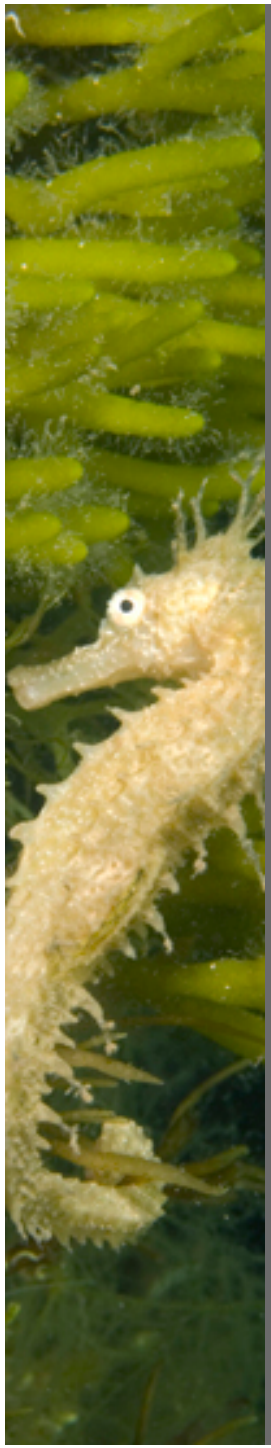
Biofouling protection for *in situ* Marine sensors

EU project Prottec

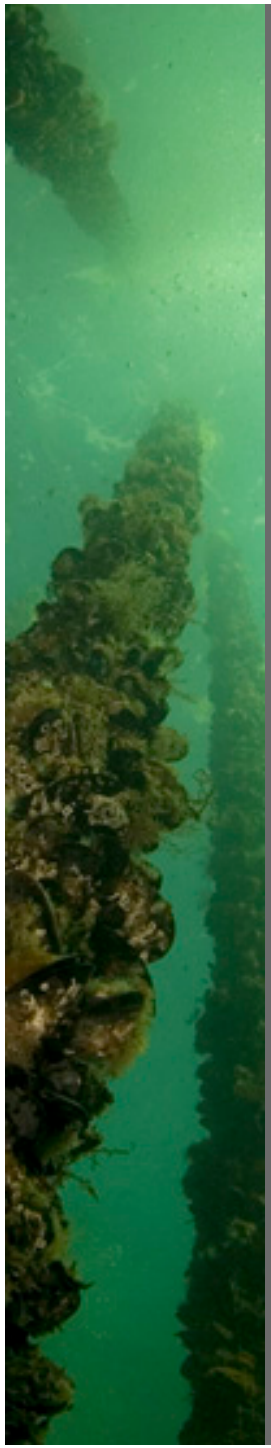
6 minutes to convince…

Laurent Delauney – RDT/EIM

laurent.delauney@ifremer.fr



Needs…



In situ measurements needs

⇒ *Observatoires fond de mer : relation entre fluide et sismicité (L. Géli)*

⇒ *Ecosystèmes profonds -> comprendre un processus (P.M. Sarradin)*

⇒ *Ecosystèmes côtiers (P. Gentien)*

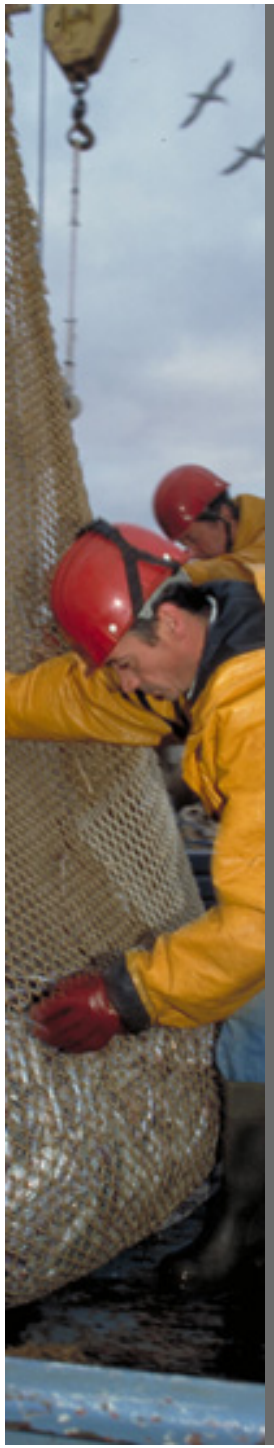
⇒ *Océanographie opérationnelle et suivi climatique (P.Y Le Traon*

⇒ *Transport de sédiments – rhéologie des sédiments (P. Le Hir*

⇒ *Analyse des contaminants chimiques (J.L Gonzales)*

⇒ *Ressources minérales et energétiques (L. Lemoine*

⇒ *Rôle de l'océan sur le changement climatique (H.Mercier)*



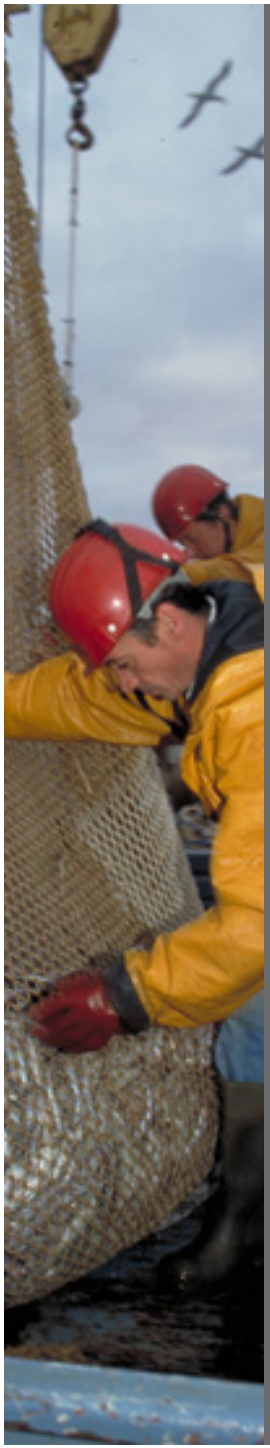
Legislation push-up

⇒ *EU Water Framework Directive*

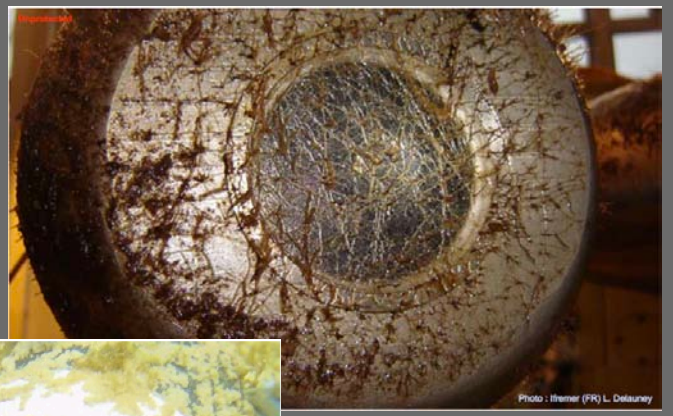
⇒ *REACH (Registration, Evaluation and Autorisation of Chemical)*

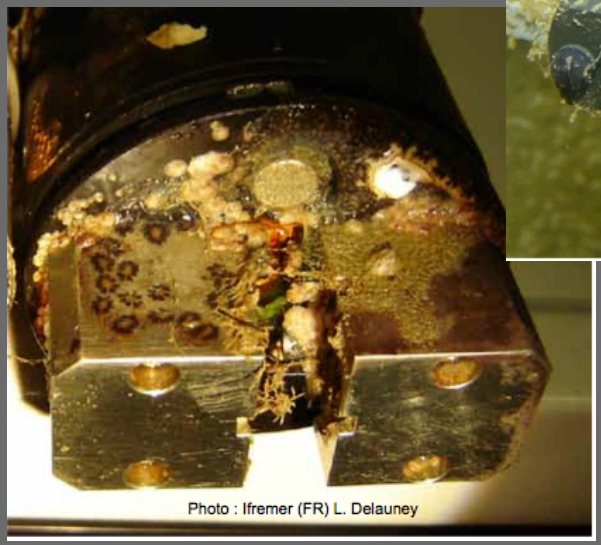
⇒ *Green Chemistry*

Growing demand for in situ automatic measurements



An agressive medium…





Coastal monitoring : three months maintenance

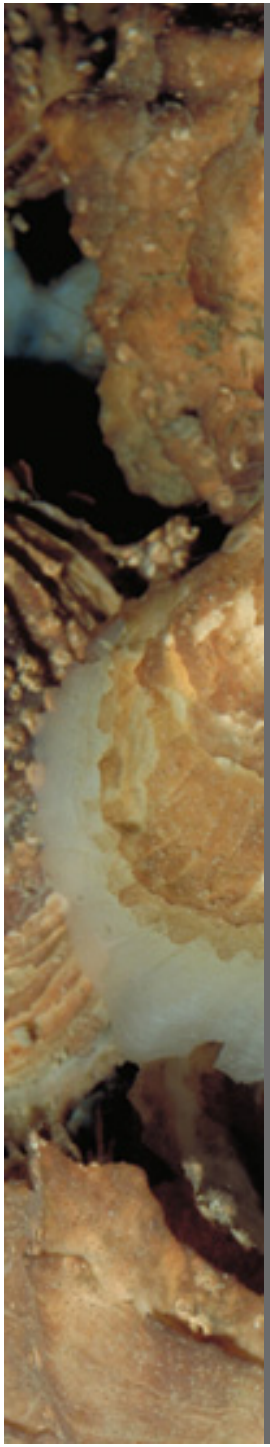
Photos : Ifremer (FR)

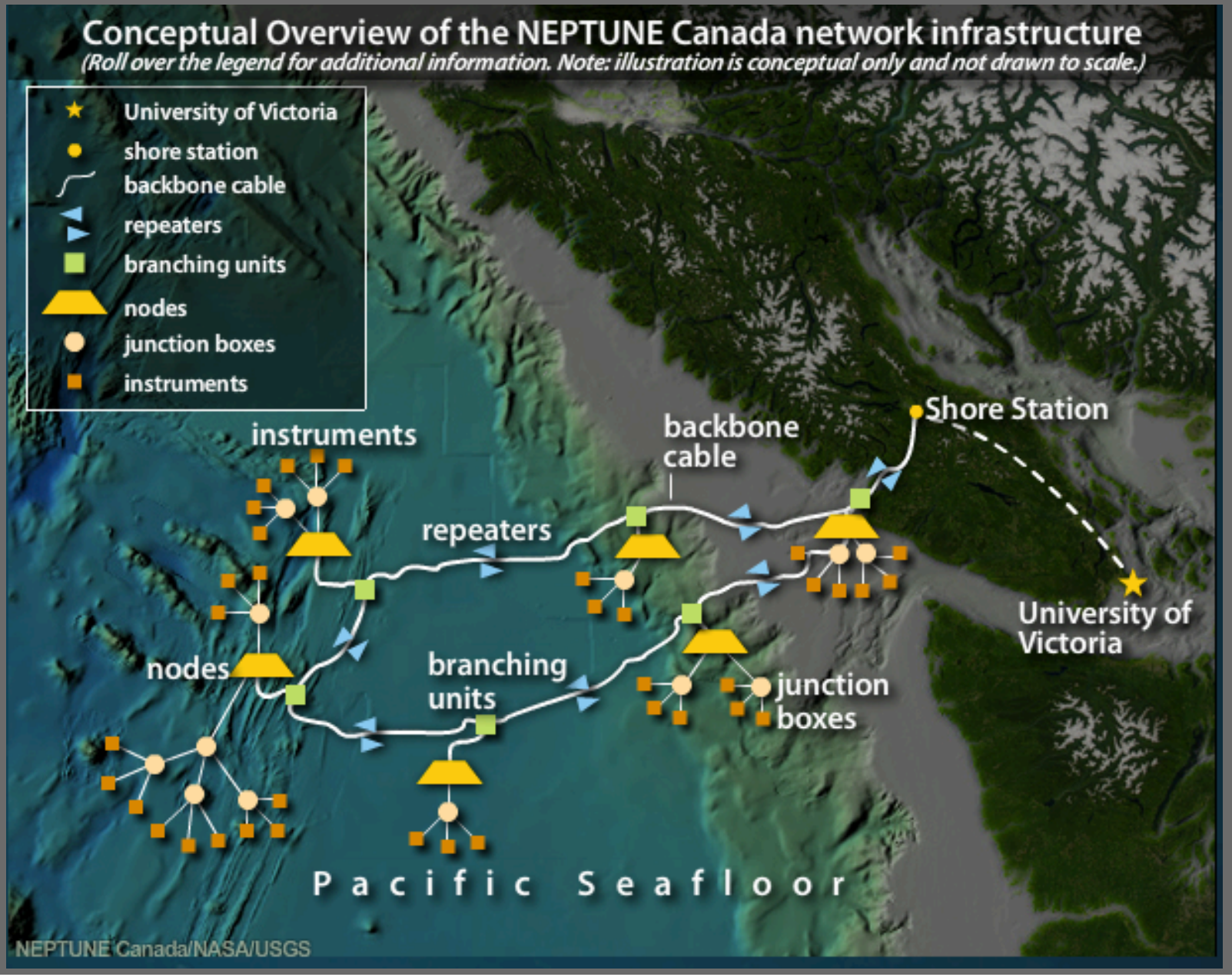

SeaFloor observaories in Europe
Arctic
Norwegian Margin
Nordic Sea
Porcupine Abyssal Plain
Ligurian Sea
Black Sea
Azores Islands
Marmara Sea
Iberian Margin
Western Ionian Sea
Hellenic Arc

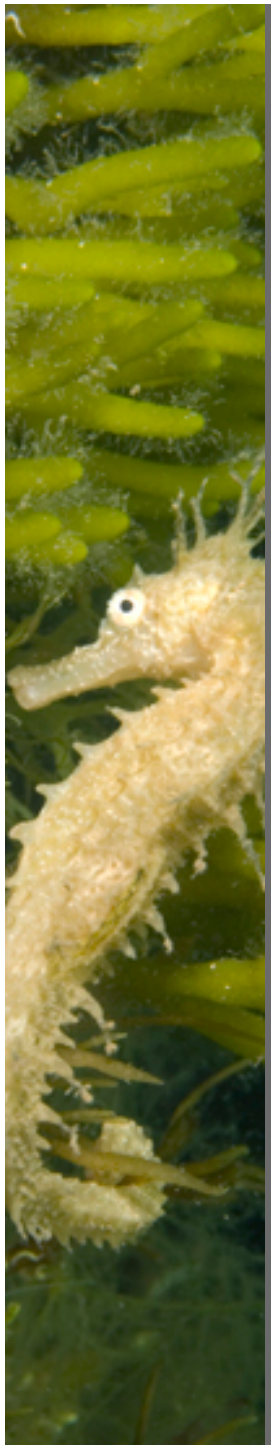
SeaFloor observatory in Canada

800 km – Depth 40 to 2500m

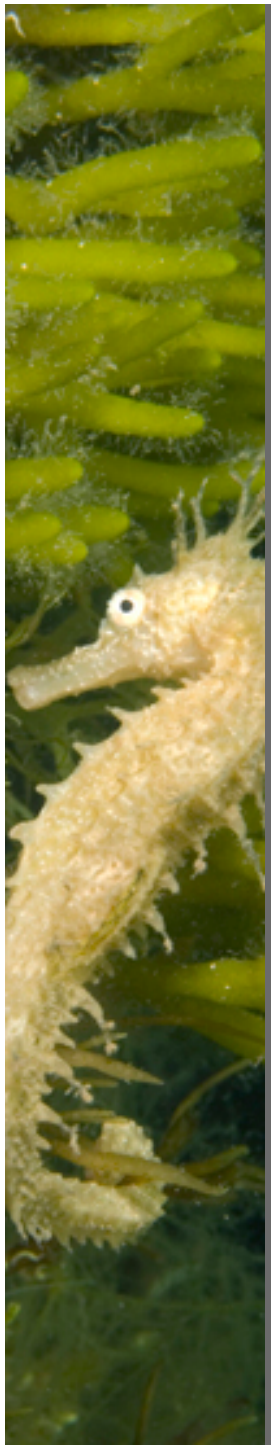
Six months maintenance





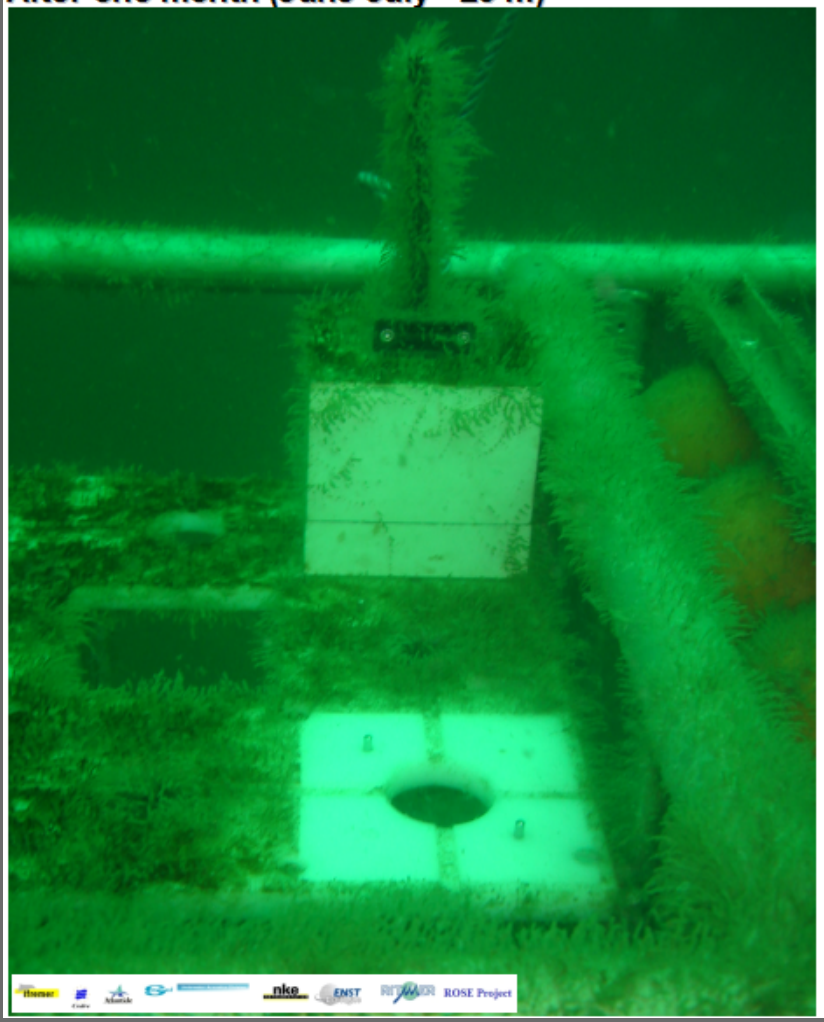


Biofouling and sensors



Marine Benthic Observatories.

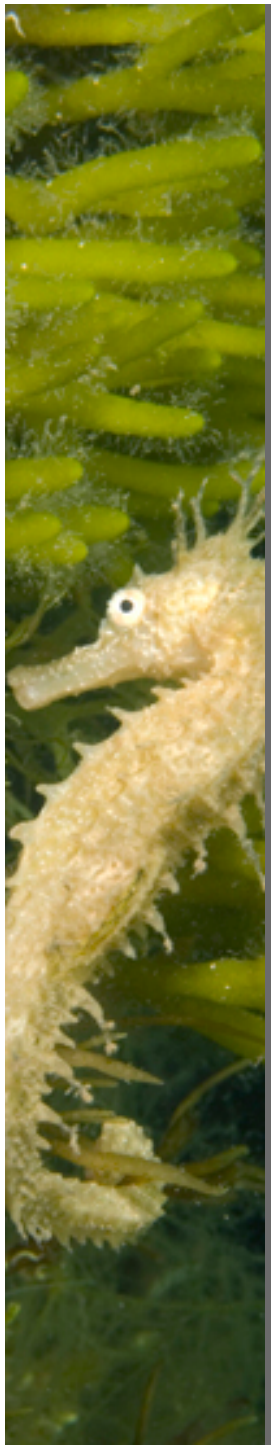
After one month (June-July - 25 m)



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

Photos : Ifremer (FR)

Biofilm development must be taken into acount ...

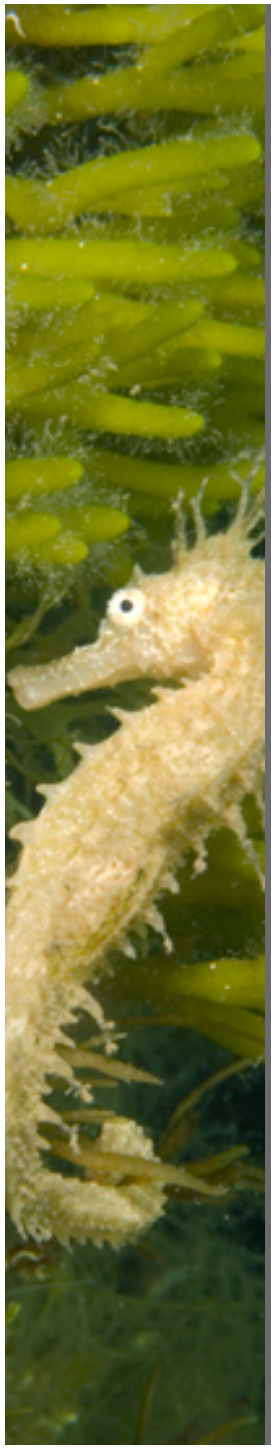


Biofouling example

YSI 6600 EDS (Extended Deployment System) - Clean SweepTM

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

Photo : Ifremer (FR) L. Delauney



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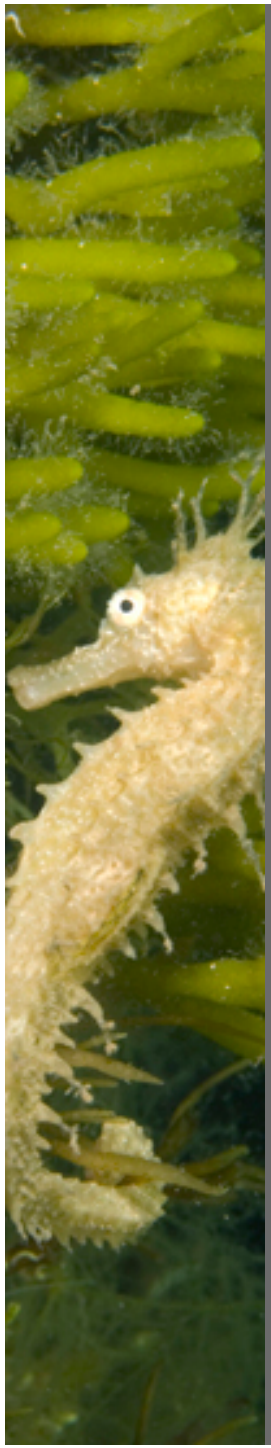
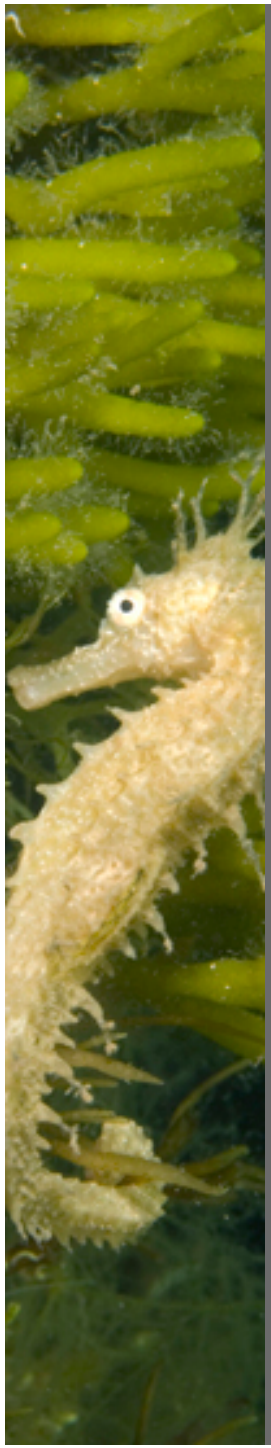


Biofouling example

Optisens Transmissometer

90 days ◆ August - October 2005 ◆ Trondheim

Photo : Ifremer (FR) L. Delauney

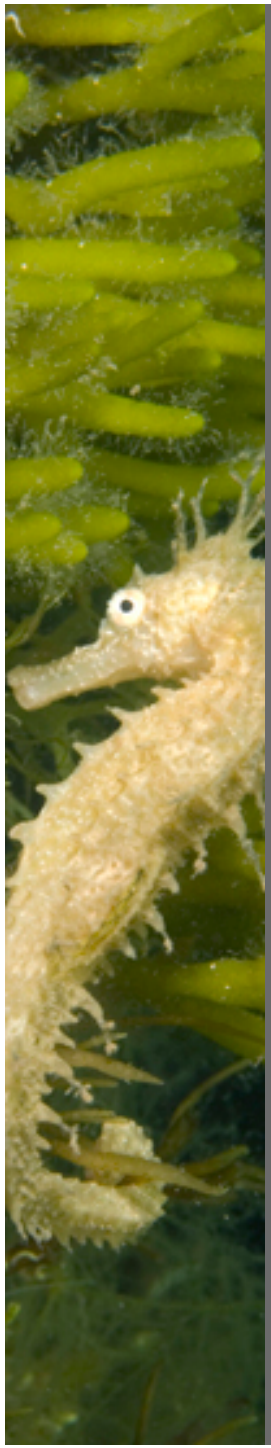


Biofouling example

Seapoint Fluorometer

90 days ◆ May - July 2006 ◆ Brest

Photo : Ifremer (FR) L. Delauney



Biofouling example

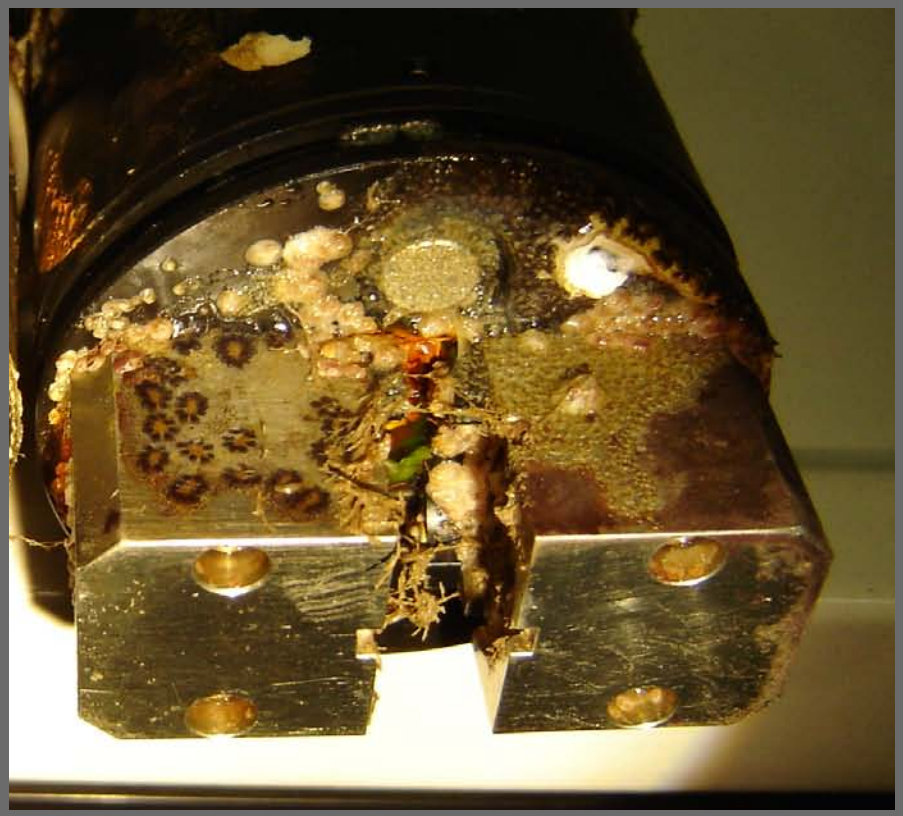
70 days ◆ June - August 2005 ◆ Helgoland - DE

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

Biofouling example

- *Materials and shape shoud be choosed very carefully in order to reduce fouling attachement.*

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

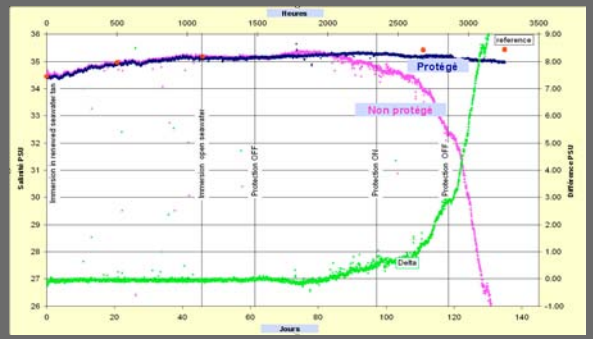
Bosphorus strait

Baltic sea

- Membrane based sensors : pH, oxygen.

  => membrane permeability modifications.

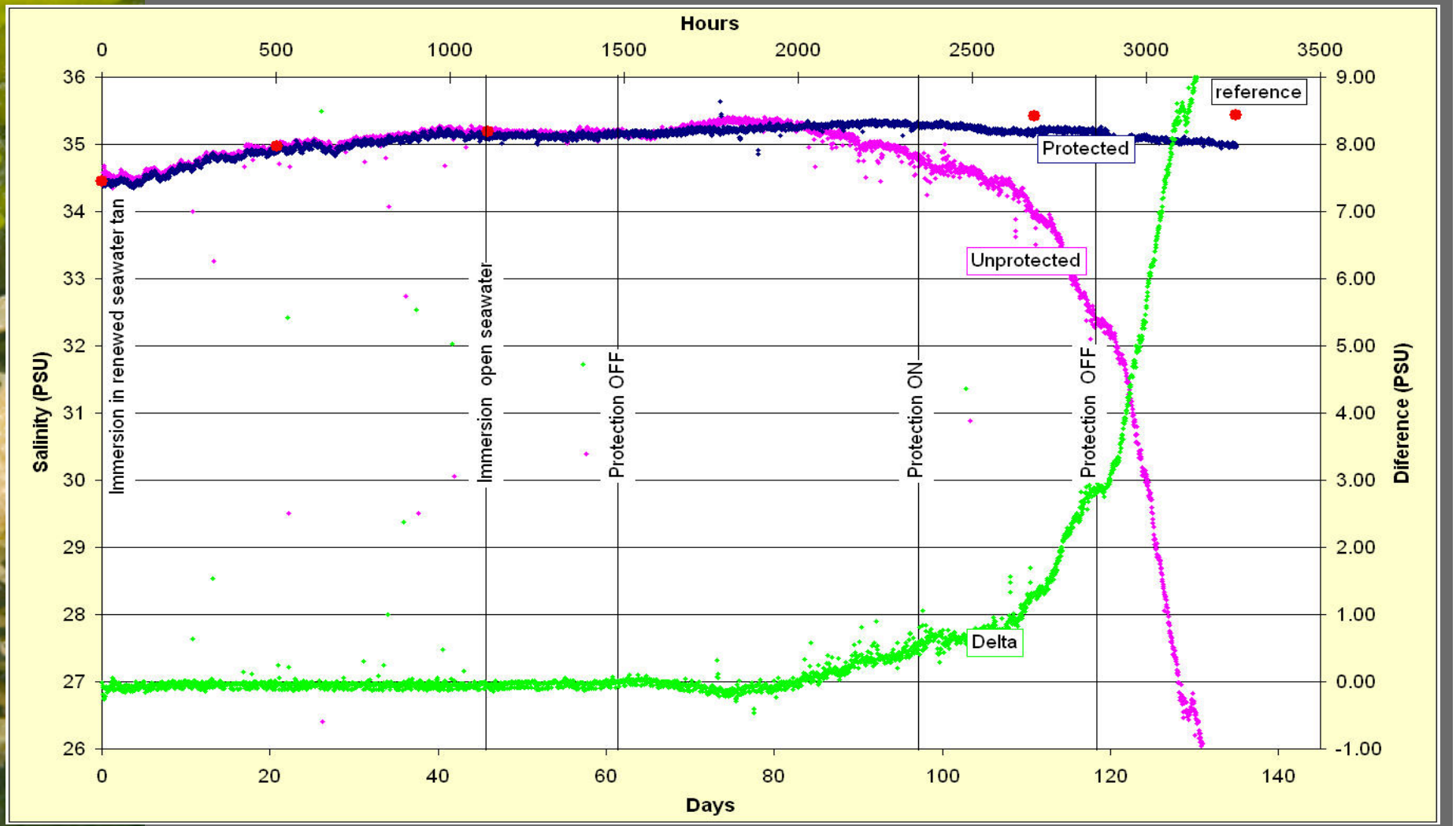
Loss of sensibility,
drift,
response time, etc.



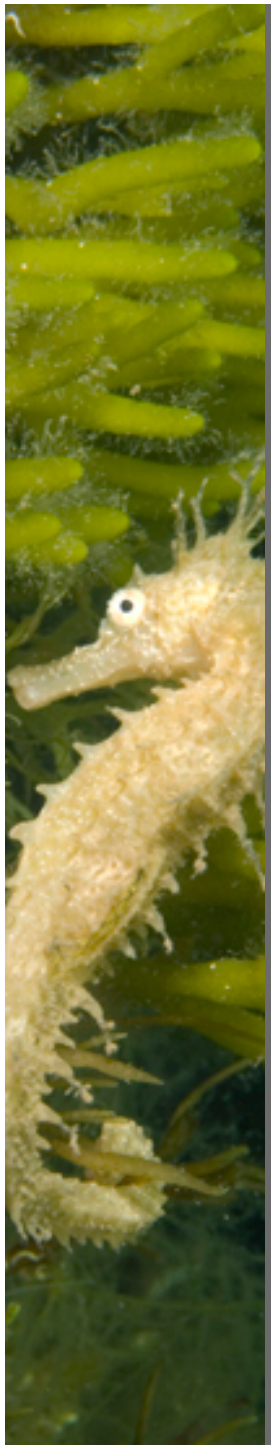
This problem must be treated as long as autonomous measurement longer than 1 week is involved.

Sensor deviation example : conductivity

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



Conductivity Measurement - TPS35 Micrel Instrument



Objectifs

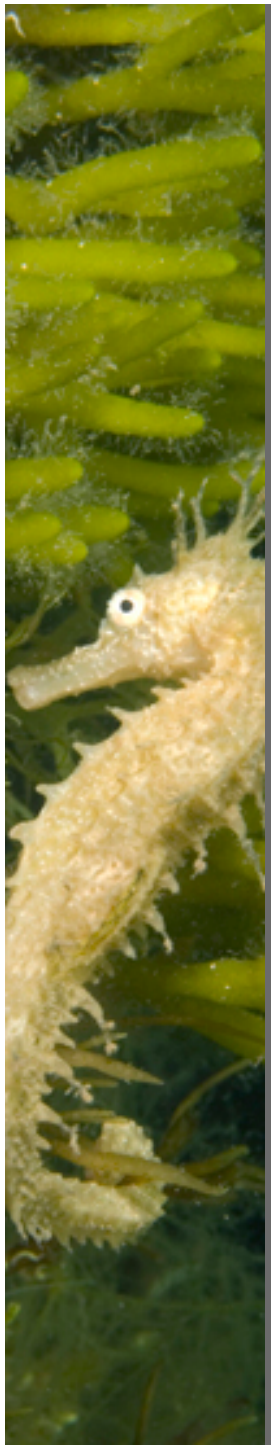
- *The protection system must delay the biofouling effect on the response of the measuring system for at least 1 month in severe conditions and for 3 months in average condition.*

  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).*

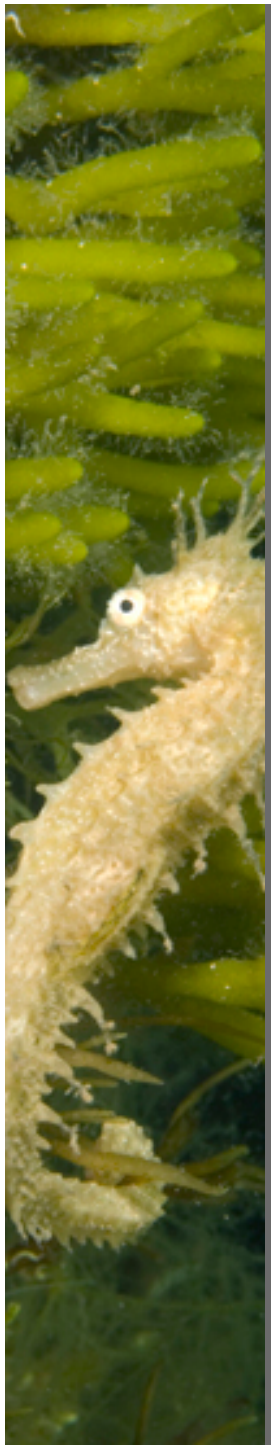
- *The protection system must be adaptable quite easily on existing instrumentation.*

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



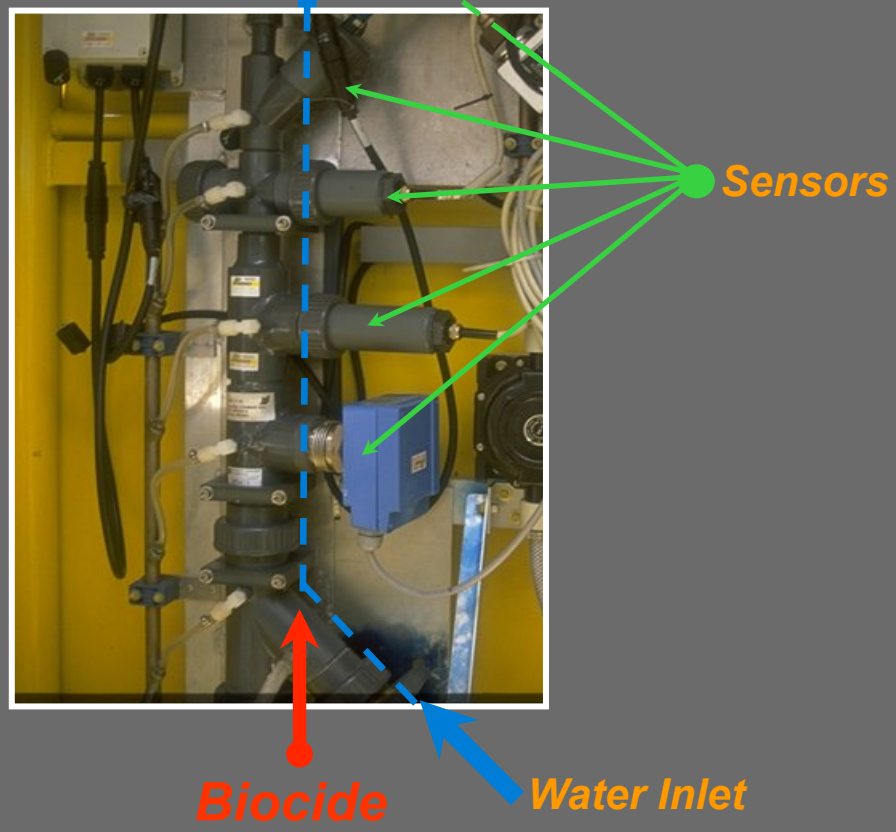
Ifremer Protection Strategy

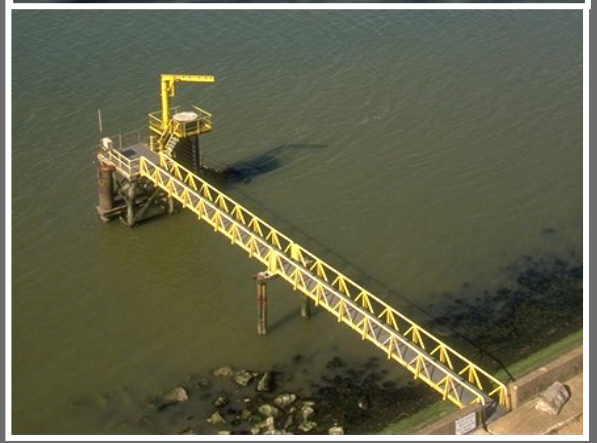
Getting closer to the measurement interface…



Global Protection

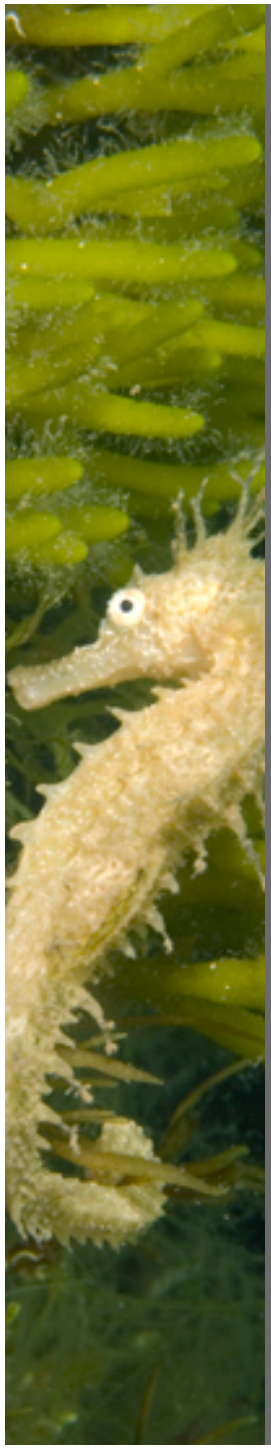
- Pumping is needed



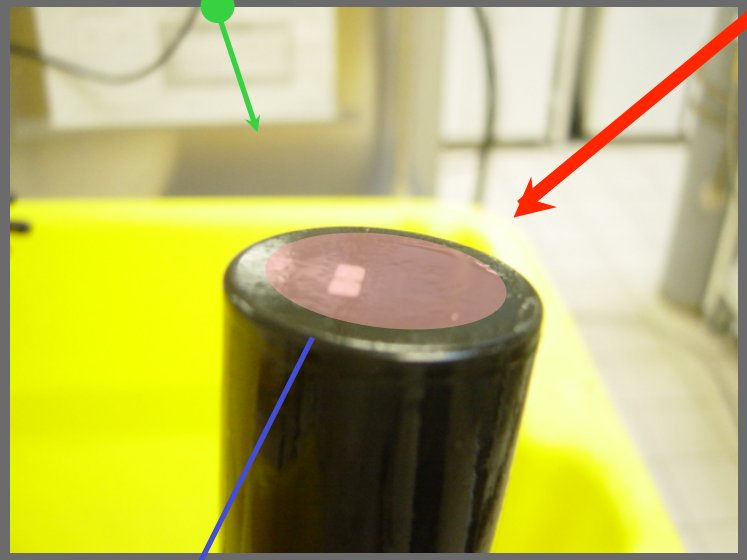


Photos : Ifremer (FR)

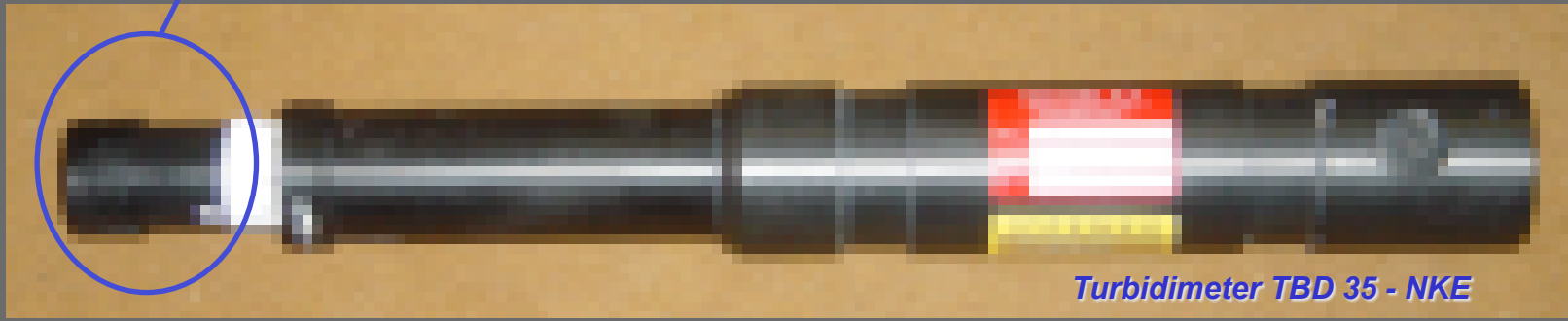
MAREL - Ifremer
Mesures Automatisées pour l'environnement littoral
(Autonomous Measurement for Coastal Environment)



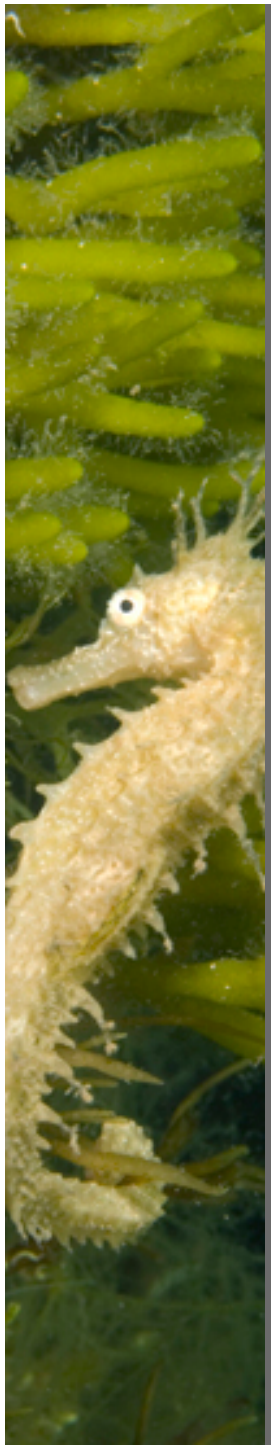
Local Protection



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



Turbidimeter TBD 35 - NKE



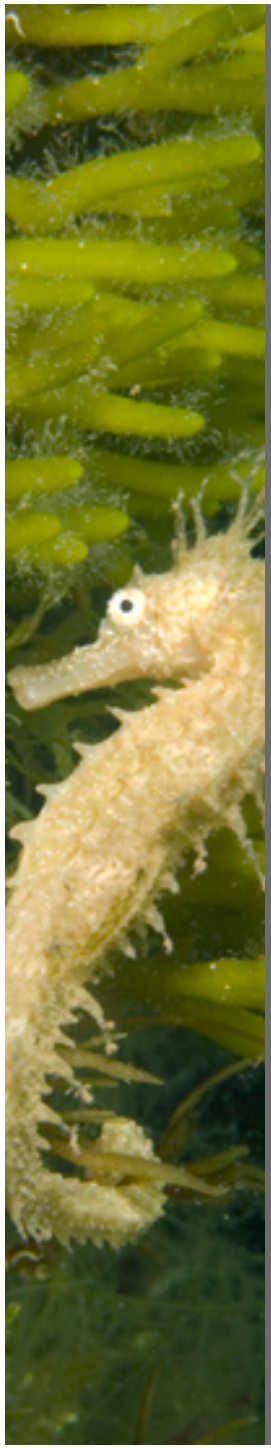
Coated window Protection

Interface Modification

Glass window coated with a specific material in order to generate biocide on the surface (Work in progress)

TriOS microFlu-chl

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

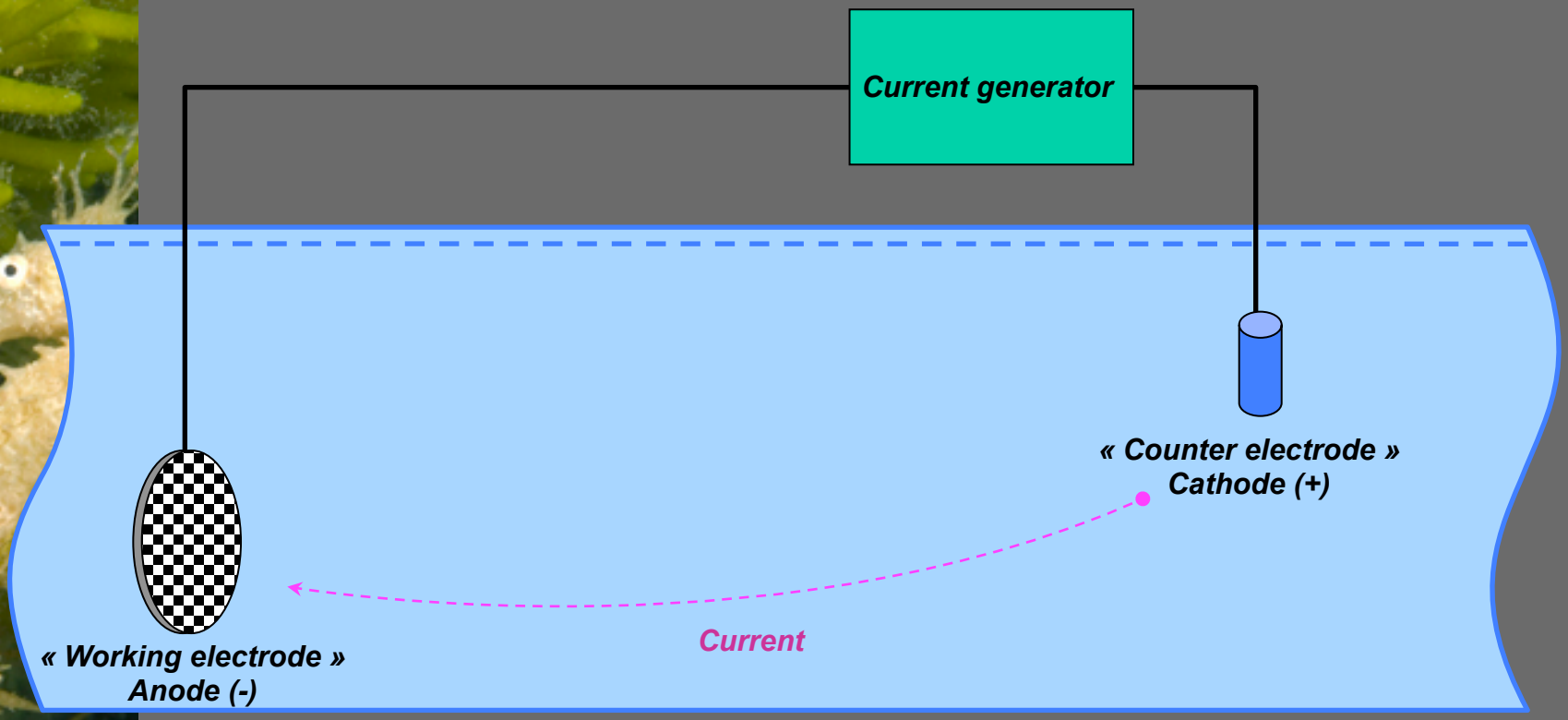


Seawater electrolysis principle

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.

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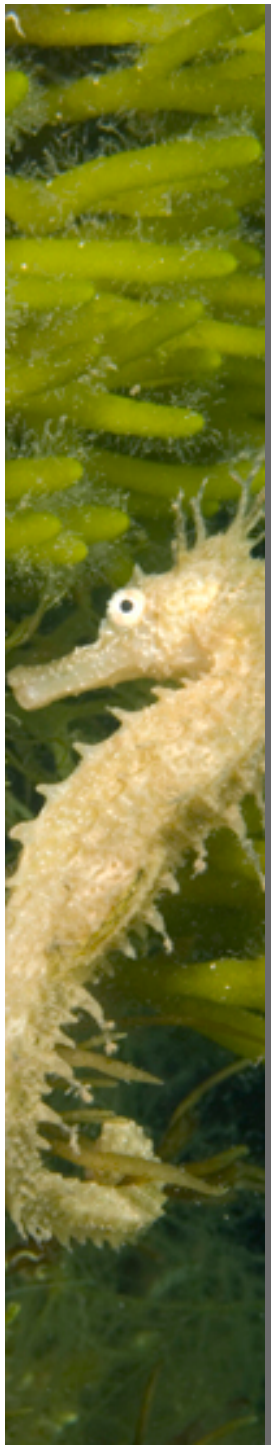

Chlorine Generation System In Sea Water

« 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

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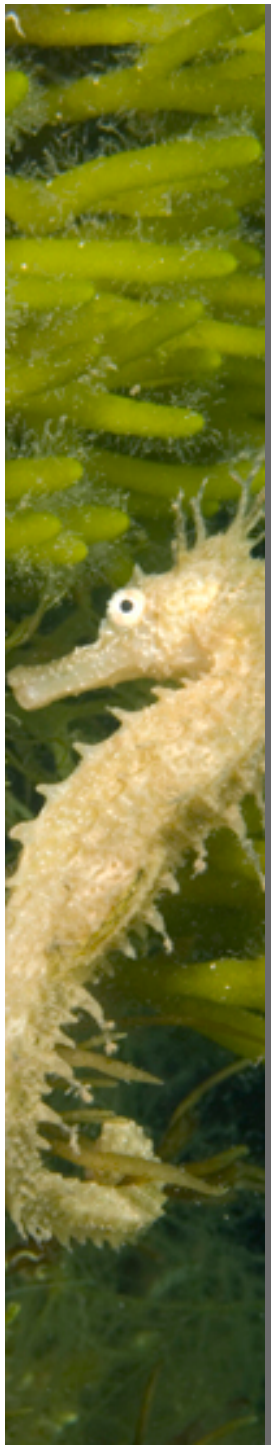

In situ results

Local chlorination

Fluorimeter

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

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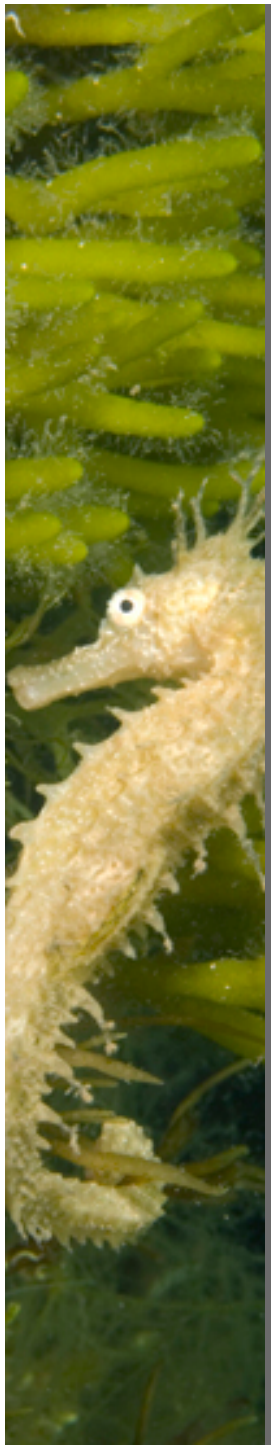


Local Chlorination

In situ biofouling prevention efficiency test

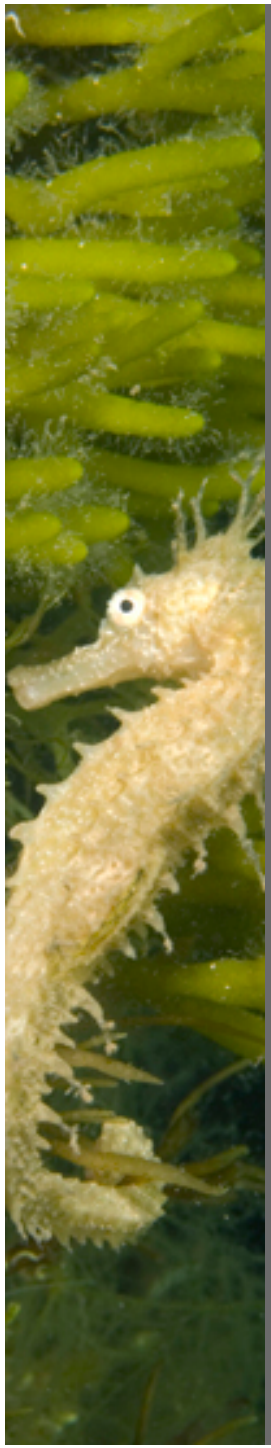
100 days duration ◆ 19th may - 31st Aug ◆ Millport

Un-Protected device

Protected device

Fluorescence Measurement - Turner Scufa instrument

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



Local Chlorination

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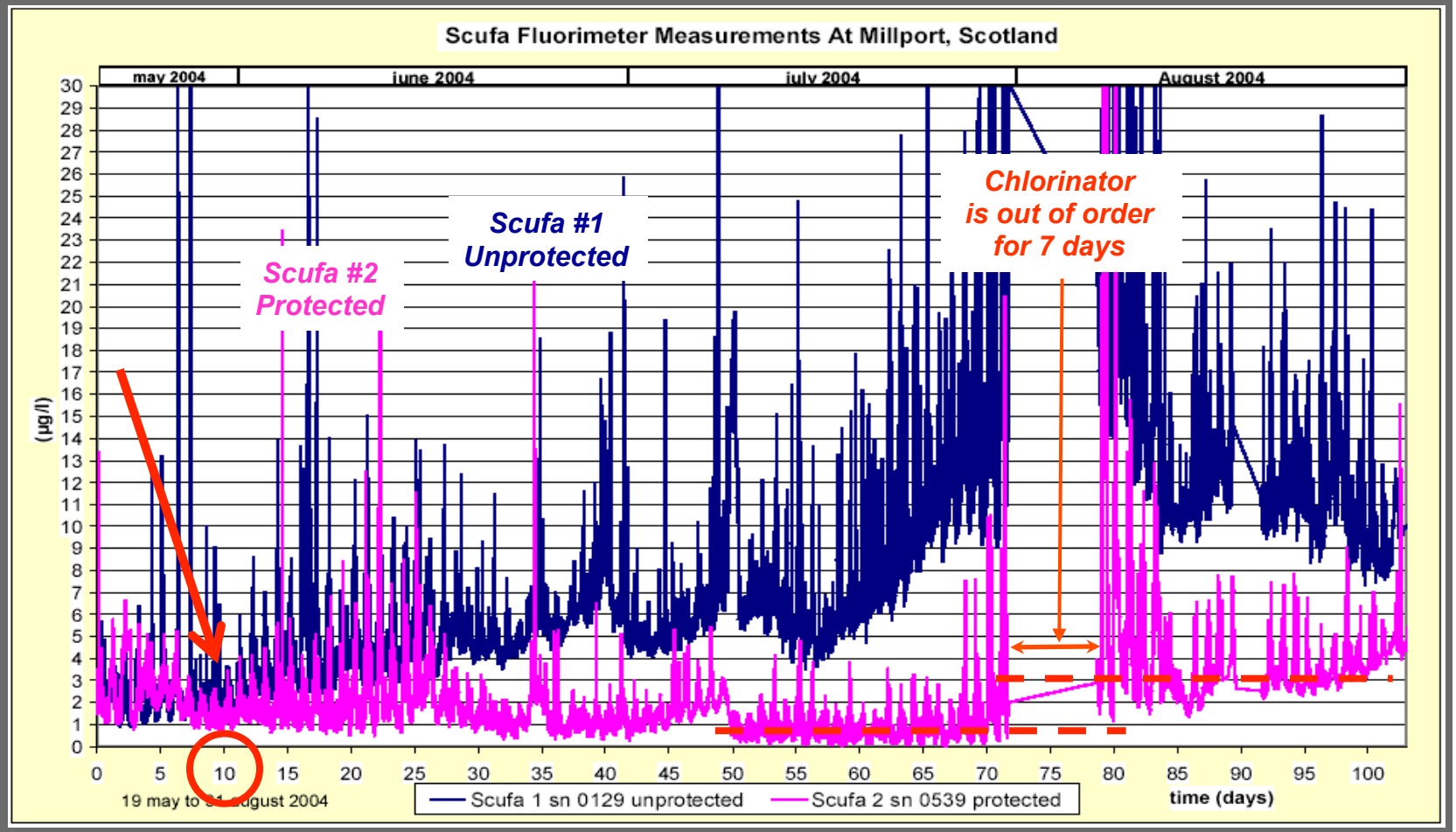

Fluorescence Measurement - Turner Scufa instrument

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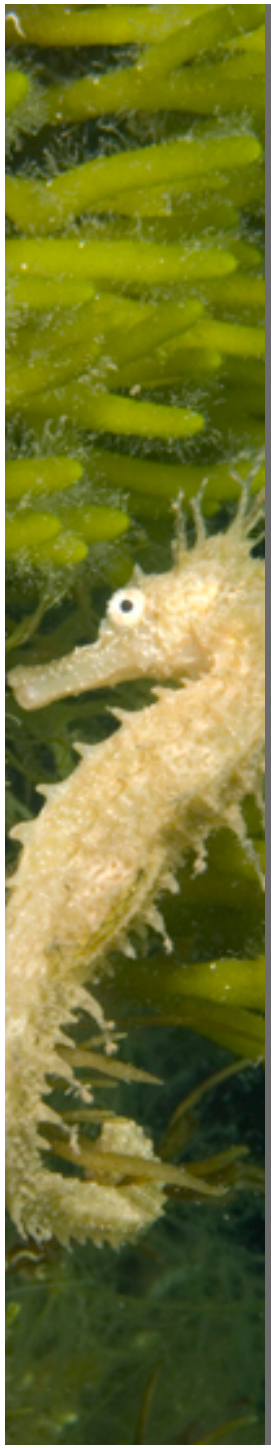


Résultats

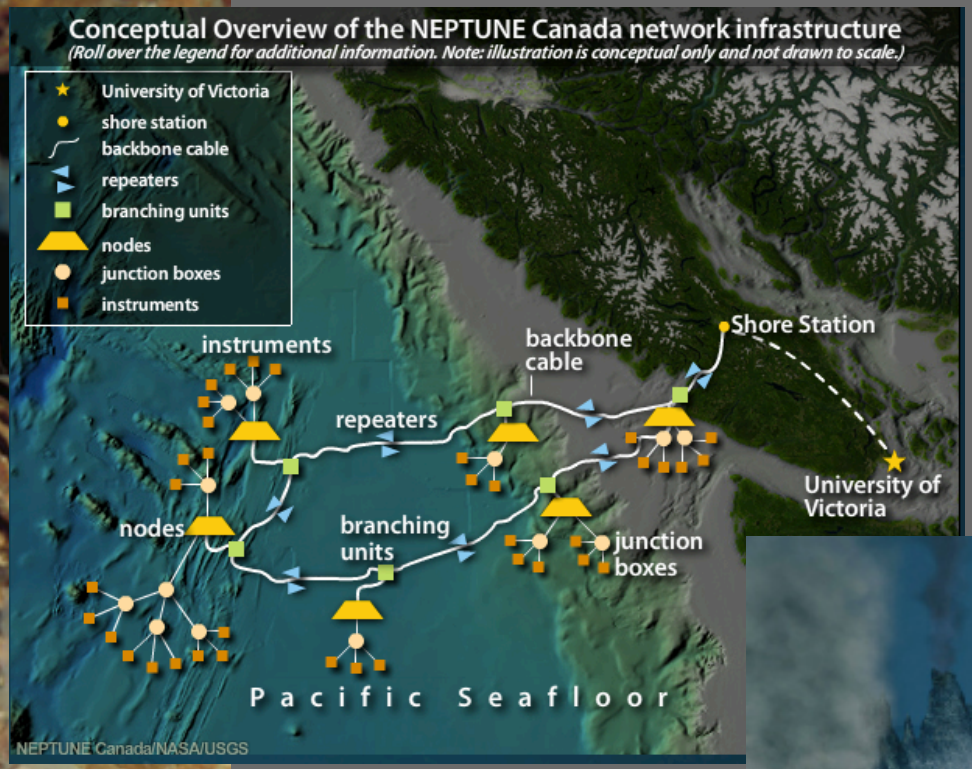
in situ

Chloration Localisée

Transmissometre

sur l'observatoire fond de mer Canadien VENUS

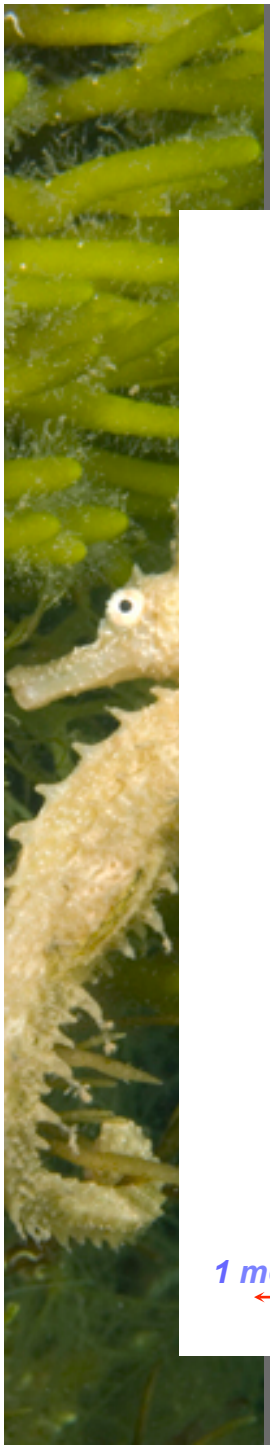
Observatoire fond de mer : NEPTUNE Canada



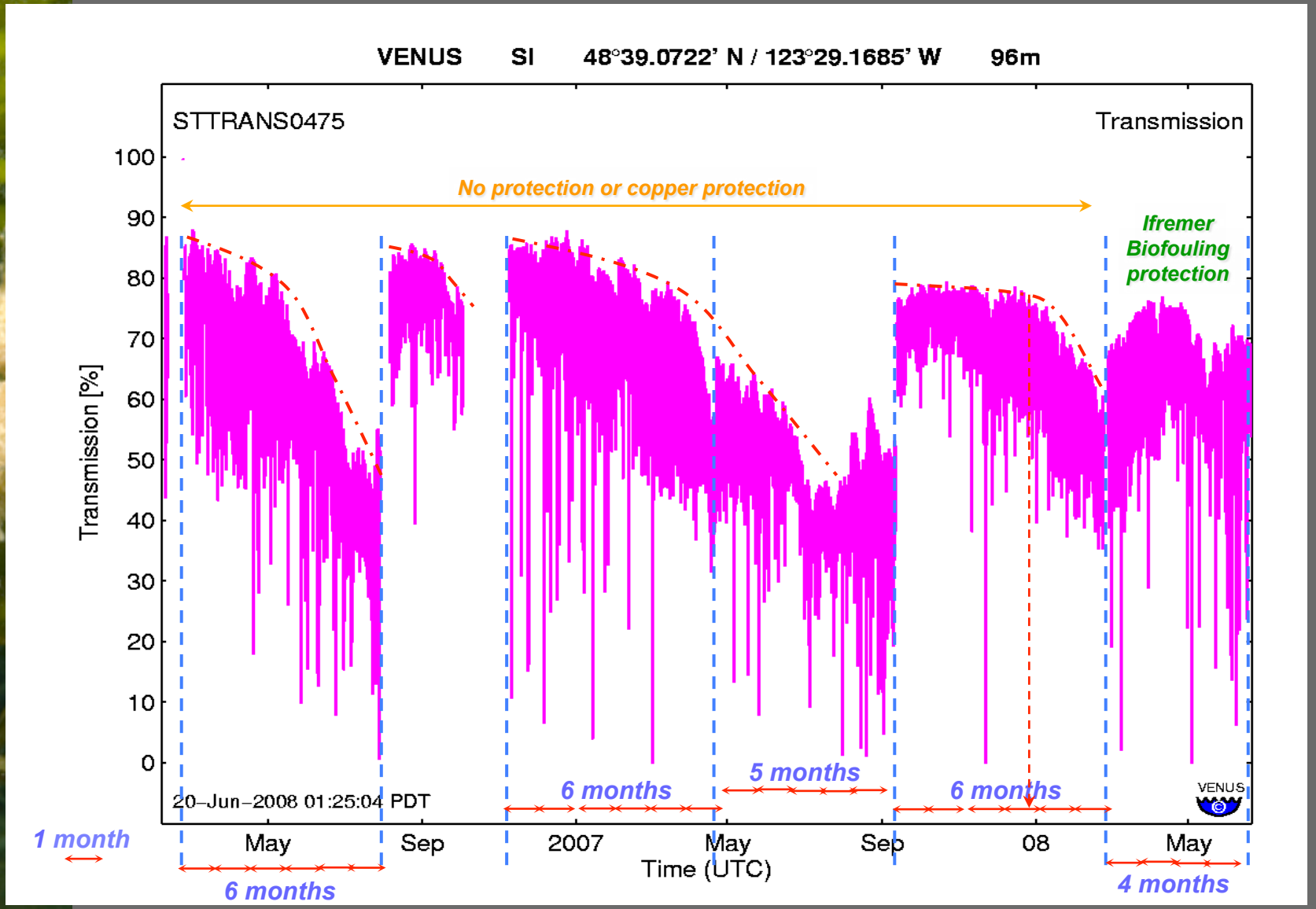
Boucle de 800 km

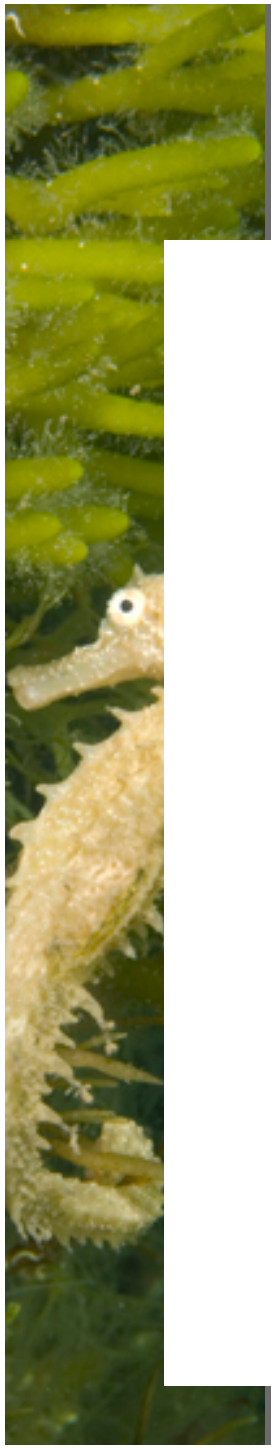
Profondeur de 40m à 2800m

6 mois entre chaque maintenance…

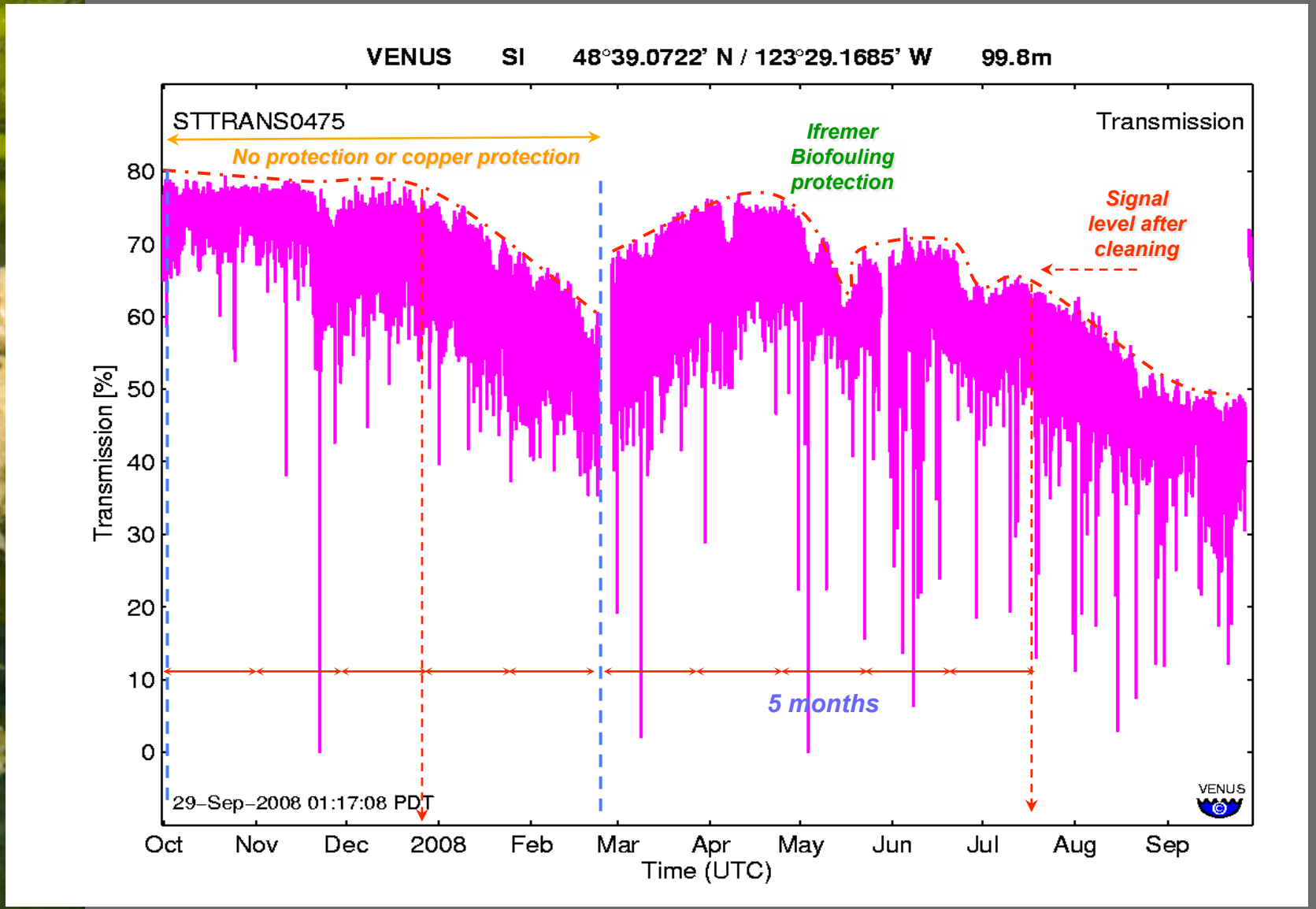


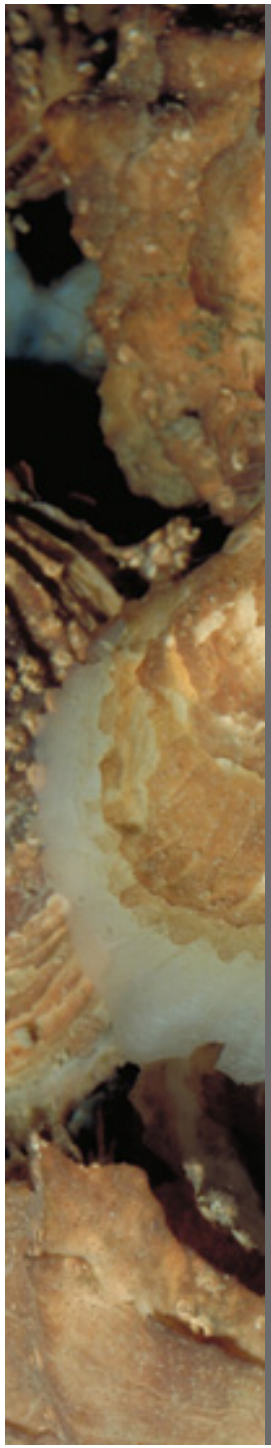
VENUS TRANSMISSOMETER
Ifremer Biofouling Protection – VENUS Data





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

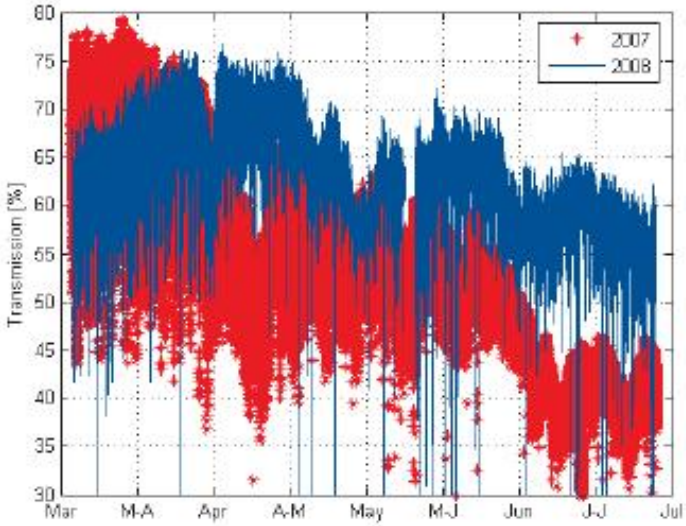
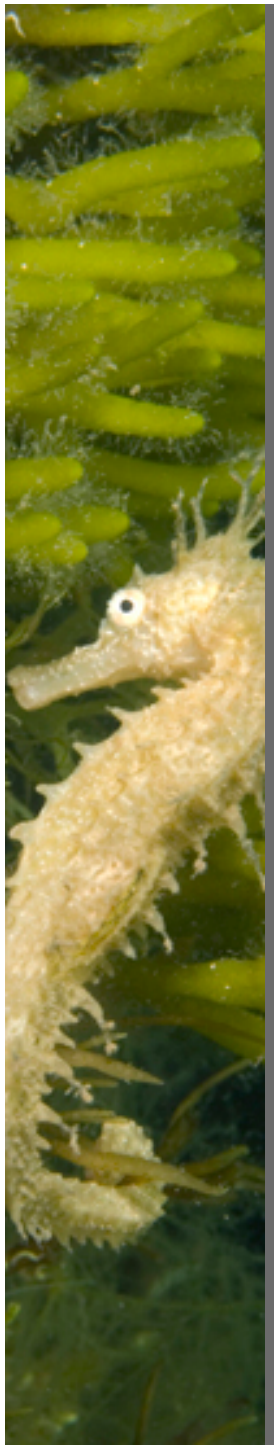


Figure 5. Transmissometer Data Comparison 2007-2008

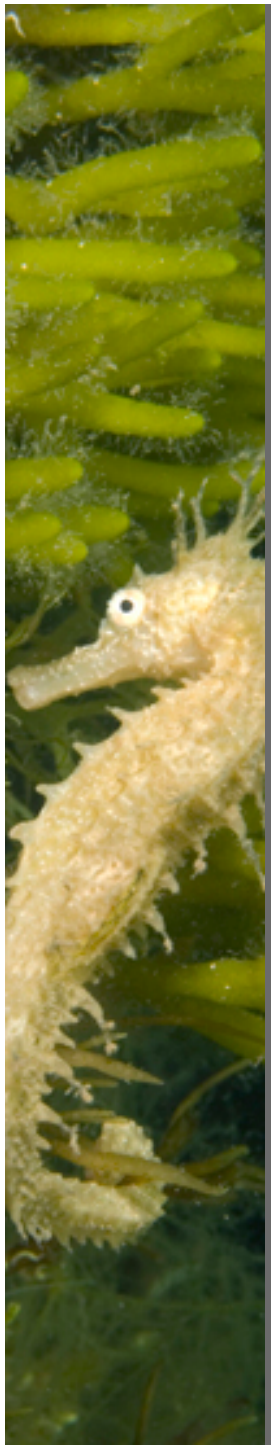
Interface Module (SIIM). The system is now powered continuously through the VENUS array.

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.



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.*



Thank you for your attention