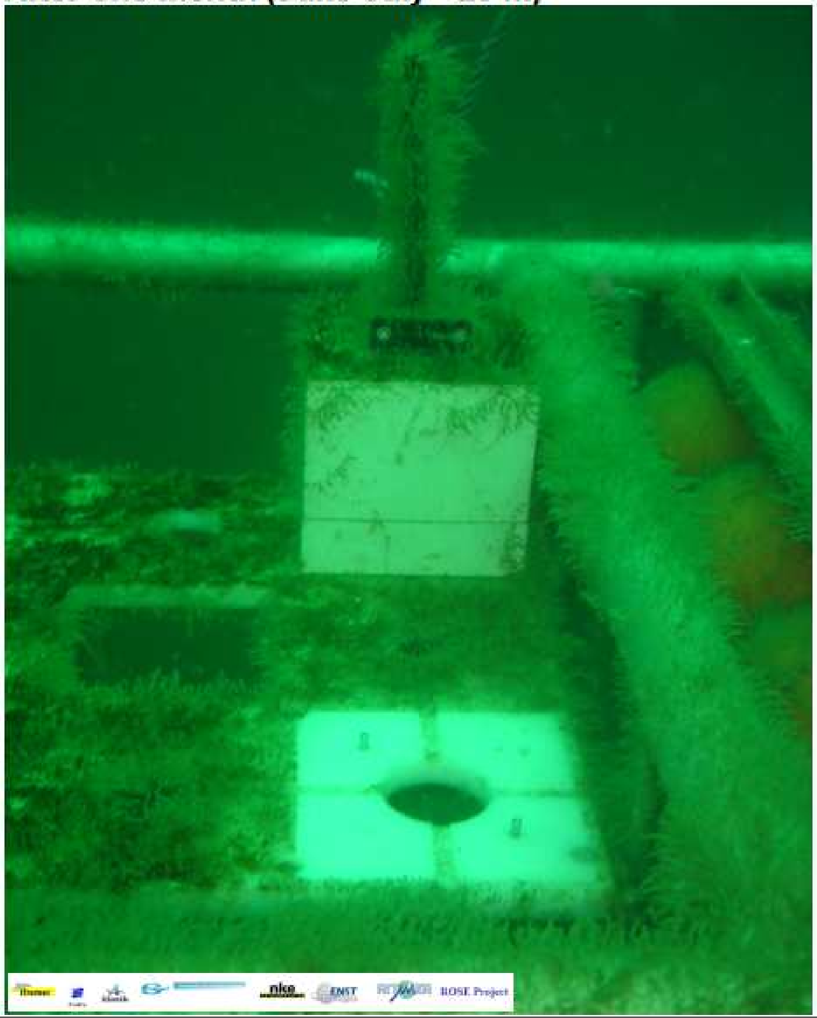


Sensors & biofouling



Biofouling example
Marine Benthic Observatories.

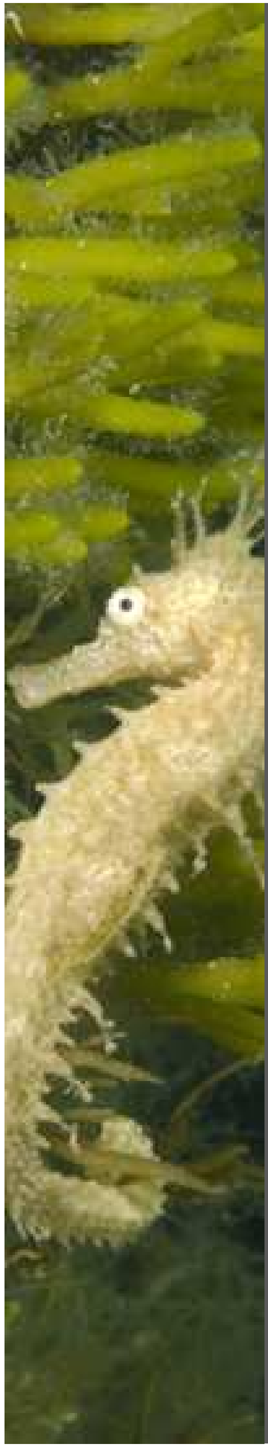
After one month (June-July - 25 m)



After three months (June-Sept. - 25 m)

Photos : Ifremer (FR)

Biofilm development must be taken into acount ...

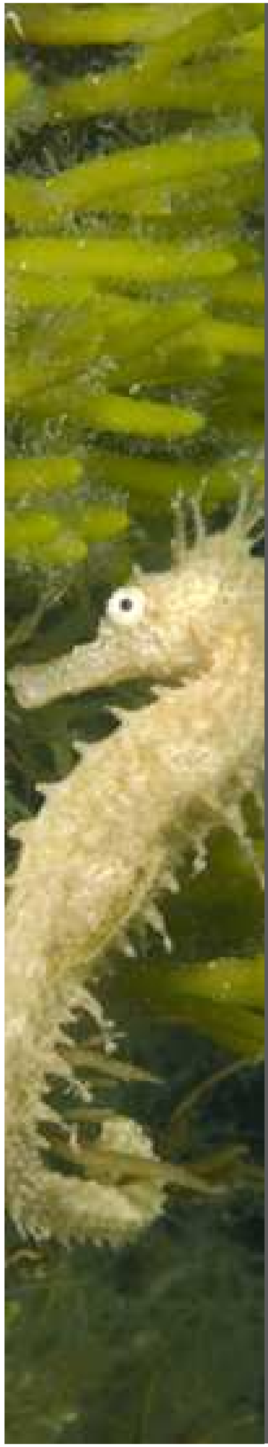


Biofouling example

YSI 6600 EDS (Extended Deployment System) - Clean SweepTM

150 days ◆ April - Sept 2005 ◆ St Anne Portzic Brest

Photo : Ifremer (FR) L. Delauney



Biofouling example

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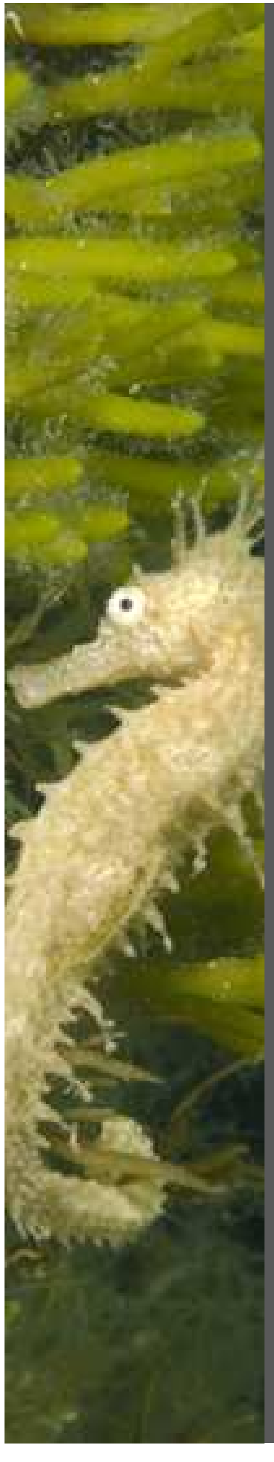
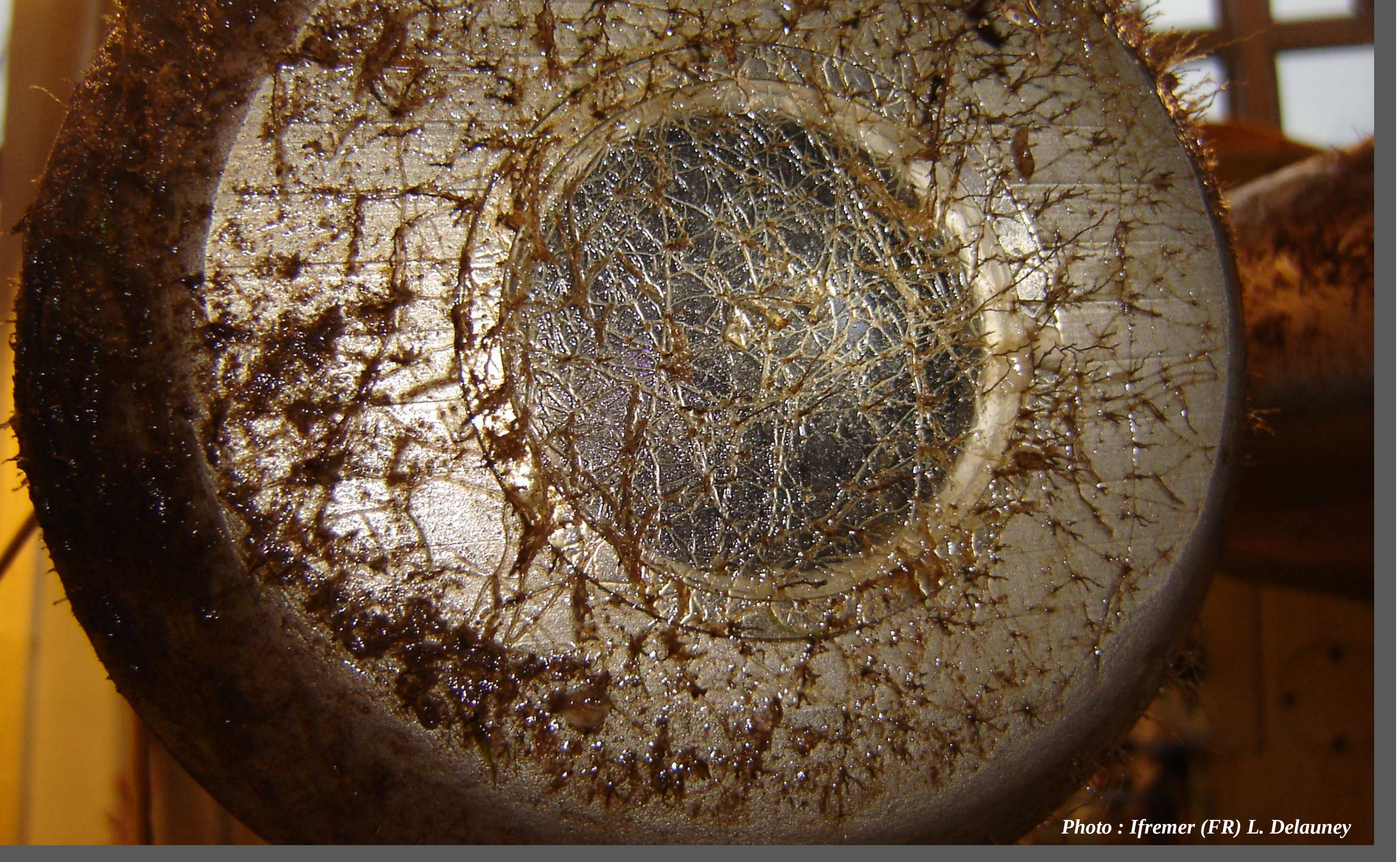
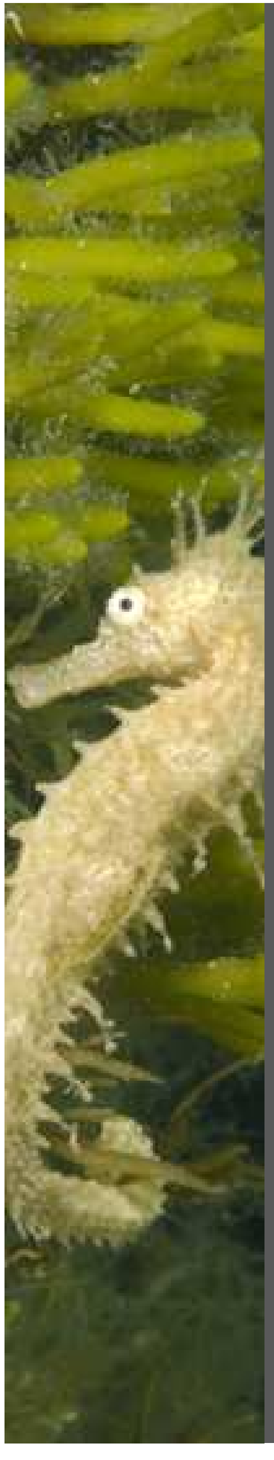


Biofouling example

Optisens Transmissometer

90 days ◆ August - October 2005 ◆ Trondheim





Biofouling example

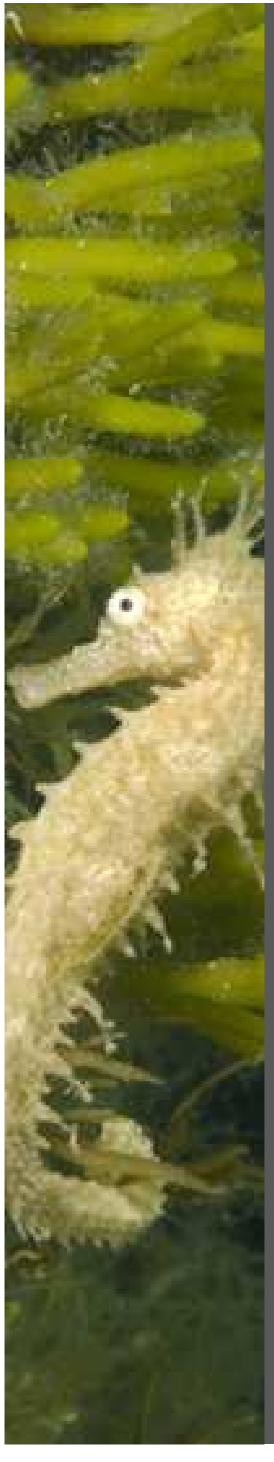
Seapoint Fluorometer

90 days ◆ May - July 2006 ◆ Brest

Photo : Ifremer (FR) L. Delauney

Biofouling example

70 days ◆ June - August 2005 ◆ Helgoland - DE

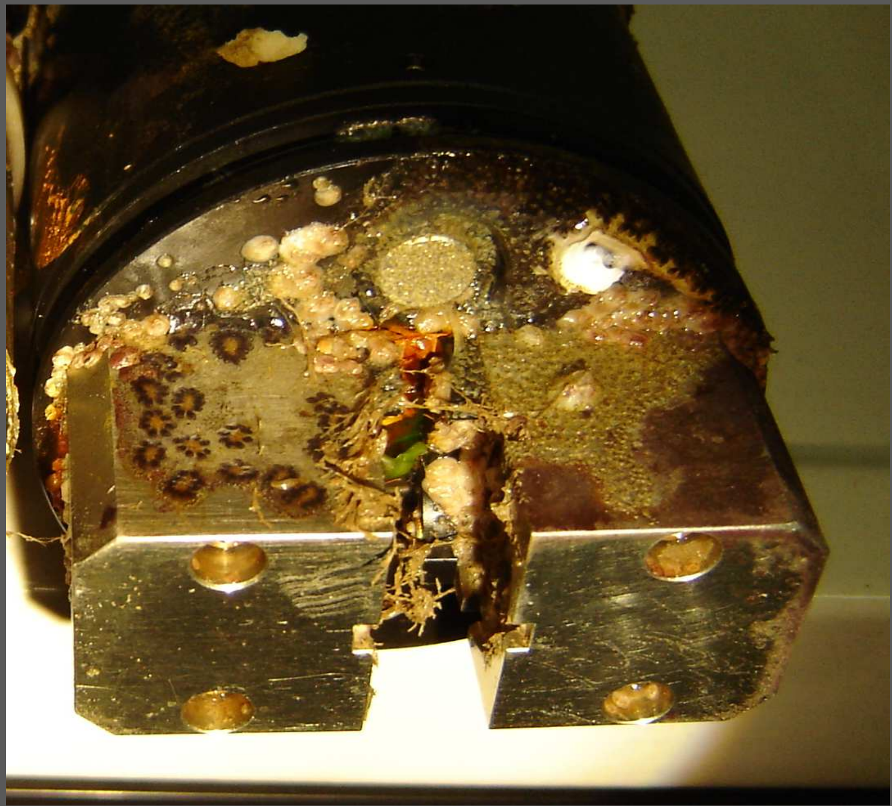


Ifremer (FR) L. Delauney Y. Faijan
GKSS (DE) K. Kröeger et Al. - CNRS UPR15 (FR) H. Cachet et Al.

Biofouling example

- ***Materials and shape should be chosen very carefully in order to reduce fouling attachment.***

40 days ◆ August - October 2005 ◆ Helgoland - DE



Photos : Ifremer (FR) L. Delauney

Biofouling effect on marine sensors : Progressive interface modification.

- Optical sensors : turbidimeter, fluorometer, ...,

  => optical property modification
  (Window opacity, interference, ...

Atlantic Ocean

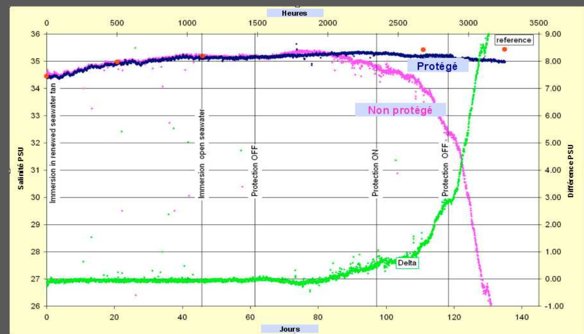
Bosphorus strait

Baltic sea

- Membrane based sensors : pH, oxygen.

  => membrane permeability modifications.

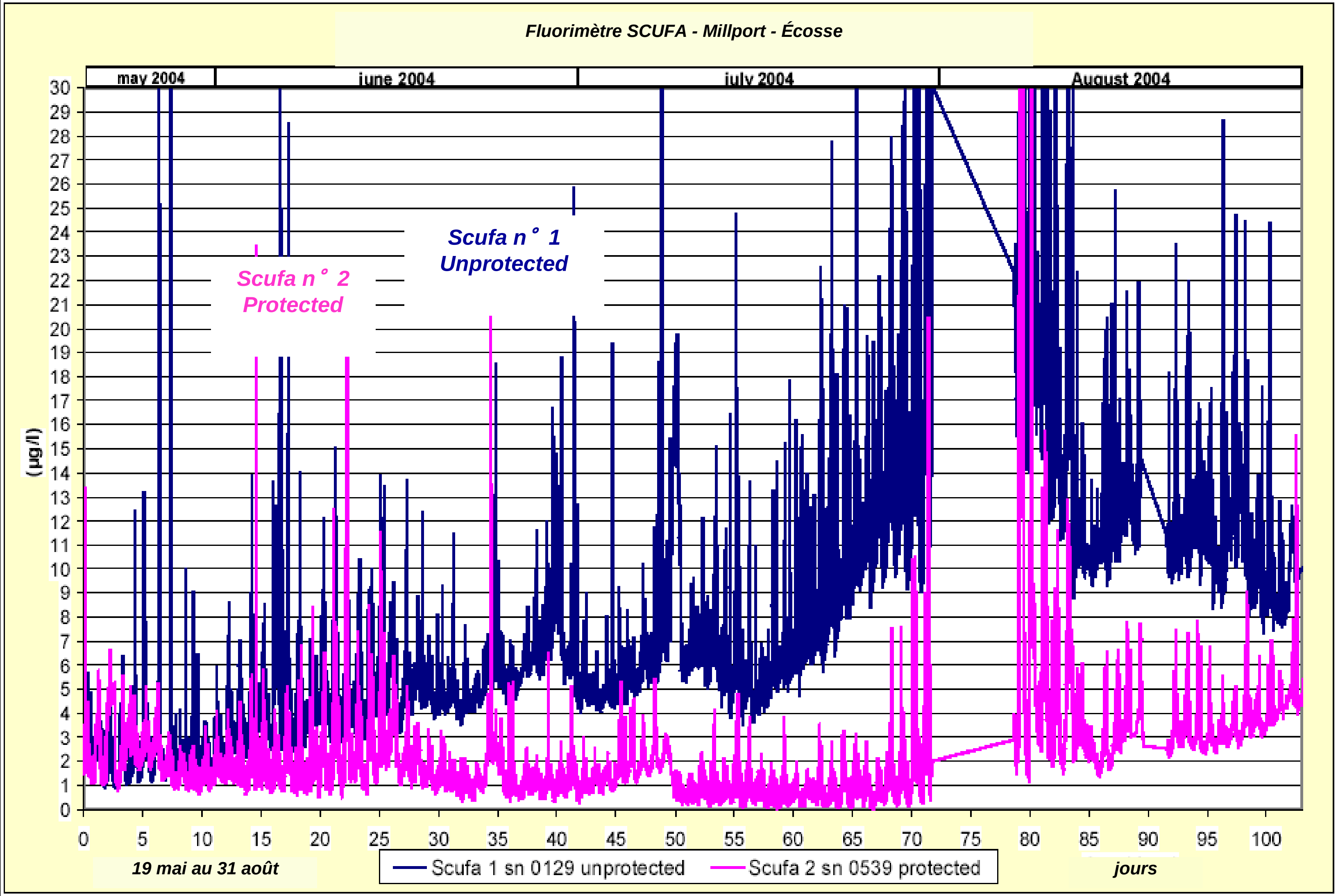
Loss of sensibility,
drift,
response time, etc.



This problem must be treated as long as autonomous measurement longer than 1 week is involved.

Biofouling effect on an in-situ Fluorometer

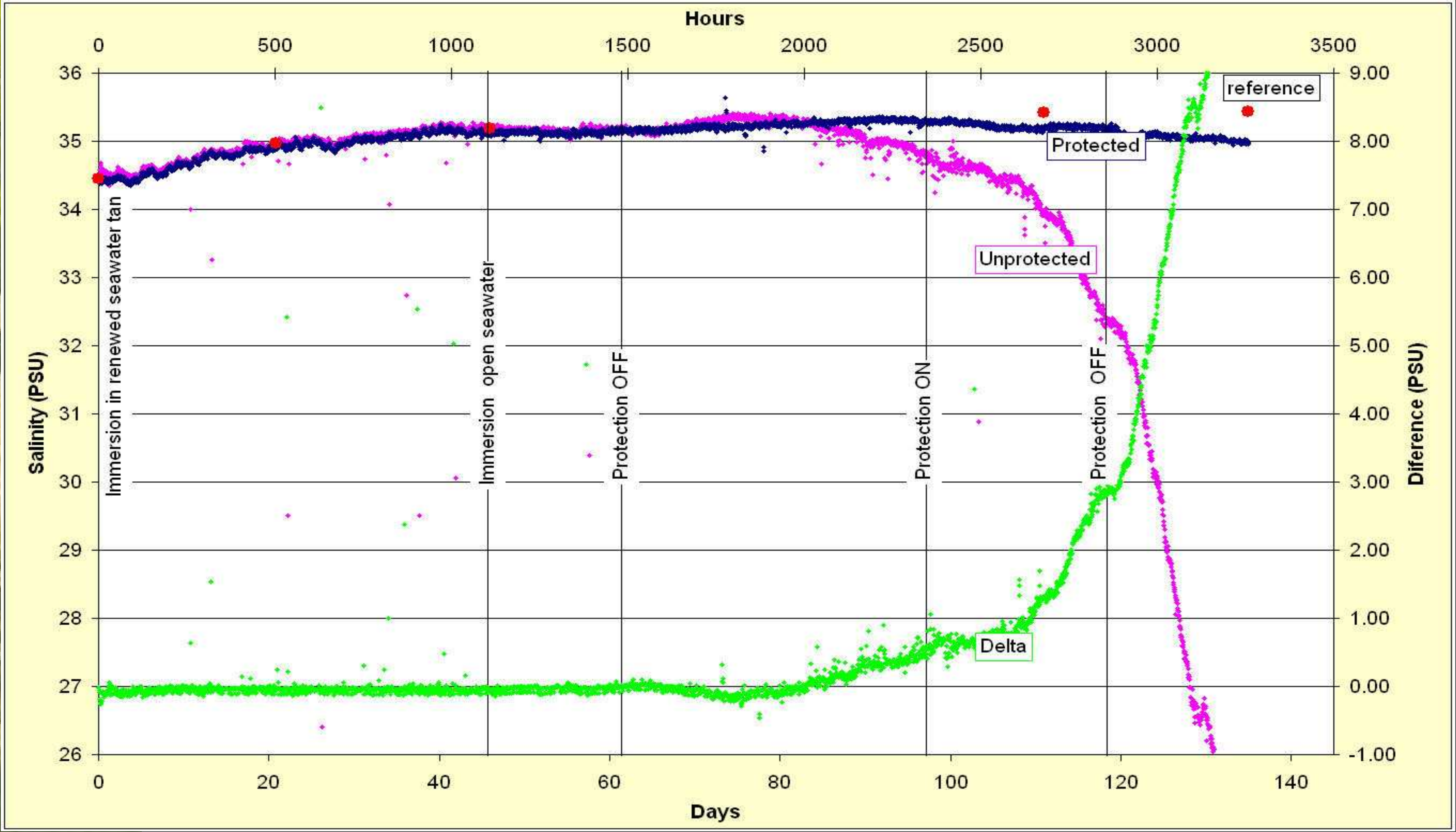
100 days ◆ 19 may - 31 August ◆ Millport



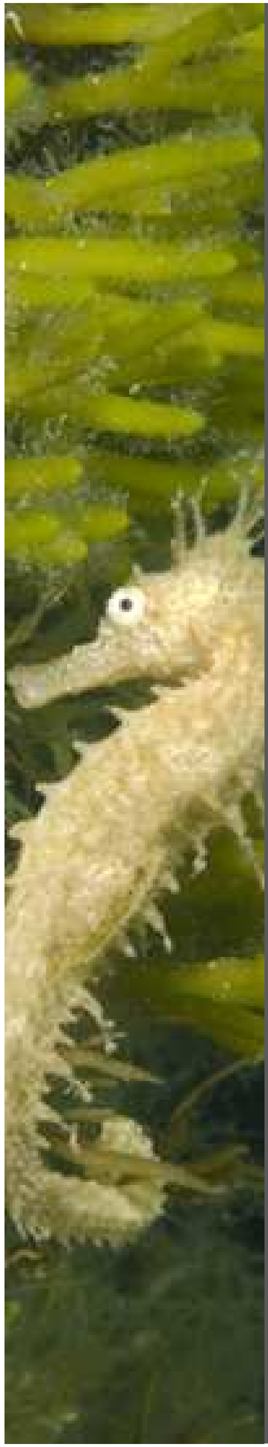
Ifremer (FR) Delauney, V.Lepage - UMBSM (UK) Dr P. Cowlie

Sensor deviation example : conductivity

133 days ◆ 03 June - 16 October 2003 ◆ St Anne Portzic Brest



Conductivity Measurement - TPS35 Micrel Instrument



Objectives

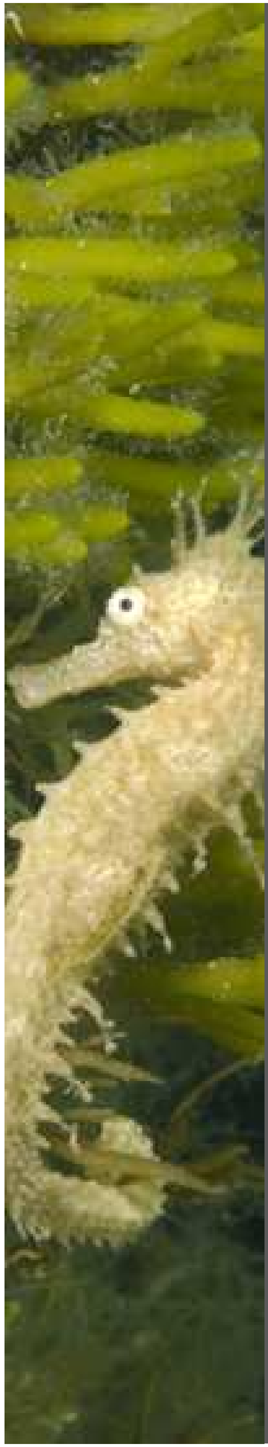
- *The protection system must delay the biofouling effect on the response of the measuring system for at least 1 month in severe conditions and for 3 months in average condition.*

  For specific applications like deep sea observatories, biofouling protection effect should last for at least 6 months.

- *The protection system should be compatible with autonomous energy supplying (batteries).*

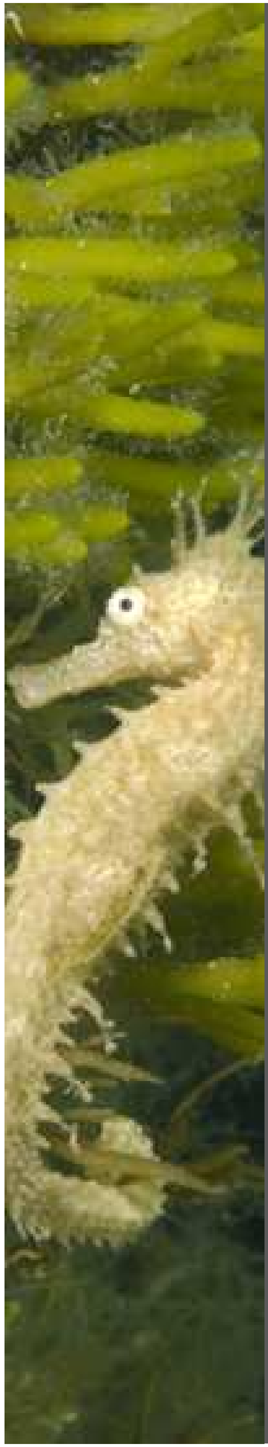
- *The protection system must be adaptable quite easily on existing instrumentation.*

- *The protection system must not affect the measurements produced.*



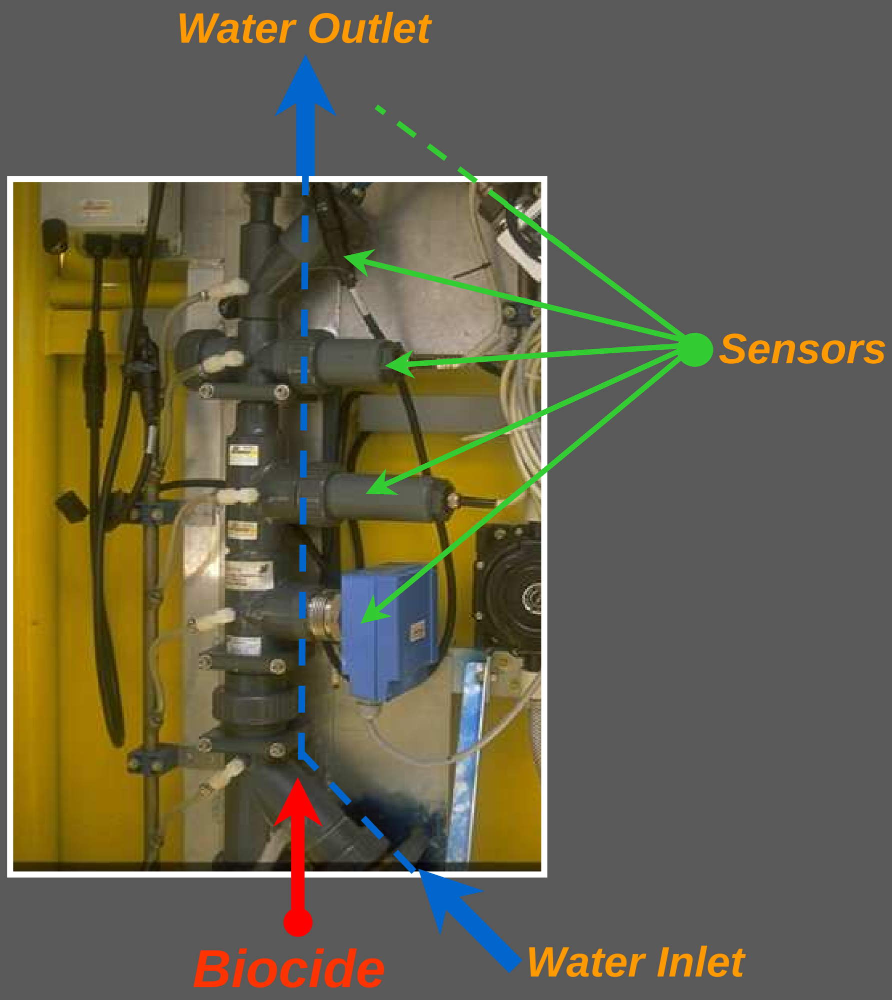
Protection Strategy

to get closer and closer
the measurement interface



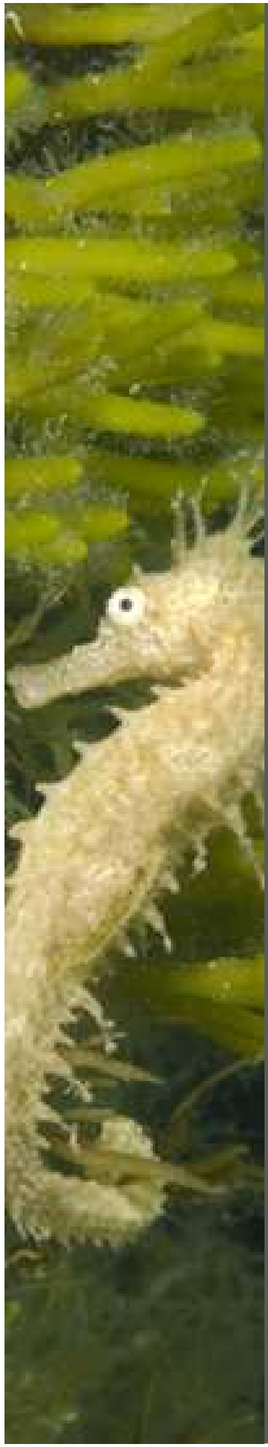
Global Protection

- Pumping is needed



Photos : Ifremer (FR)

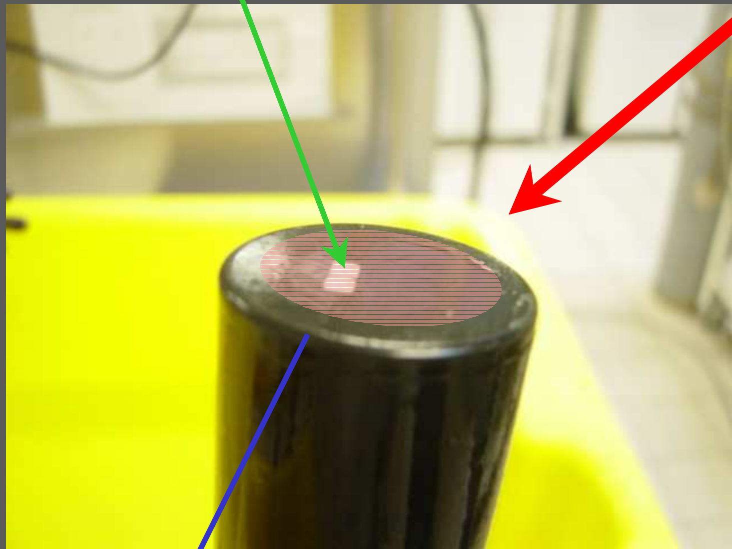
MAREL - Ifremer
Mesures Automatisées pour l'environnement littoral
(Autonomous Measurement for Coastal Environment)



Local Protection

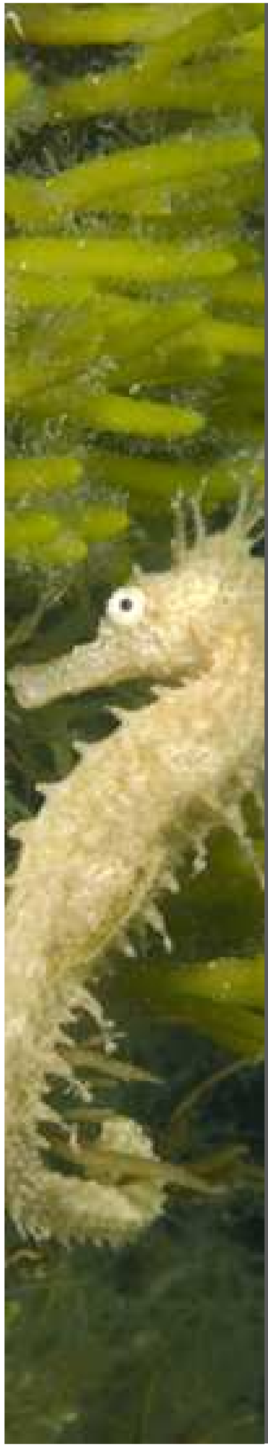
Sensor

Biocide



- Pumping system not needed
- Biocide can be localised as close as possible of the sensing element of the instrument.

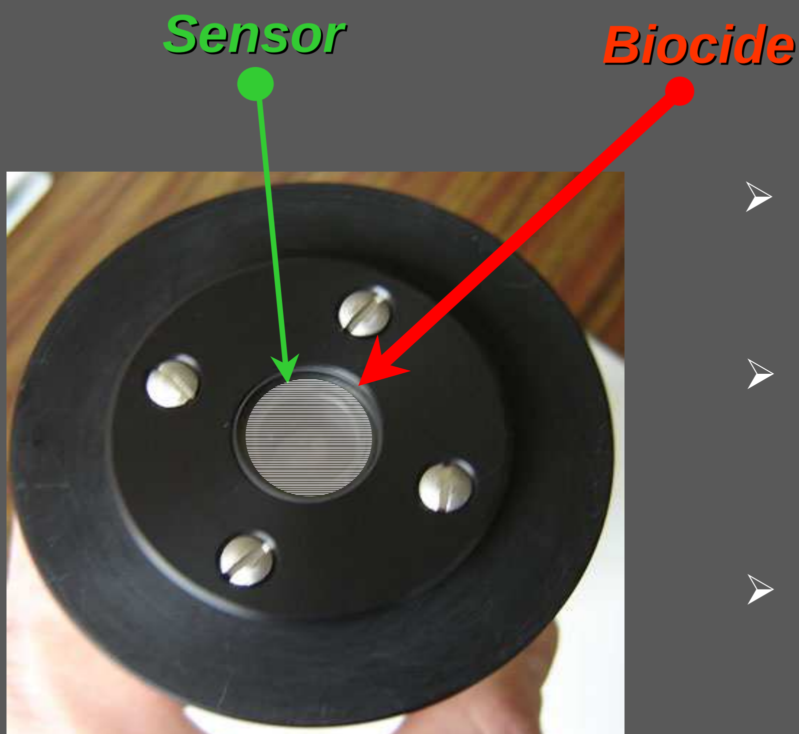
Turbidimeter TBD 35 - NKE



Coated window Protection

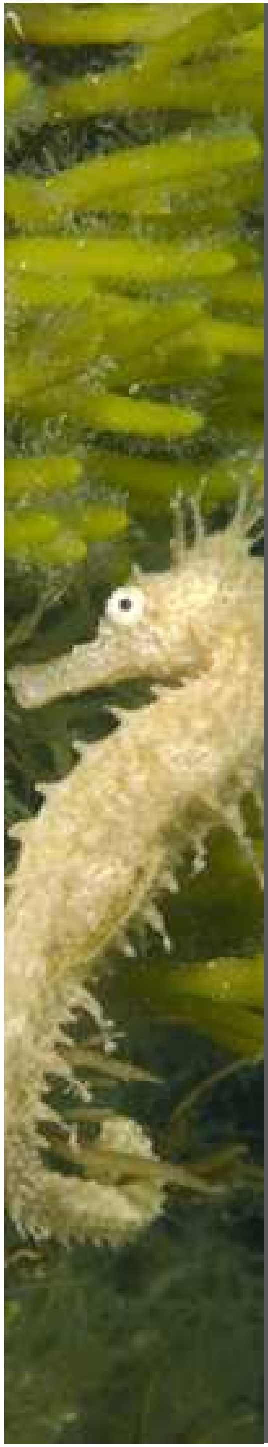
Interface Modification

Glass window coated with a specific material
in order to generate biocide on the surface



TriOS microFlu-chl

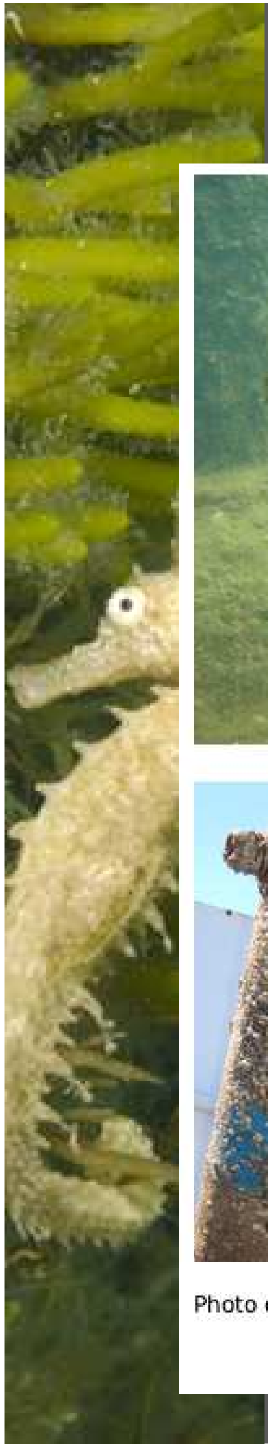
- *Optical sensor, camera, lights, ...*
- *Biocide generation is situated on the window surface.*
- *Biocide quantity needed is very low.*



Existing biofouling protection for oceanographic sensors

Mechanical Protection

YSI 6600 EDS (Extended Deployment System) - Clean SweepTM



Mechanical Protection

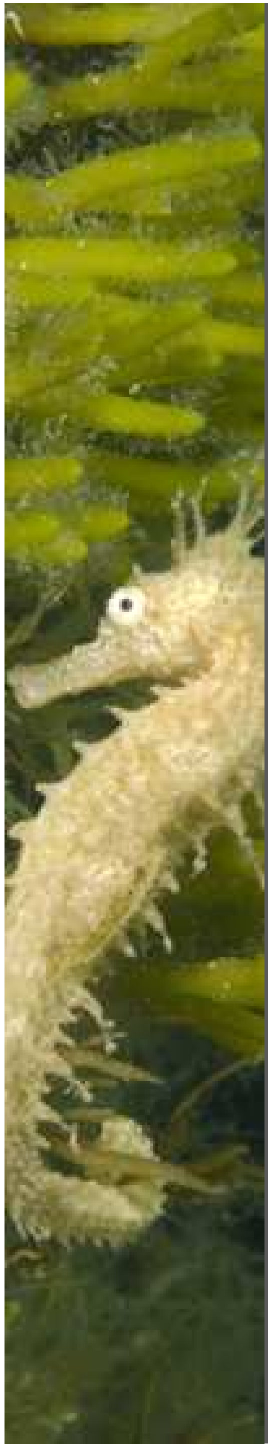
ZEBRA-TECH (NZ) – Hydro Wiper

Photos courtesy of MScience Pty Ltd, Australia

Photo courtesy of USGS, Santa Cruz

Photo courtesy of NIWA, New Zealand

Photos : Zebra-Tech Web Site



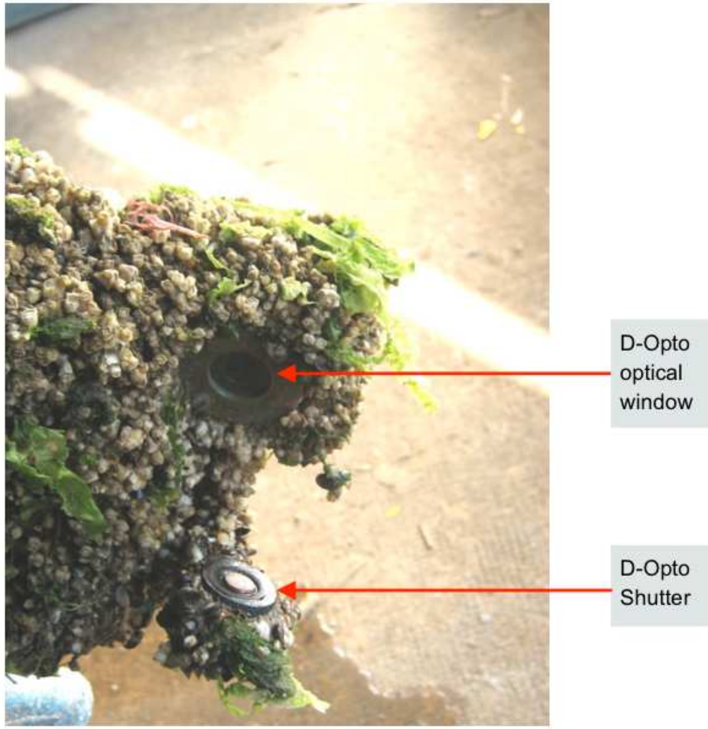
Mechanical Protection

ZEBRA-TECH (NZ) – Opto Shutter

D-Opto dissolved oxygen sensor with Shutter fitted

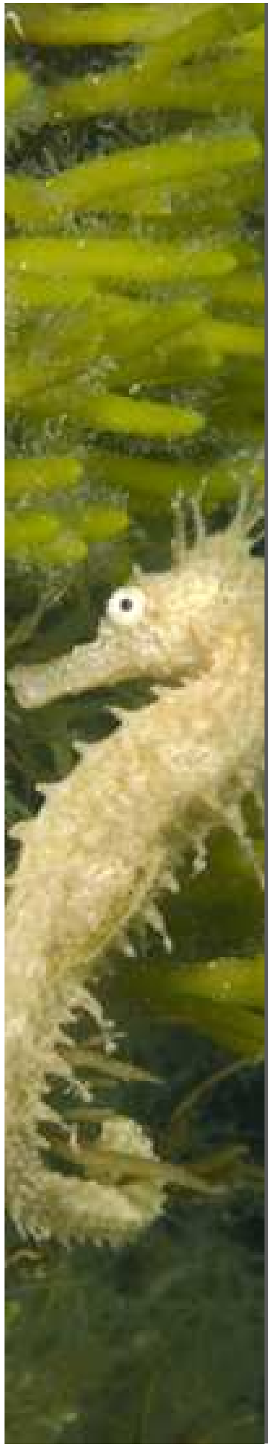
Shutter closed

Shutter open



Shutter open

Photos : Zebra-Tech Web Site



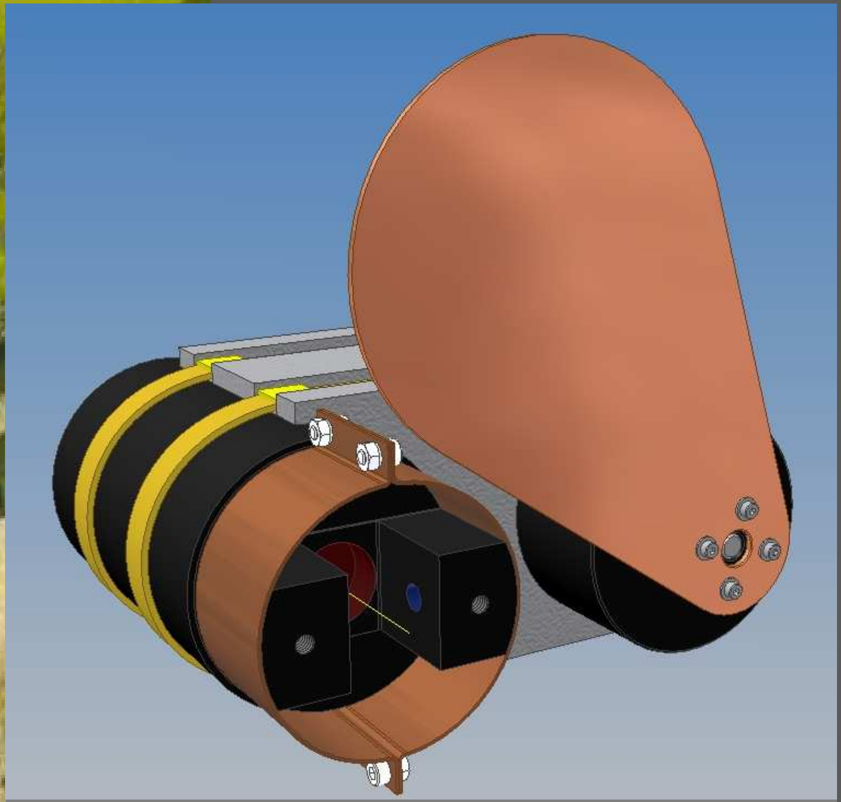
Mechanical Protection

ZEBRA-TECH (NZ) – Opto Shutter

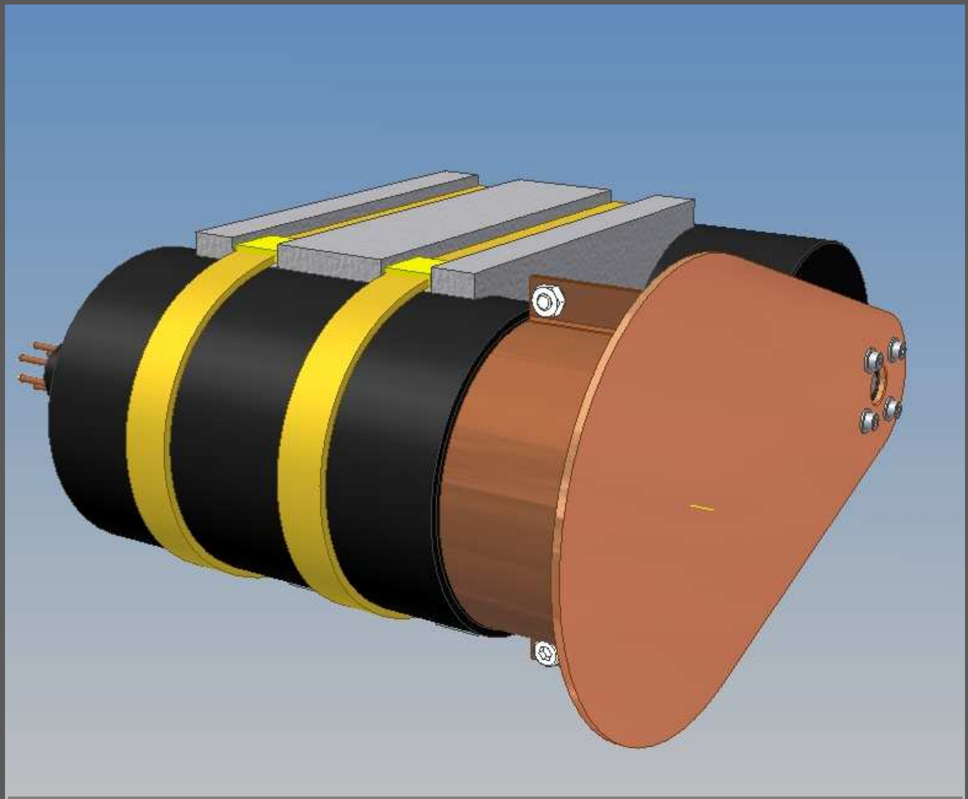
Film : Courtesy of NORTEKMED

Copper Biofouling protection

Fluorimeter Seapoint + Hobilabs Hydroshutter



Ifremer (FR) L. Delauney



Ifremer (FR) L. Delauney

- ***The instrument must be customised in order to build a Copper cell.***

- ***The Hydroshutter must be controlled by an external unit in order to open and to close it.***

Copper Biofouling protection

Fluorimeter Seapoint + Hobilabs Hydroshutter

Ifremer (FR) L. Delauney

Biocide tablets

Seabird conductivity sensor => TBT

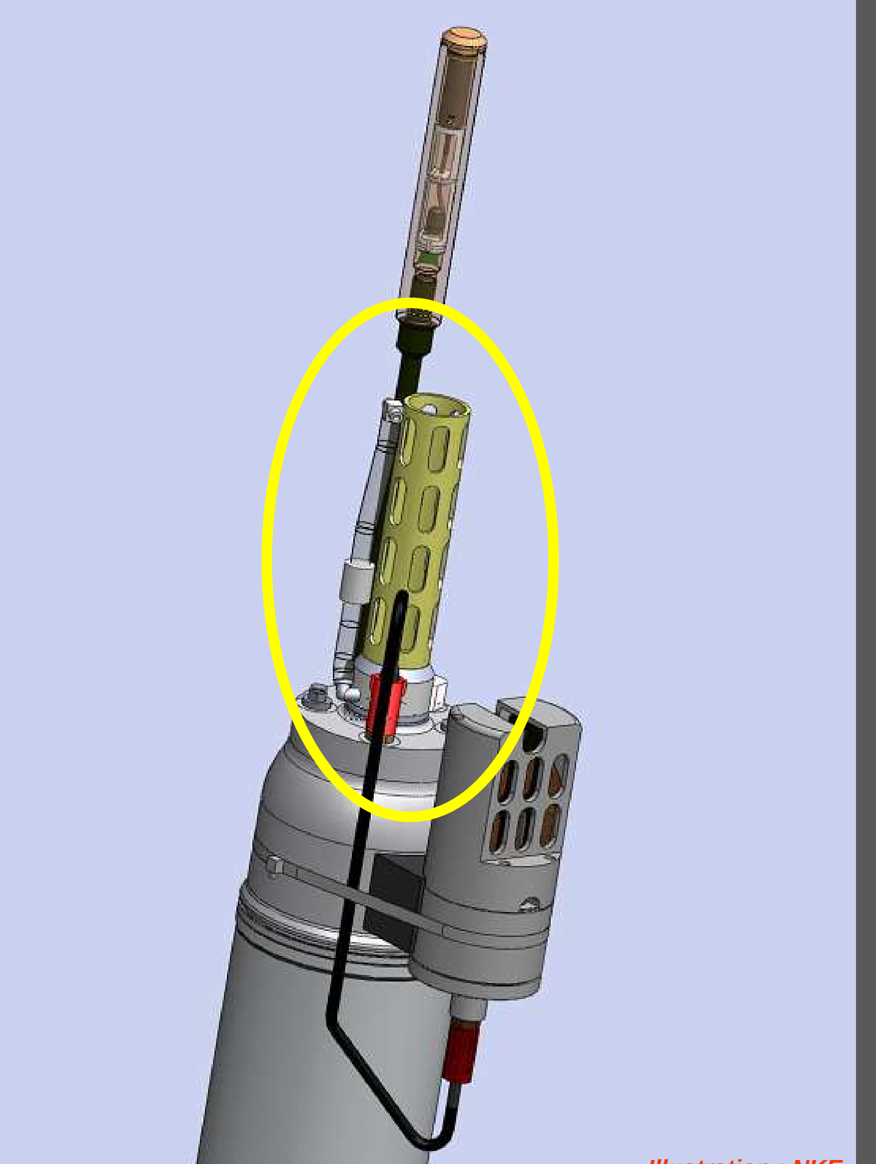


Illustration : NKE

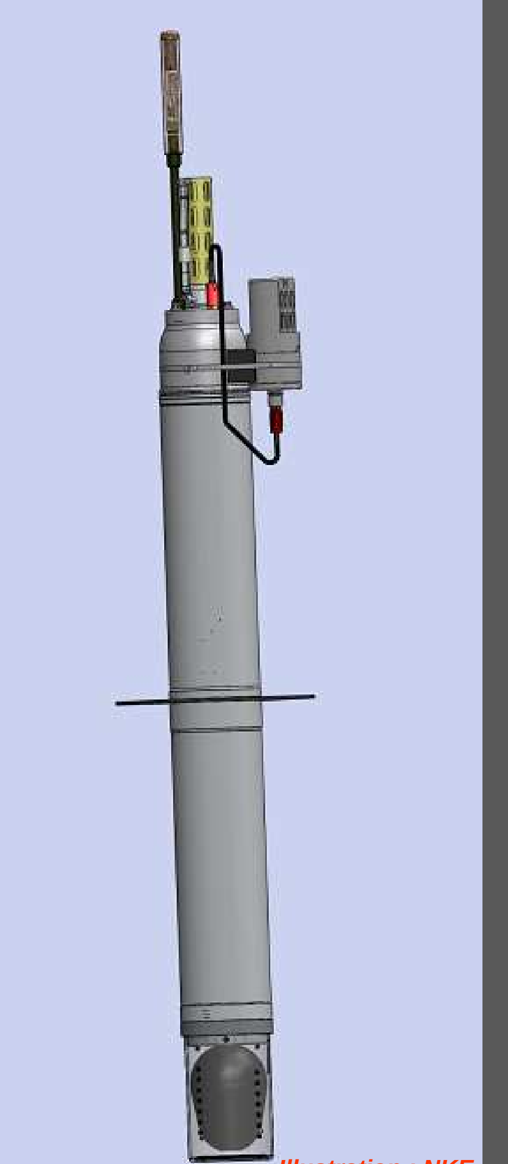
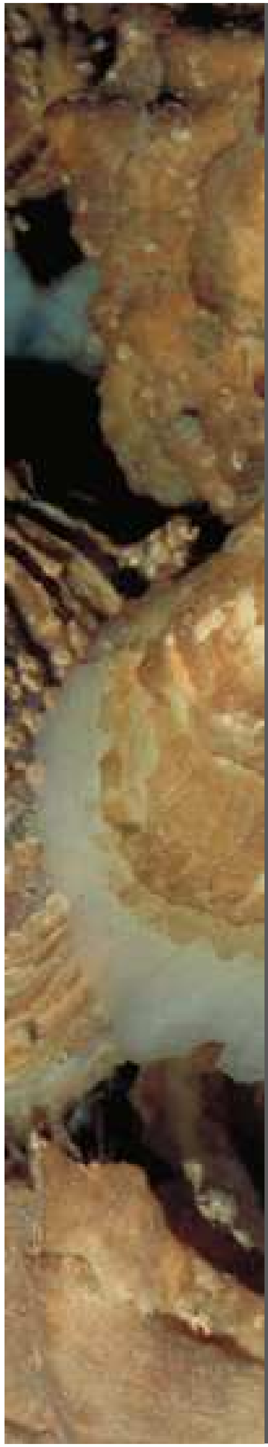


Illustration : NKE

Projet NOSS : NKE, Telecom Bretagne, SHOM, ifremer

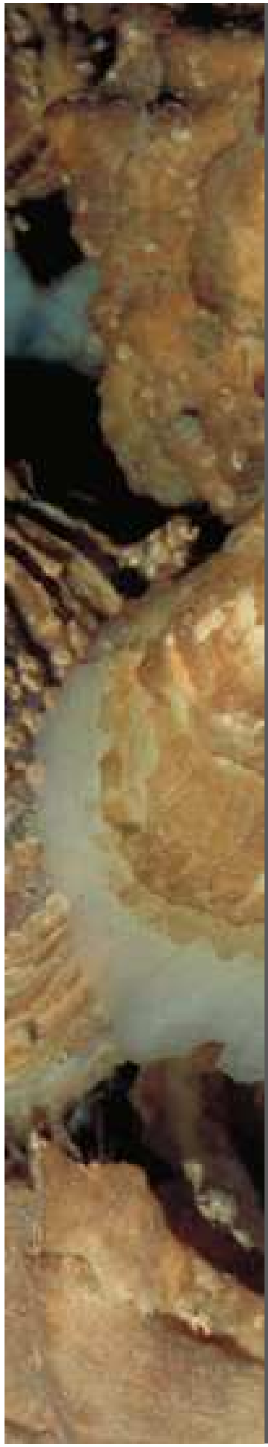


Sensors biofouling protection by seawater electrolysis

ROSE Experiment results

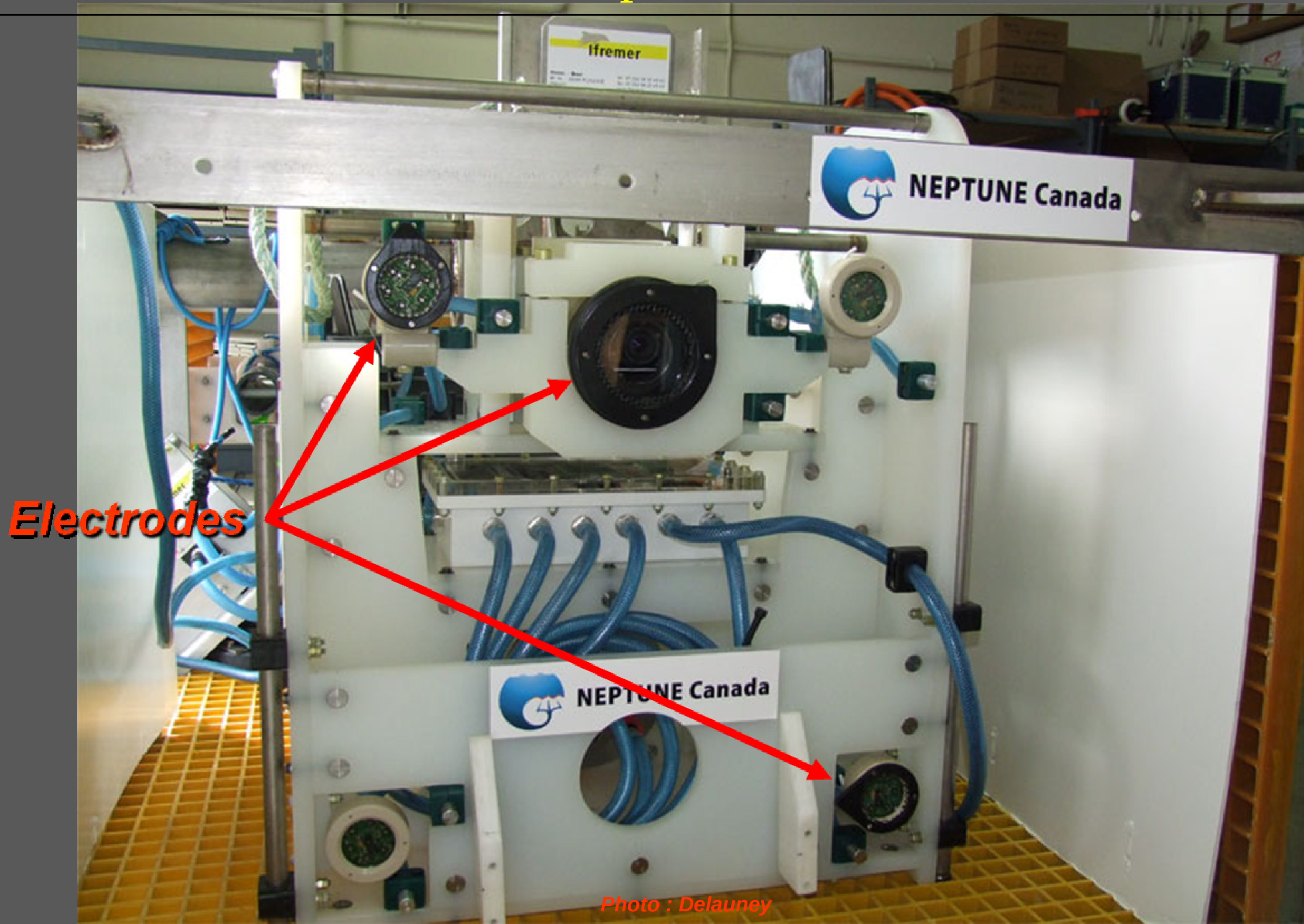
Benthic station – June to September 2006 - 25 meters deep

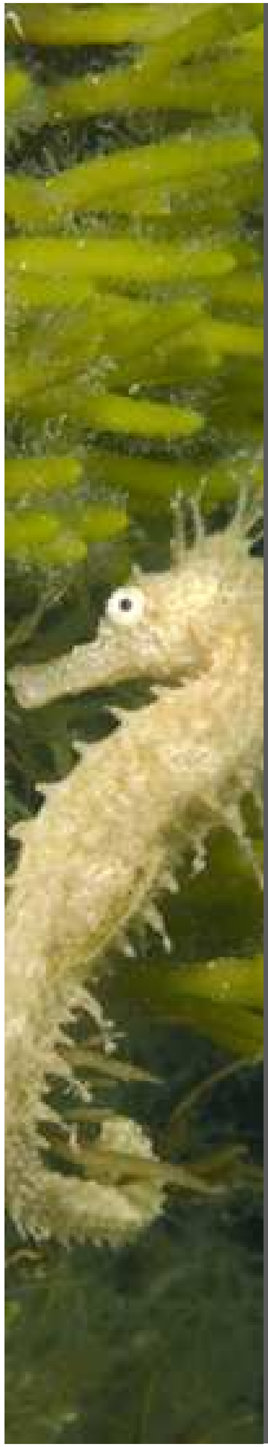
- *Hydrocarbon fluorometer : Trios EnviroFlu-HC*



Sensors biofouling protection by seawater electrolysis

Tempo mini





Coated window Protection

40 days ◆ August - October 2005 ◆ Helgoland - DE

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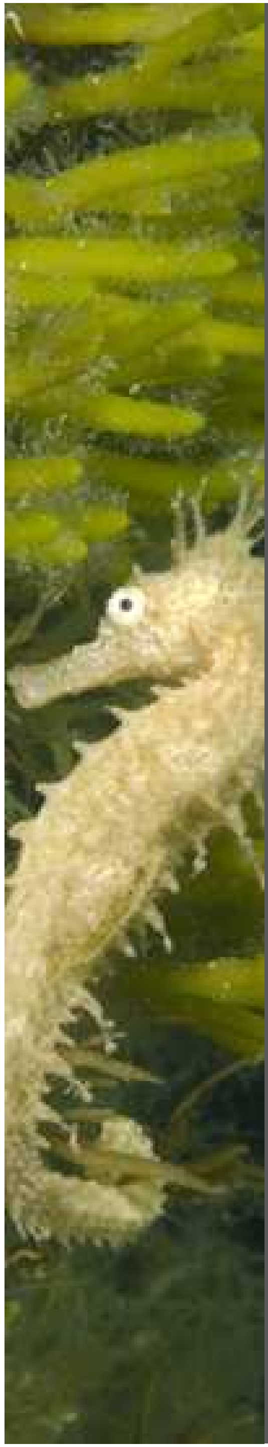
GKSS (DE) K. Kröeger et Al. - CNRS UPR15 (FR) H. Cachet et Al.



Conclusion

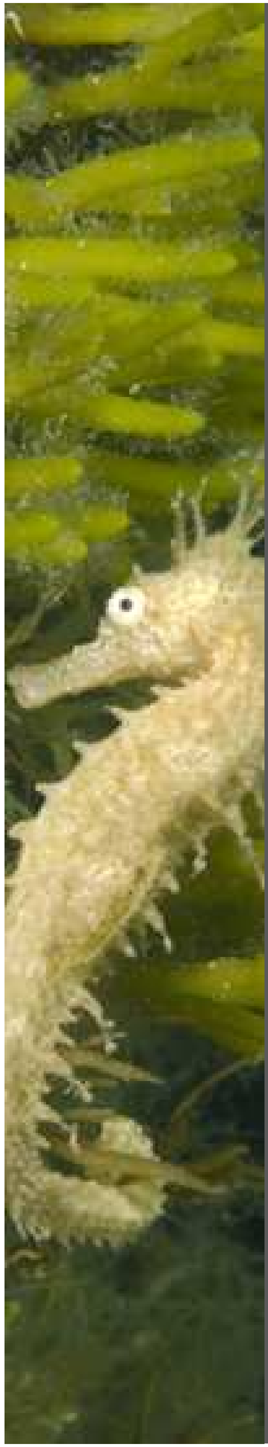
- Various techniques are now available to protect windows :
  - Wipers
  - Copper shutter
  - Bleach
  - Local biocide generation

- The choice can be driven by different aspects :

  Hardware matter :
  - Robustness (depth of use)
  - Mechanical complexity
  - Easiness of adaptation to the existing instrument
  - Level of integration

  Metrological aspect :
  - Adverse effect to the measured parameter.
  - Is system can be turned on and off.

  Economical aspect :
  - Availability on the market.
  - Price.

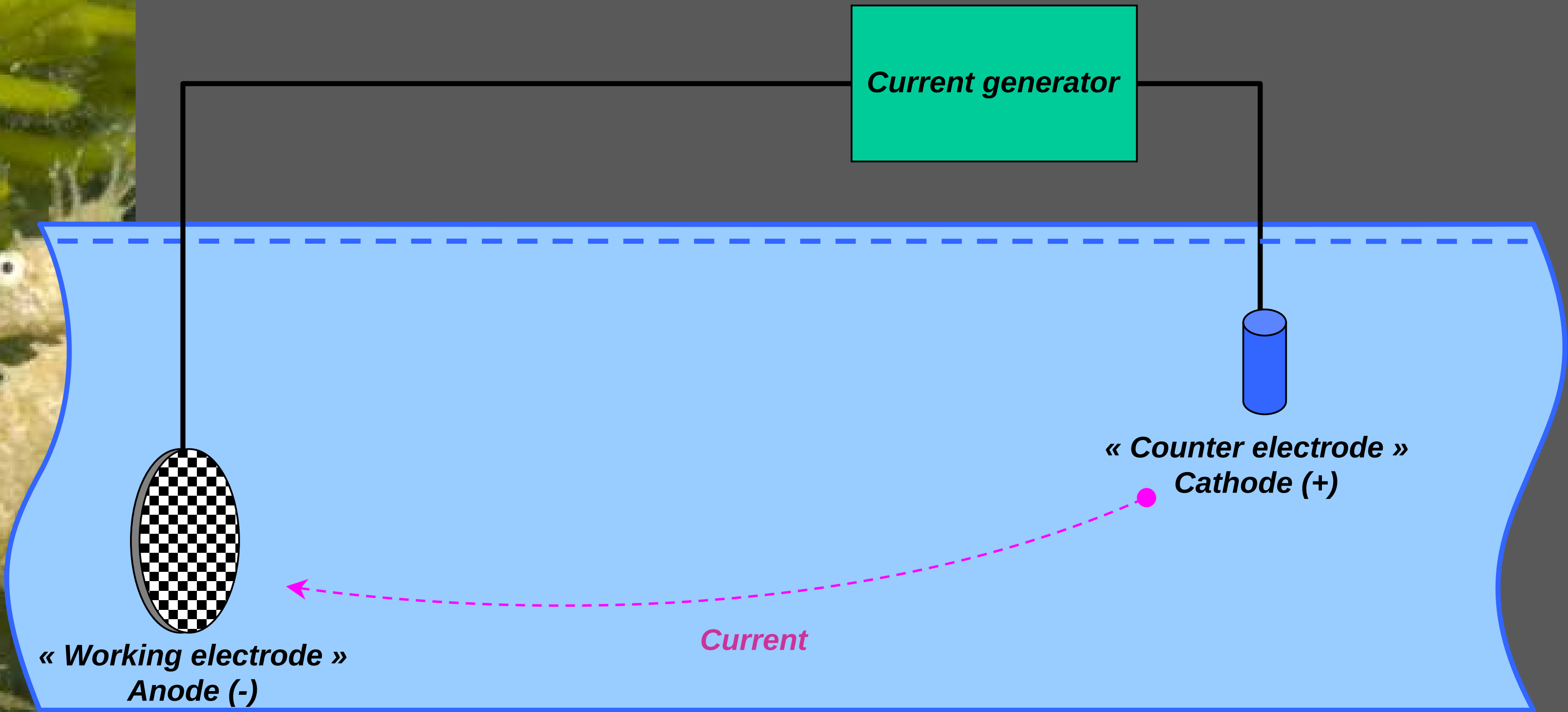


Local chlorination by seawater electrolysis for biofouling protection of oceanographic sensors

Ifremer (FR) L. Delauney
laurent.delauney@ifremer.fr

Chlorine Generation System In Sea Water

- ***Sea water electrolysis : Hypochlorous Acid generation.***

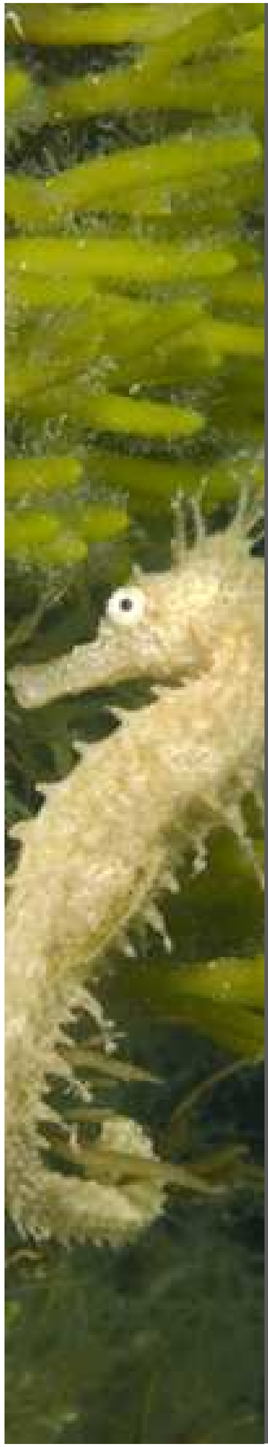


$$2\,Cl^- \longrightarrow Cl_2 + 2\,e^-$$

$$2H_2O + 2\,e^- \longrightarrow 2\,OH^- + H_2$$

Note : Anode and Cathode naming is electrochemistry convention, electricity convention is the opposite.

Ifremer (FR) L. Delauney
laurent.delauney@ifremer.fr



Chlorine Generation System In Sea Water

« Working electrode »
Anode

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

Then in function of pH and Temperature :

$$Cl_2 + H_2O \rightleftharpoons H^+ + Cl^- + HClO$$

Hypochlorous Acid

$$HClO \rightleftharpoons H^+ + ClO^-$$

When pH => btw 7 and 8.5, temperature has no effect (Chambers et al.)
Seawater pH = 8.2

Ifremer (FR) L. Delauney
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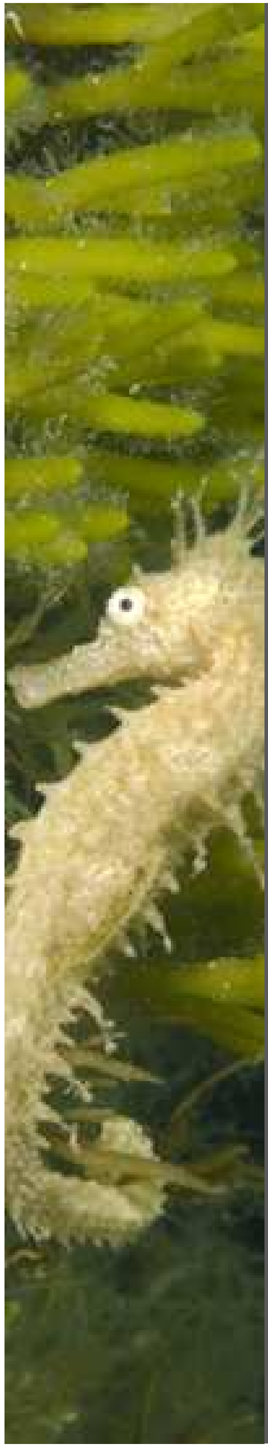

Chlorine Generation System In Sea Water

« Counter electrode » Cathode

$$2H_2O + 2e^- \longrightarrow 2OH^- + H_2$$

A deposit can be observed on the counter electrode :

$$HCO_3^- + OH^- \longrightarrow H_2O + CO_3^{2-}$$

$$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3$$

$$Mg^{2+} + 2OH^- \longrightarrow Mg(OH)_2$$

$$Ca^{2+} + Mg^{2+} + 2CO_3^- \longrightarrow \underline{CaCO_3.MgCO_3}$$

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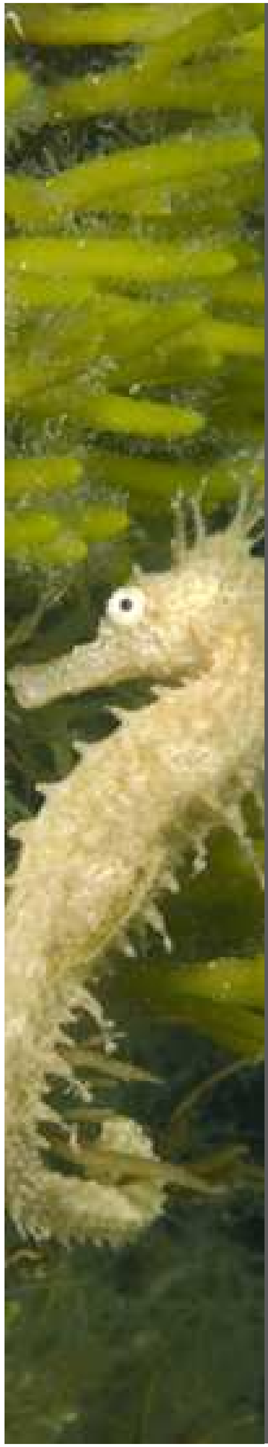


Laboratory and *in situ* tests

Tests performed :

- ***Fluorescence sensors :***

  - Scufa Turner Designs - Millport island, Scotland

  - microFlu-chl TriOS - Helgoland, Germany

  - Seapoint - Brest - France

- ***Transmissometer : Optisens***

  - Trondheim, Norway

- ***Turbidity : TBD 35 NKE***

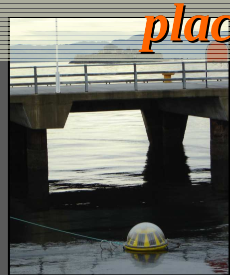
  - Sainte Anne du Portzic Brest, France

  - Mont Saint Michel Bay, France

- ***Oxygène : Optode Aanderaa***

  - Sainte Anne du Portzic Brest, France

Various places for test



Tests performed :

- ***Fluorescence sensors :***
  - *- Scufa Turner Designs - Millport island, Scotland*
  - *- microFlu-chl TriOS - Helgoland, Germany*
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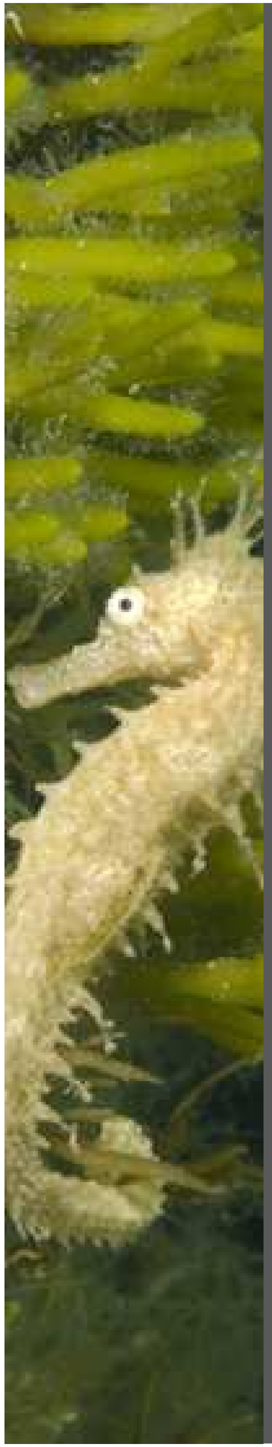
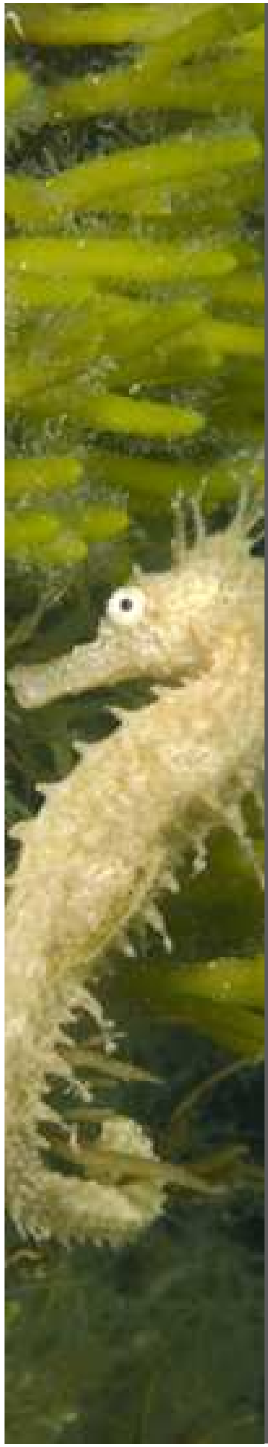


in situ results

Local chlorination

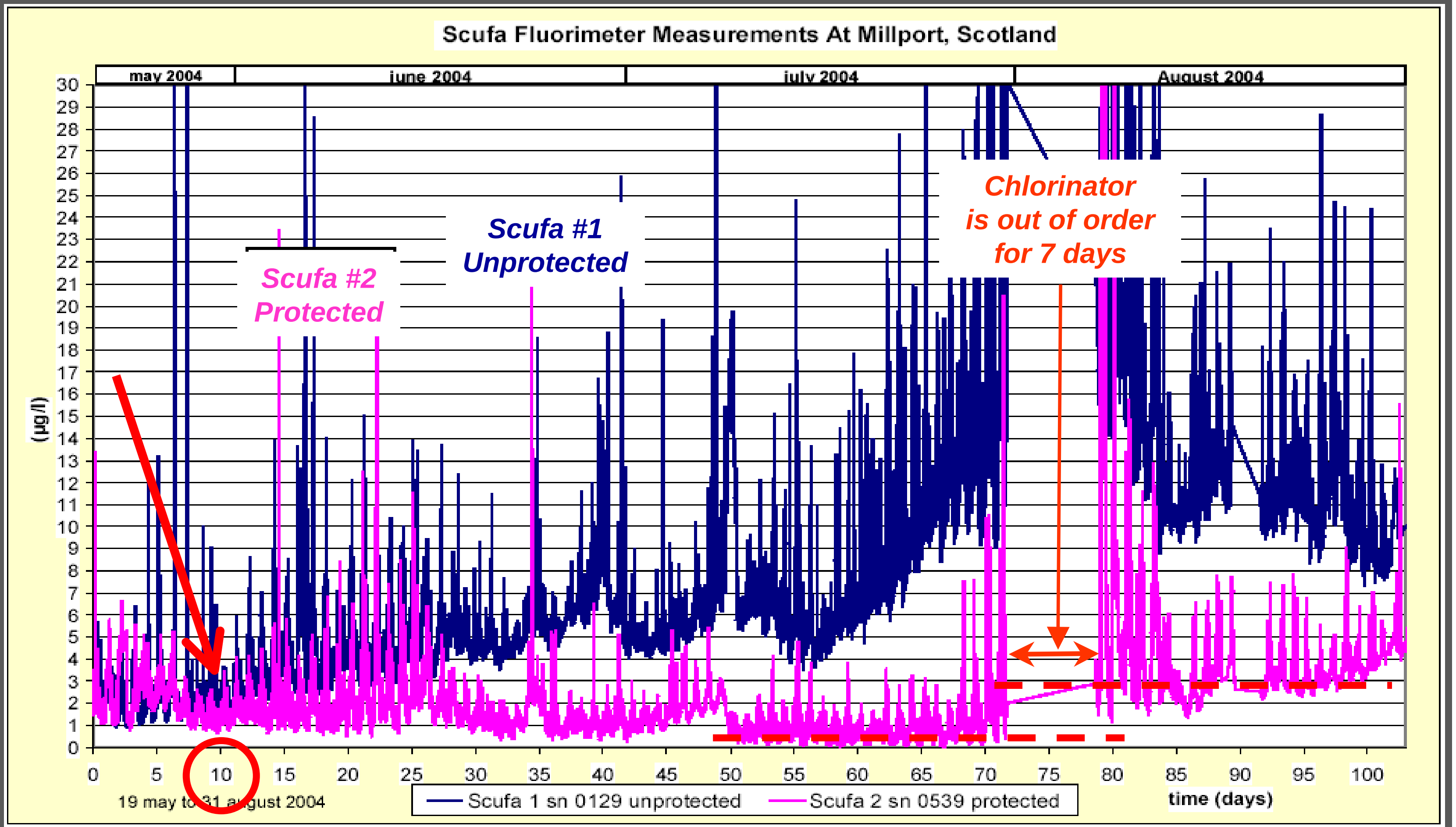
by seawater electrolysis



Local Chlorination

In situ biofouling prevention efficiency test

100 days duration ◆ 19th may - 31st Aug ◆ Millport



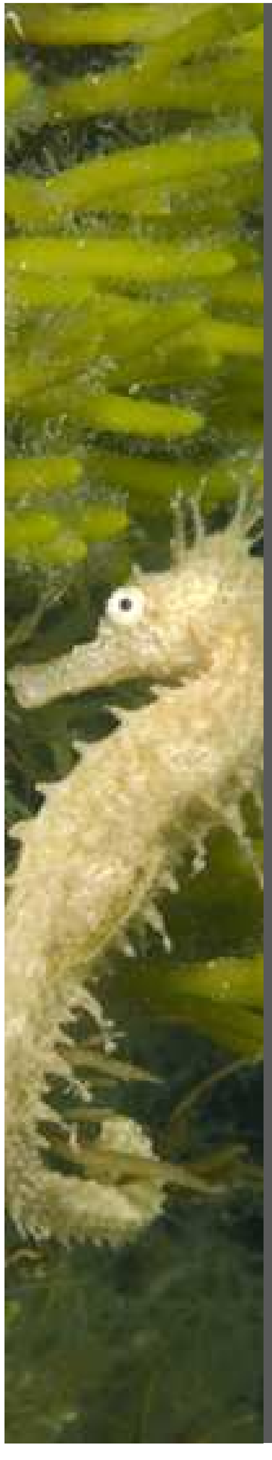
Fluorescence Measurement - Turner Scufa instrument

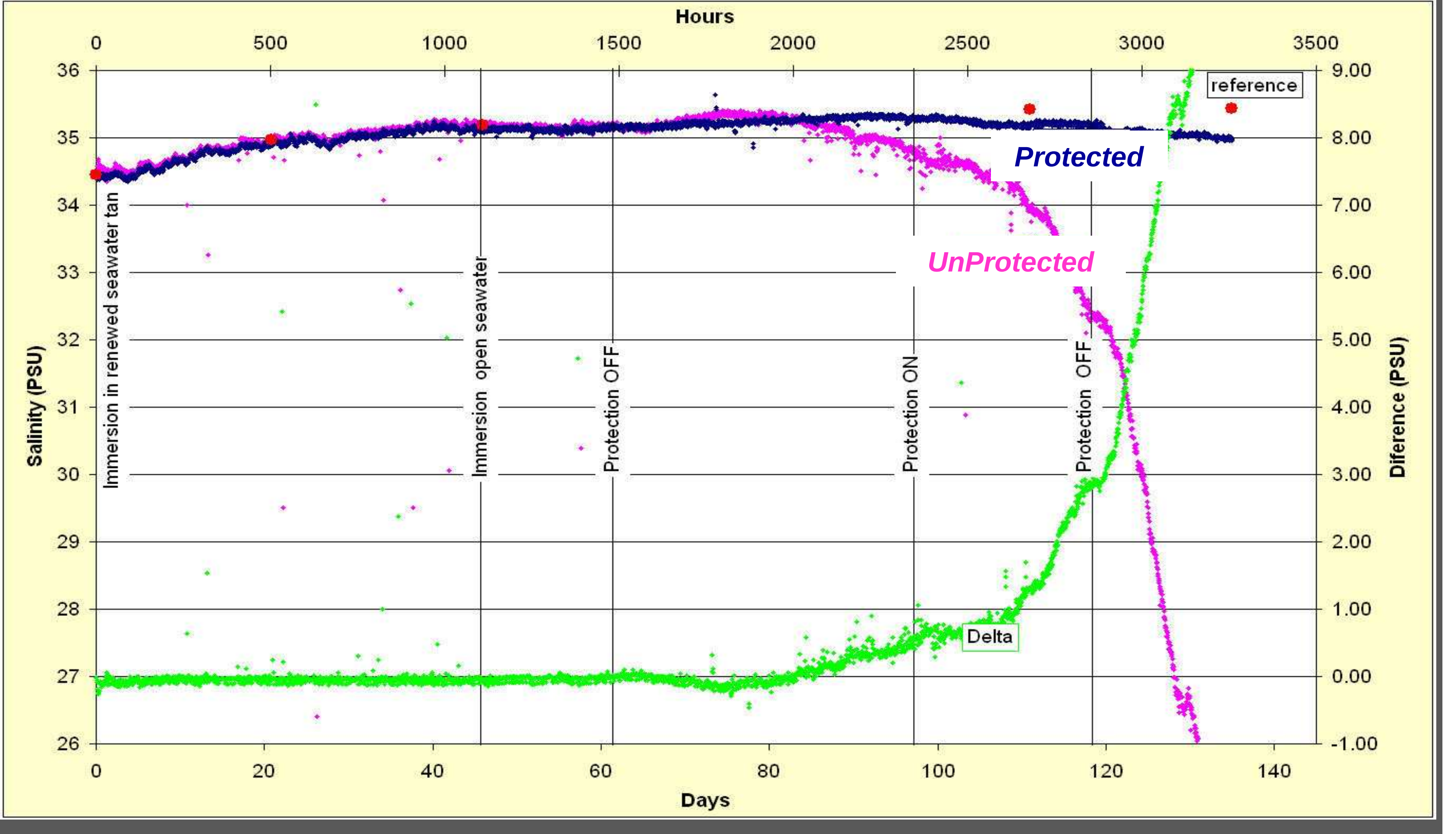
Ifremer (FR) Delauney, V.Lepage - GMTC (UK) Pr M.J. Cowling - Dr P. Cowlie

Local Chlorination

In situ biofouling prevention efficiency test

133 days ◆ 03 June - 16 October 2003 ◆ St Anne Portzic Brest



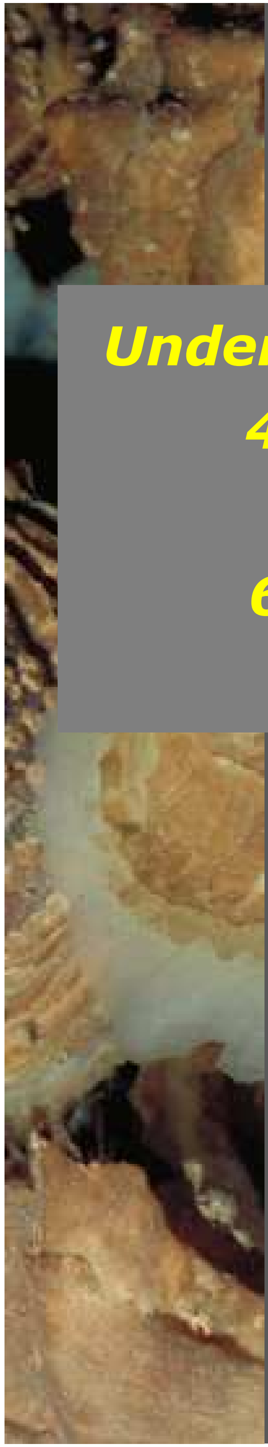


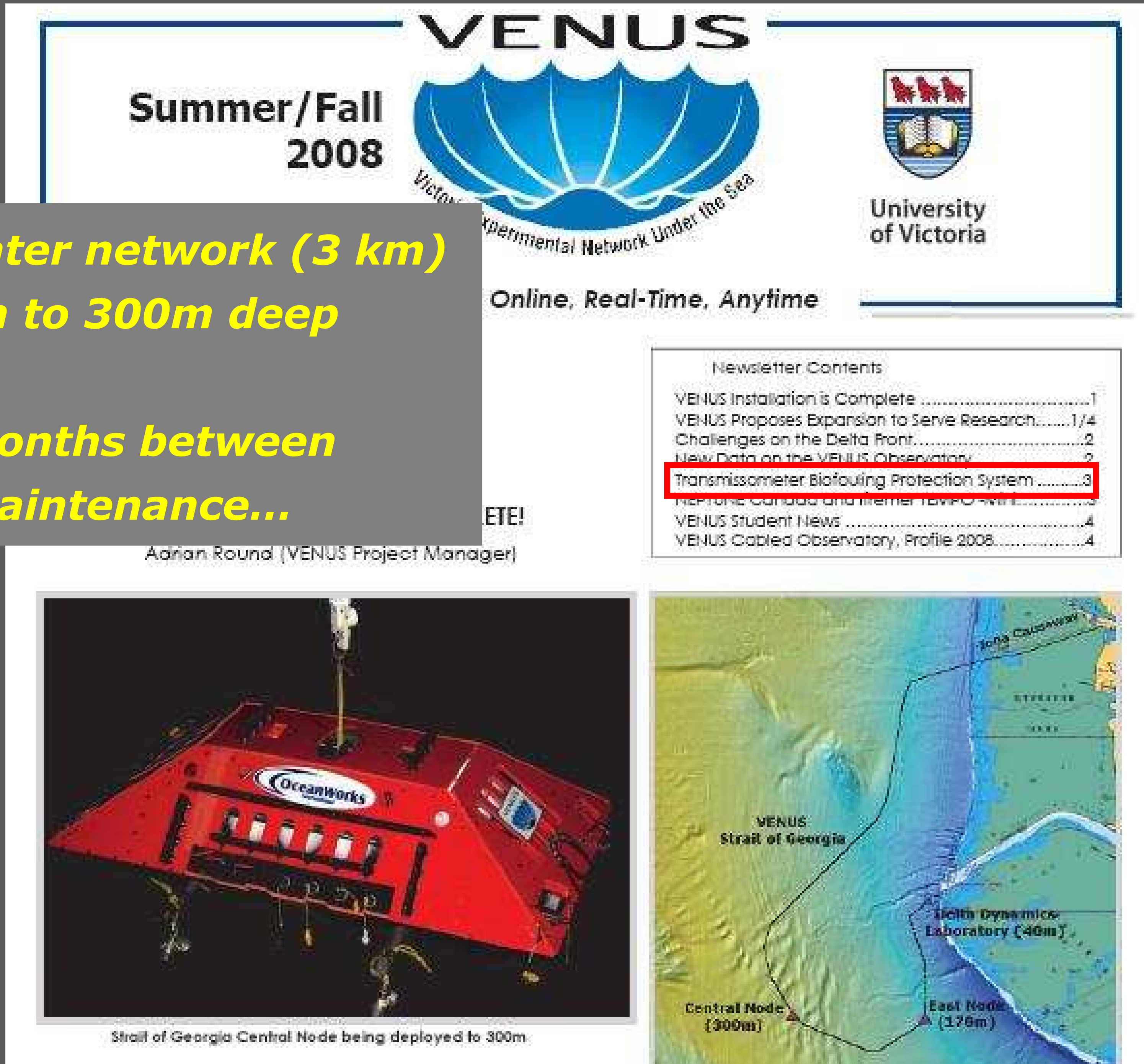
Conductivity Measurement - TPS35 Micrel Instrument

Underwater network (3 km)

40m to 300m deep

6 months between maintenance...





VENUS

Summer/Fall 2008

Victoria Experimental Network Under the Sea

University of Victoria

Online, Real-Time, Anytime

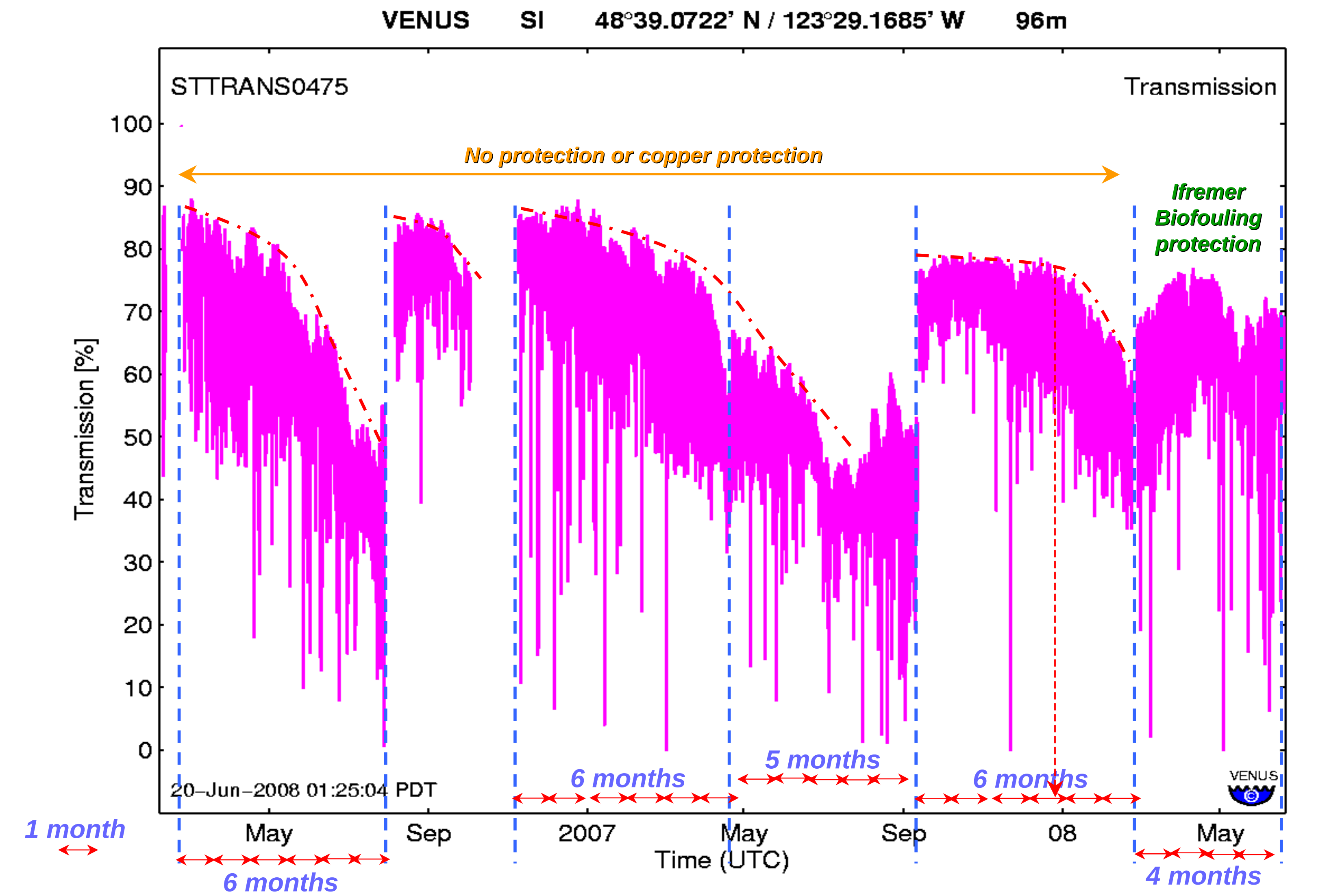
Newsletter Contents

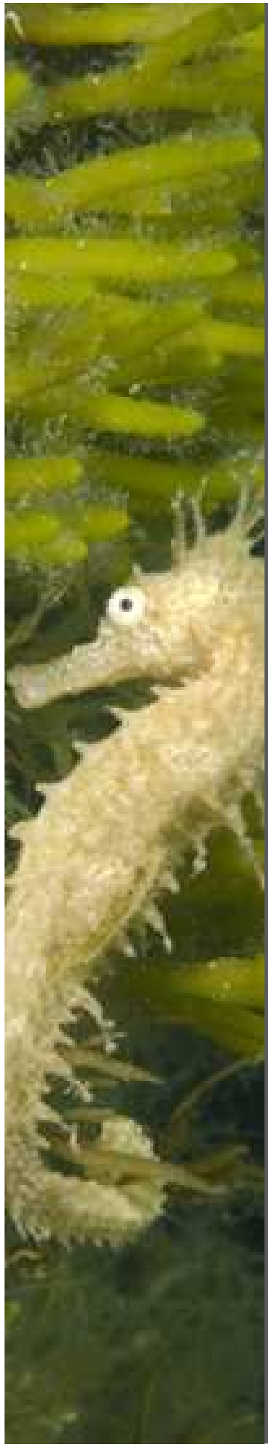
ETE!

Adrian Round (VENUS Project Manager)

Strait of Georgia Central Node being deployed to 300m

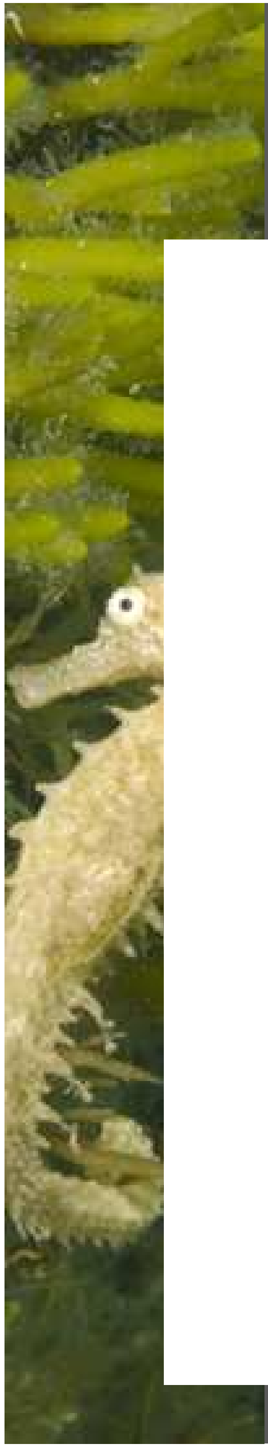
VENUS TRANSMISSOMETER
Ifremer Biofouling Protection – VENUS Data

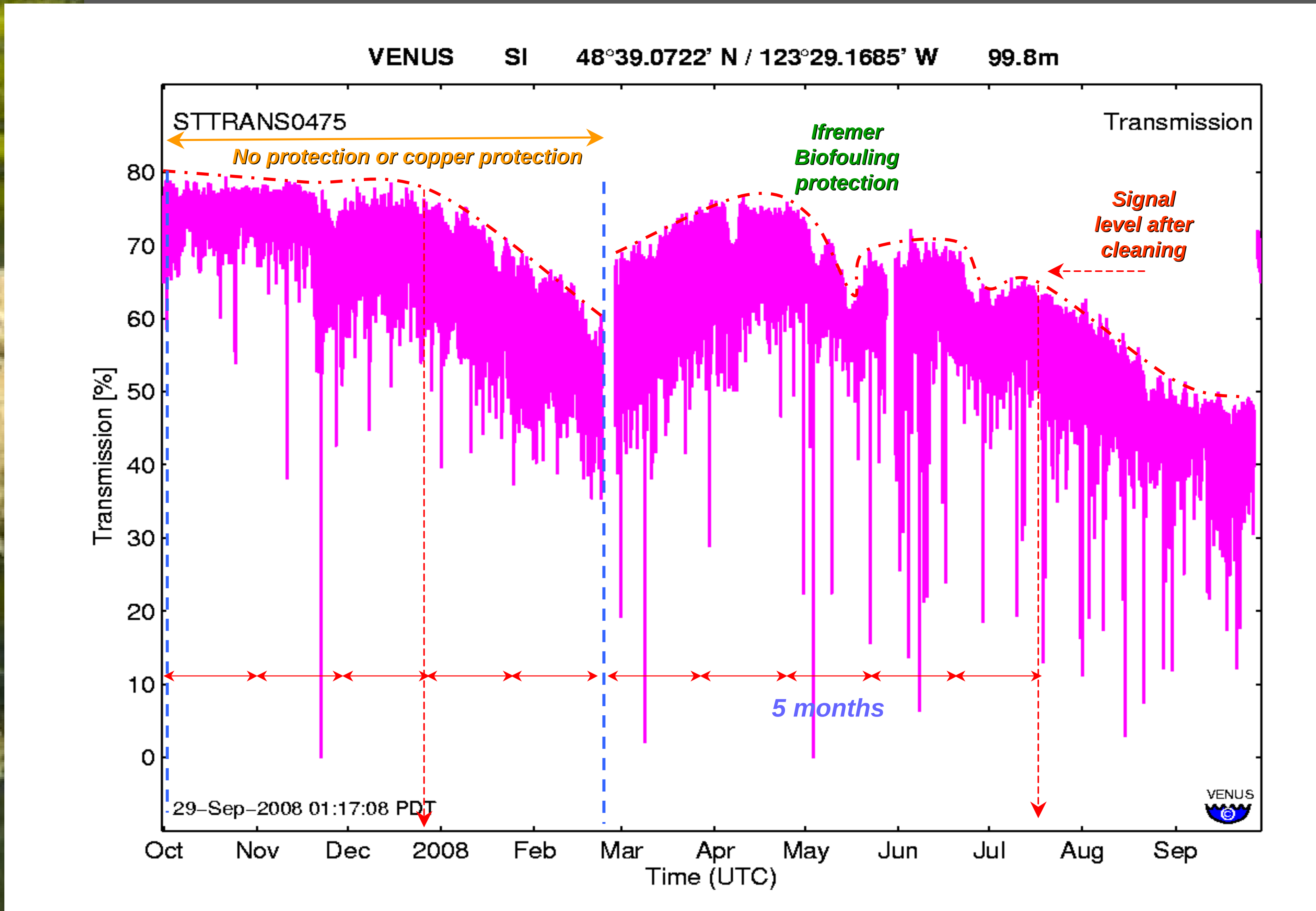


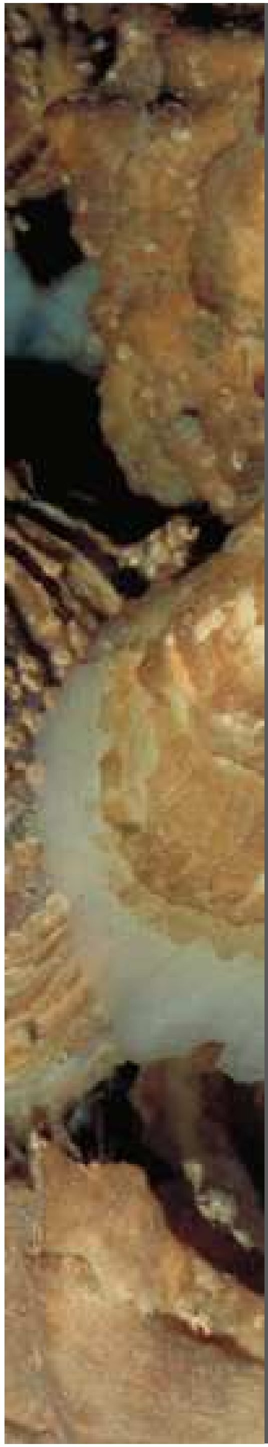


VENUS TRANSMISSOMETER
Biofouling Protection

VENUS TRANSMISSOMETER
Ifremer Biofouling Protection – VENUS Data







Protection antisalissure

chloration localisée (procédé ifremer)

Transmissometer Biofouling Protection System

Paul Macoun (VENUS Project Engineer)

Figure 4. INFREMER Biofouling system on VENUS

A customized bio-fouling protection system was installed on the Saanich Inlet SeaTech Transmissometer in February 2008. This local chlorination system was developed by engineers at the French research institute IFREMER.

The system is comprised of 3 electrodes, one adjacent to each optical window on the Transmissometer, and one centrally located between the two windows. The electrodes are supported by a small housing which contains the system controller and several Lithium cells.

The principle used to reduce bio-fouling is the electrolysis of sea water, which produces free chlorine in the vicinity of the optical windows. The controller alternates voltage potential between the central electrode and each window electrode switching every 10 minutes.

Figure 4 shows the IFREMER system mounted on the SeaTech Transmissometer. Figure 5 is a graph of Transmissometer data from March 1—Aug 1 2007 (+ symbol) overlaid with data from the same interval the following year (lines). There is a noticeable difference from before and after the system was mounted to the Transmissometer. The 2007 data indicate progressive fouling and resulting signal attenuation. The 2008 data look reasonable until mid-summer. The engineers at IFREMER believe the Lithium cells had become depleted at this point, and as a result we begin to see signal attenuation in June and July 2008.

In September 2008 the bio-fouling system was redeployed on the Transmissometer. The latest improvement to the system was the inclusion of a cable linkage to a Scientific Instrument

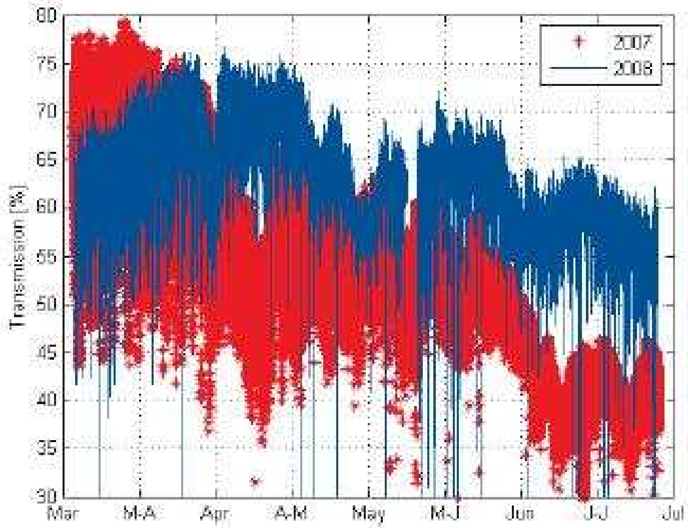
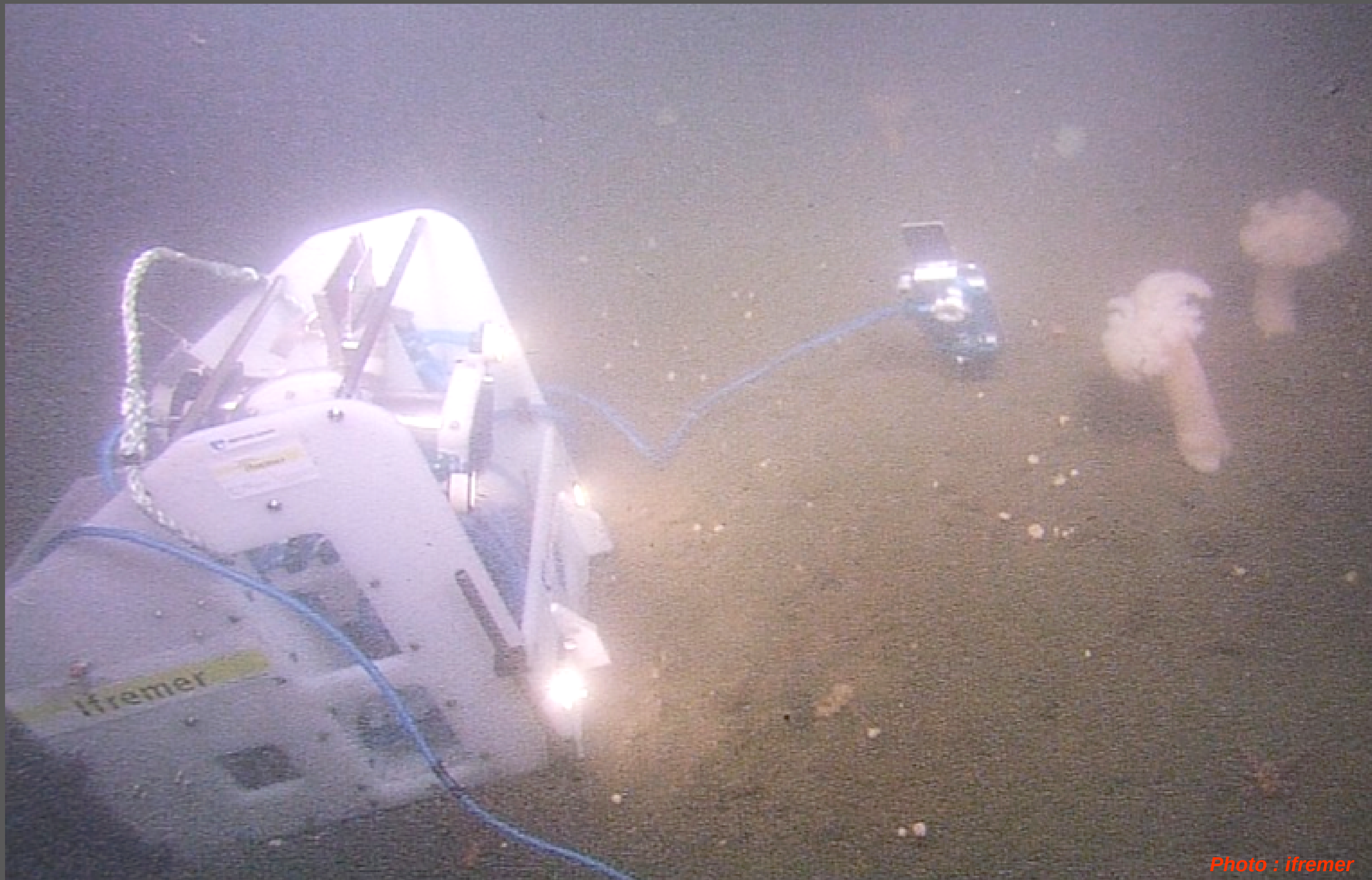


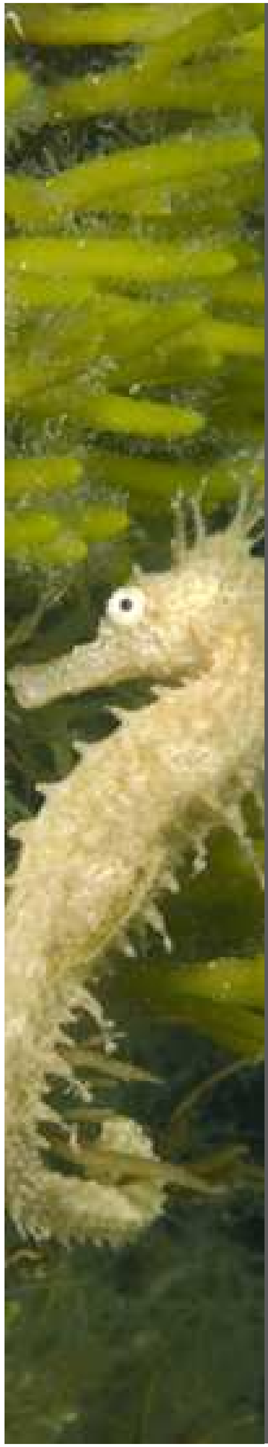
Figure 5. Transmissometer Data Comparison 2007-2008

Interface Module (SIIM). The system is now powered continuously through the VENUS array.

VENUS and IFREMER will continue to collaborate on bio-fouling protection systems. The present plan is to use the local chlorination system to protect other optical instruments on the various observatory platforms.

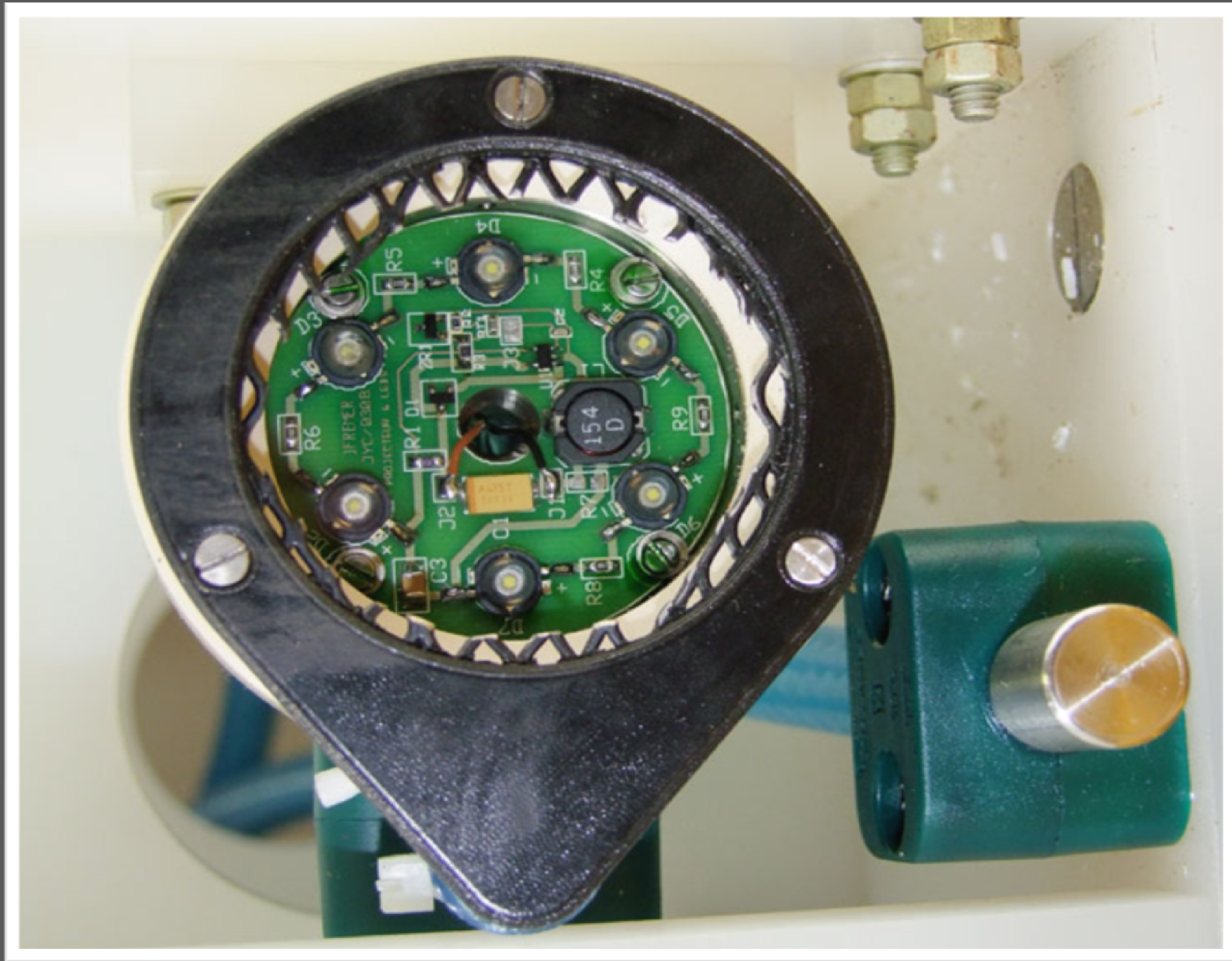
Seafloor observatory
Neptune





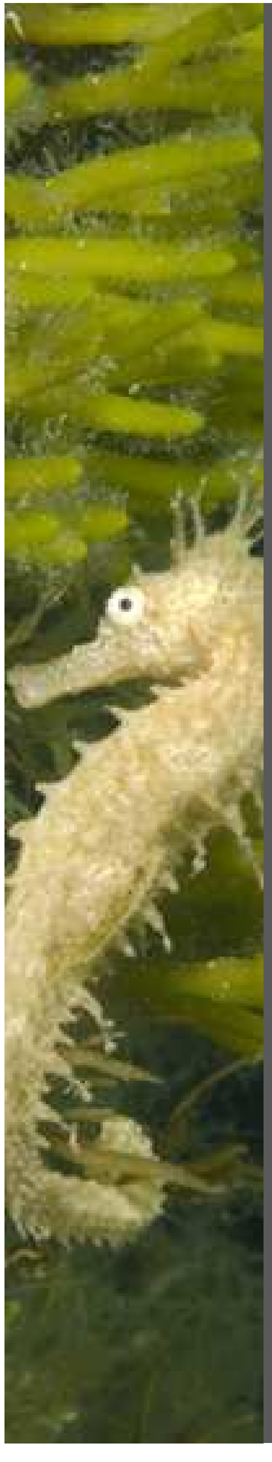
Tempo Mini

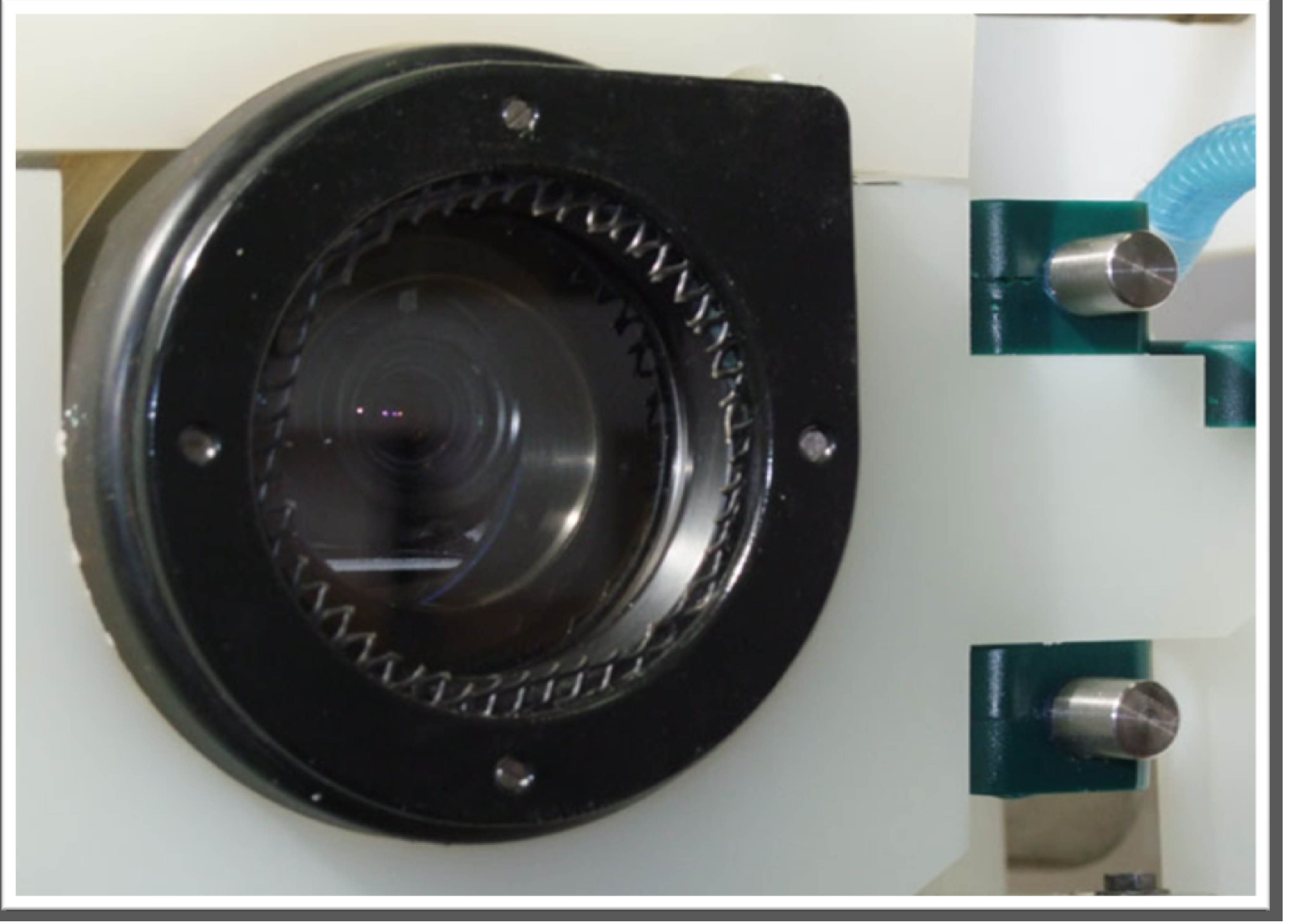
Biofouling protection



Tempo Mini

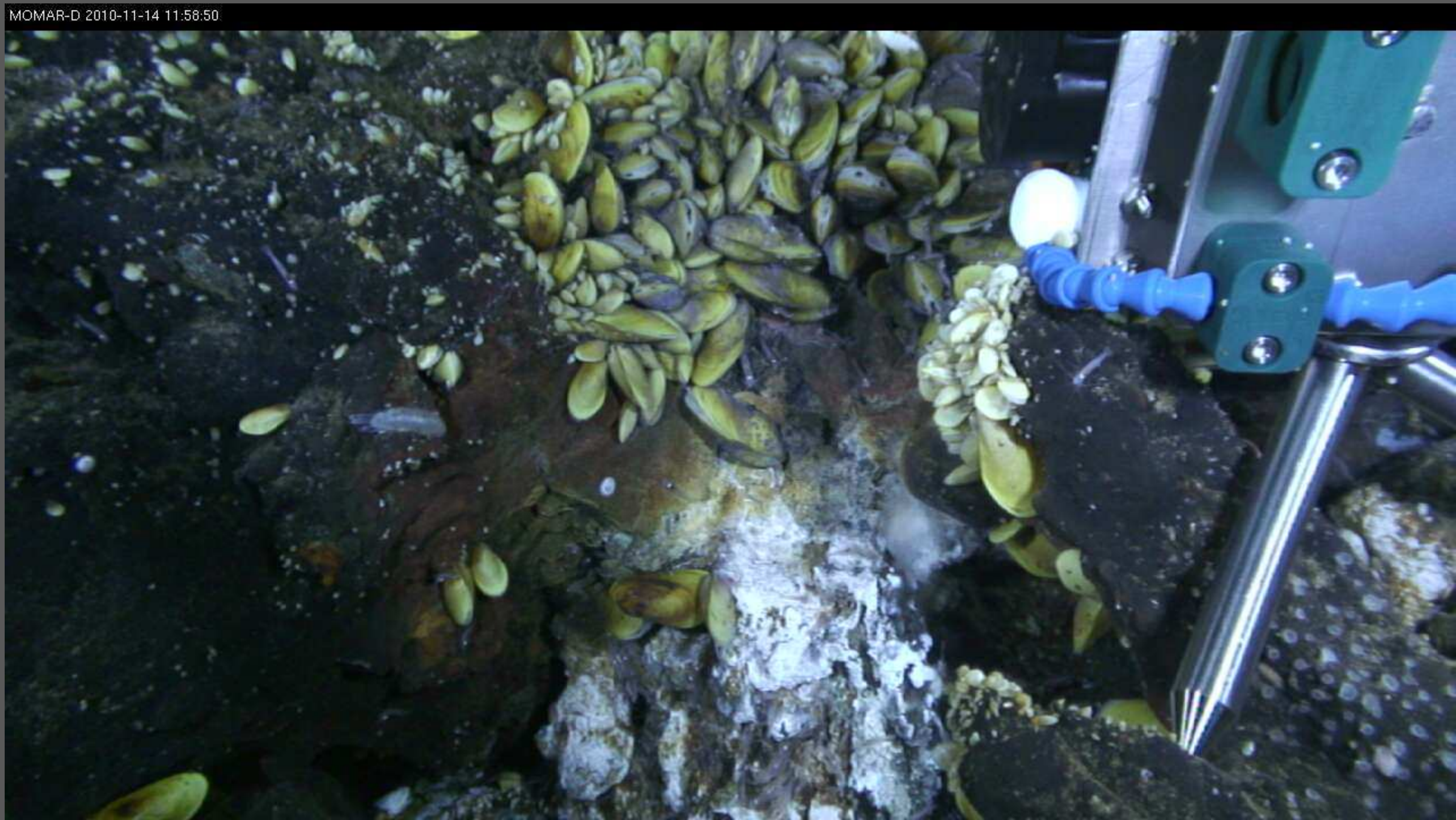
Biofouling protection



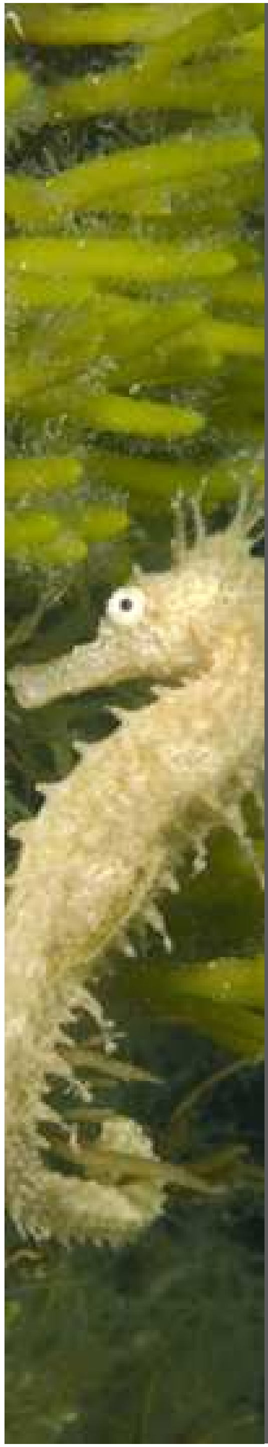


MOMAR-D – Lucky Strike - Açores

RDT & DEEP & IDM



Observatoire déployé en octobre 2010 par 1700m sur le site hydrothermal Lucky Strike
Image extraite de la caméra HD IFREMER « SMOOVE » et transmise quotidiennement à terre par lien acoustique et satellite



Conclusion

• *Local Protection can be adapted to many kind of instrument quite easily.*

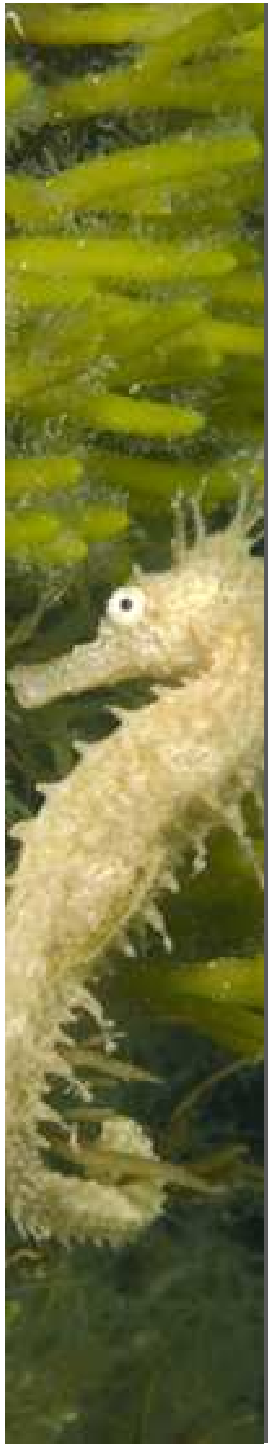
• *The energy need is compatible with autonomous monitoring (2 D cell for 3 months).*

• *Good results have been obtained for parameters commonly used for marine monitoring.*

• *local Protection can be scheduled in order to leave free time interval to perform the measurement (if needed).*

• *50 mm diameter windows of optical sensors have been protected with success.*

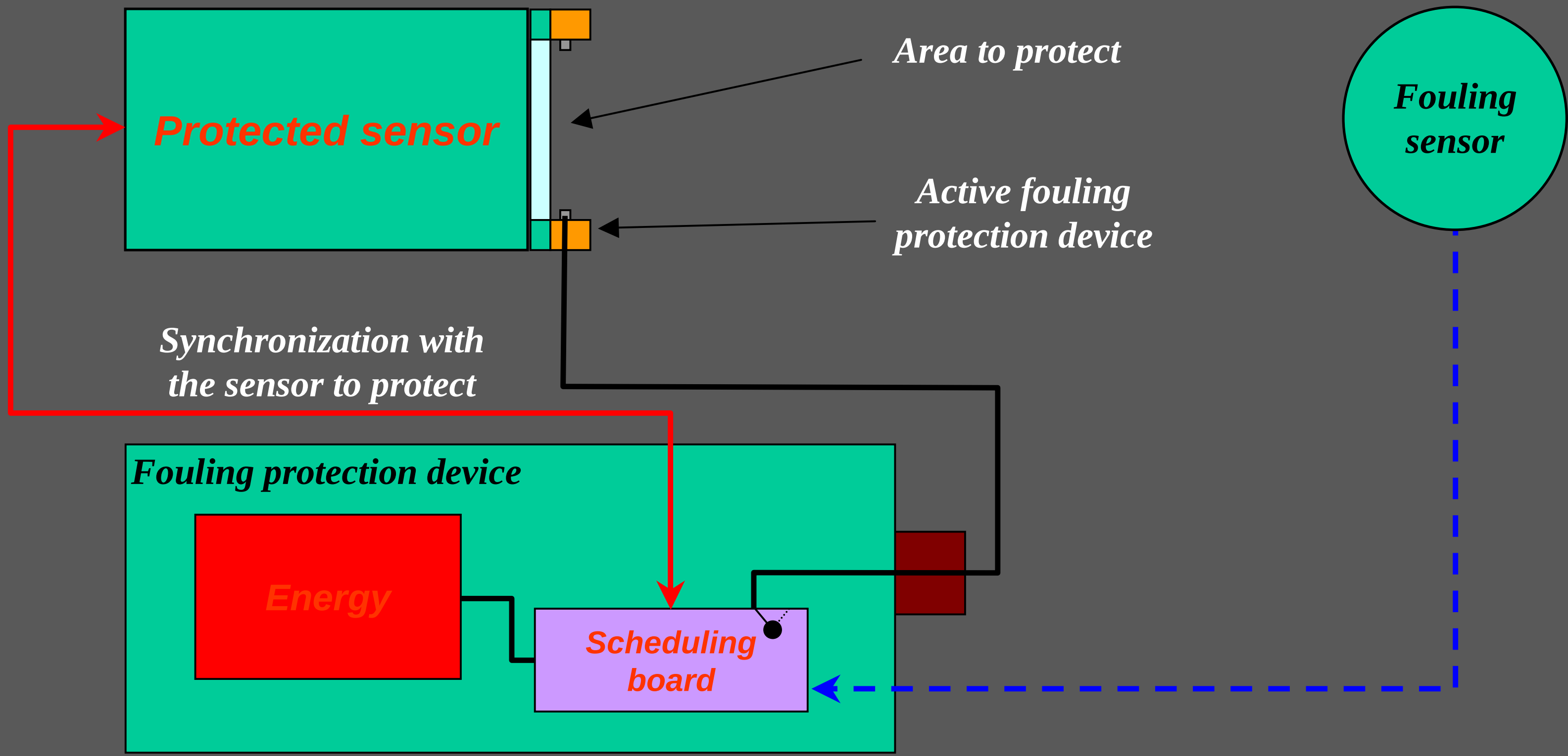
• *In some situations, pumping should be kept in order to flush the system to prevent sediment trap or deposit on sensors.*



Prospective

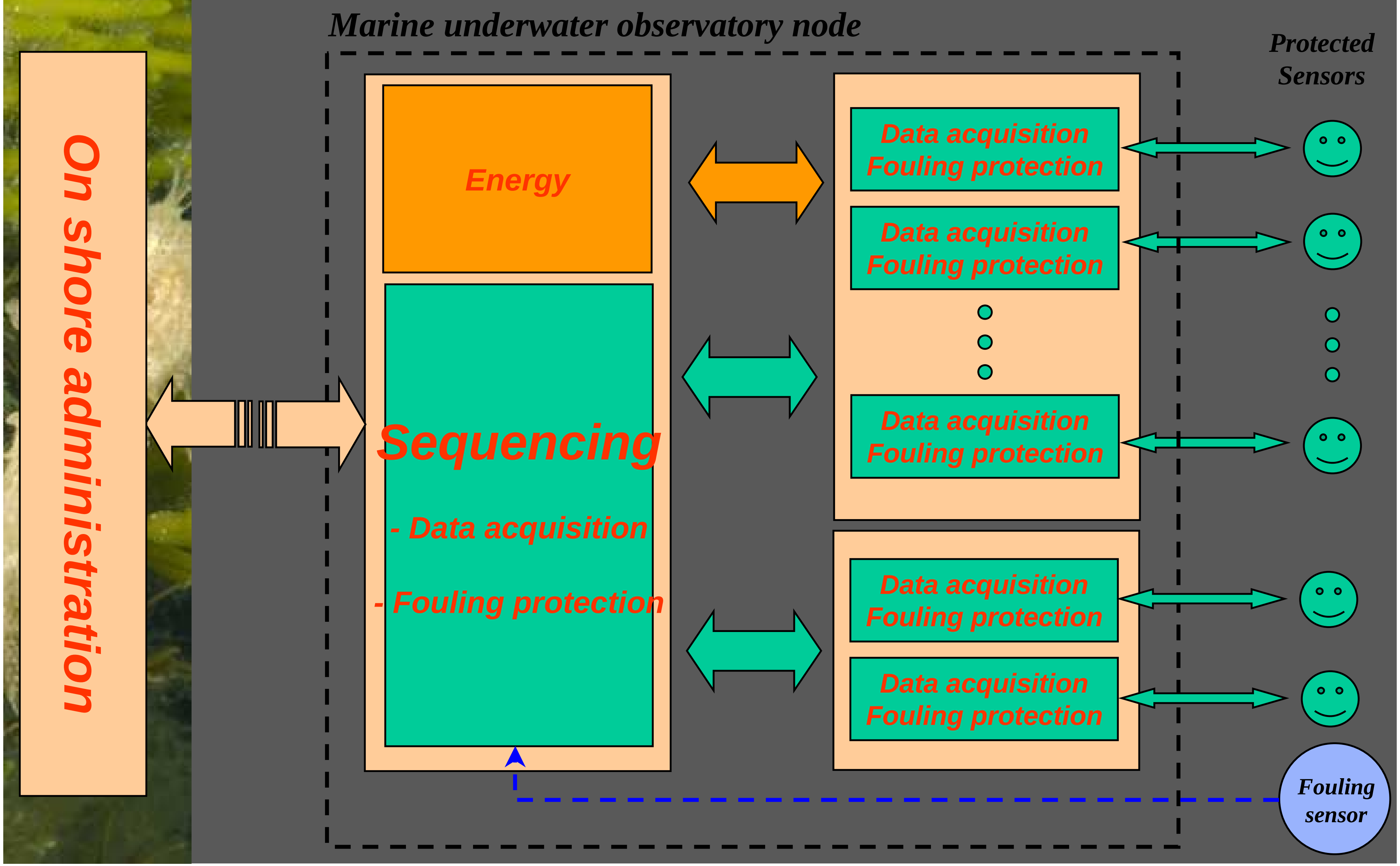
Biofouling management

- *Fouling sensor for optimized scheduling*
- *Synchronization with the sensor to protect*



Prospective

Global Biofouling management

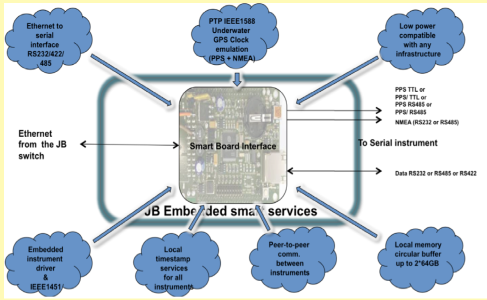


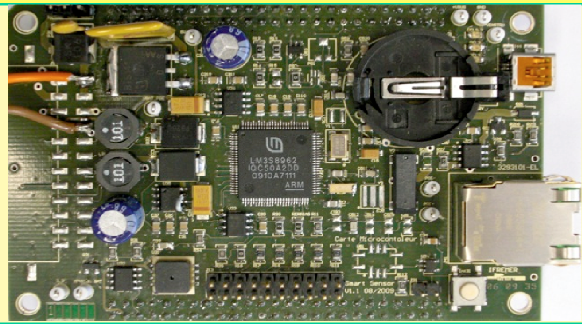
Prospective

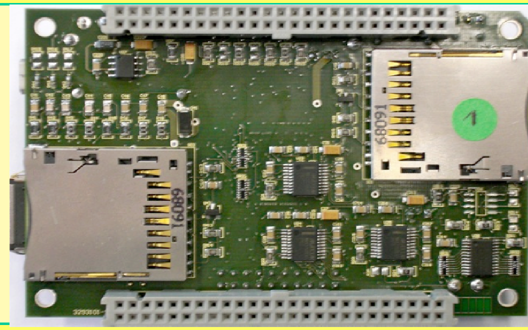
Biofouling management

Smart Sensors

R&D







Applications

- Composant clé dans l'architecture des observatoires pour assurer l'interopérabilité et la compatibilité des instruments sur différentes architectures câblées et non câblées.
- Cœur numérique de nouvelle génération:
  - Ajoute des services et des fonctionnalités réseaux aux instruments actuels
  - Permet la conception d'instruments/capteurs de nouvelle génération, communicants, basés sur Ethernet

Valorisation

- Création d'un consortium basé sur un développement collaboratif regroupant plusieurs instituts: Ifremer, Ensieta, IPGP/INSU, UPC Barcelone/SARTI (Espagne), KDM (Allemagne): Collaborations, publications…