

Malta Summer School 2018  
Operational Oceanography for Blue Growth



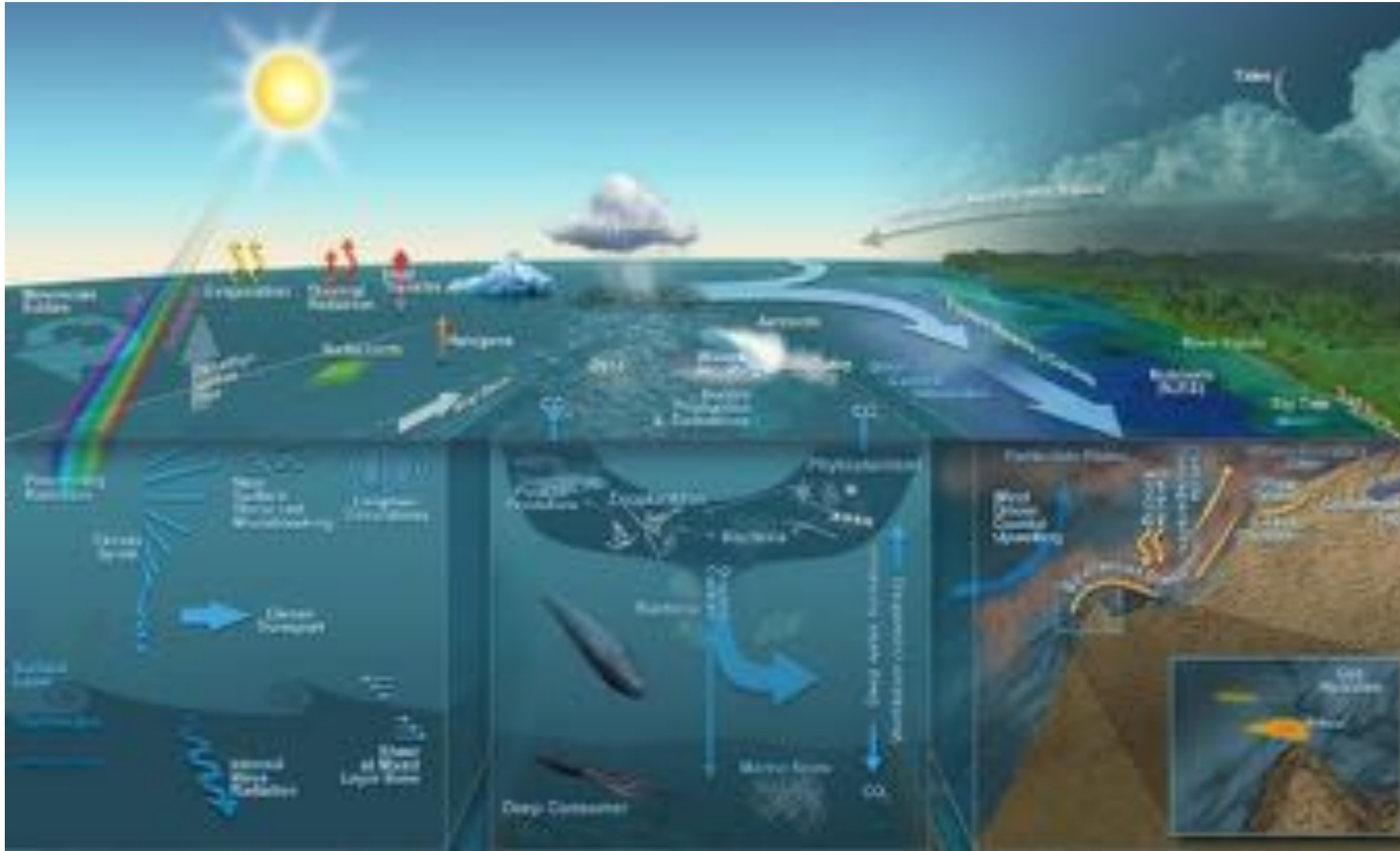
# Existing marine observation technologies: platforms, systems, sensors. Sharing, harmonisation and future developments.

Laurent Delauney - Ifremer

[Laurent.delauney@ifremer.fr](mailto:Laurent.delauney@ifremer.fr)



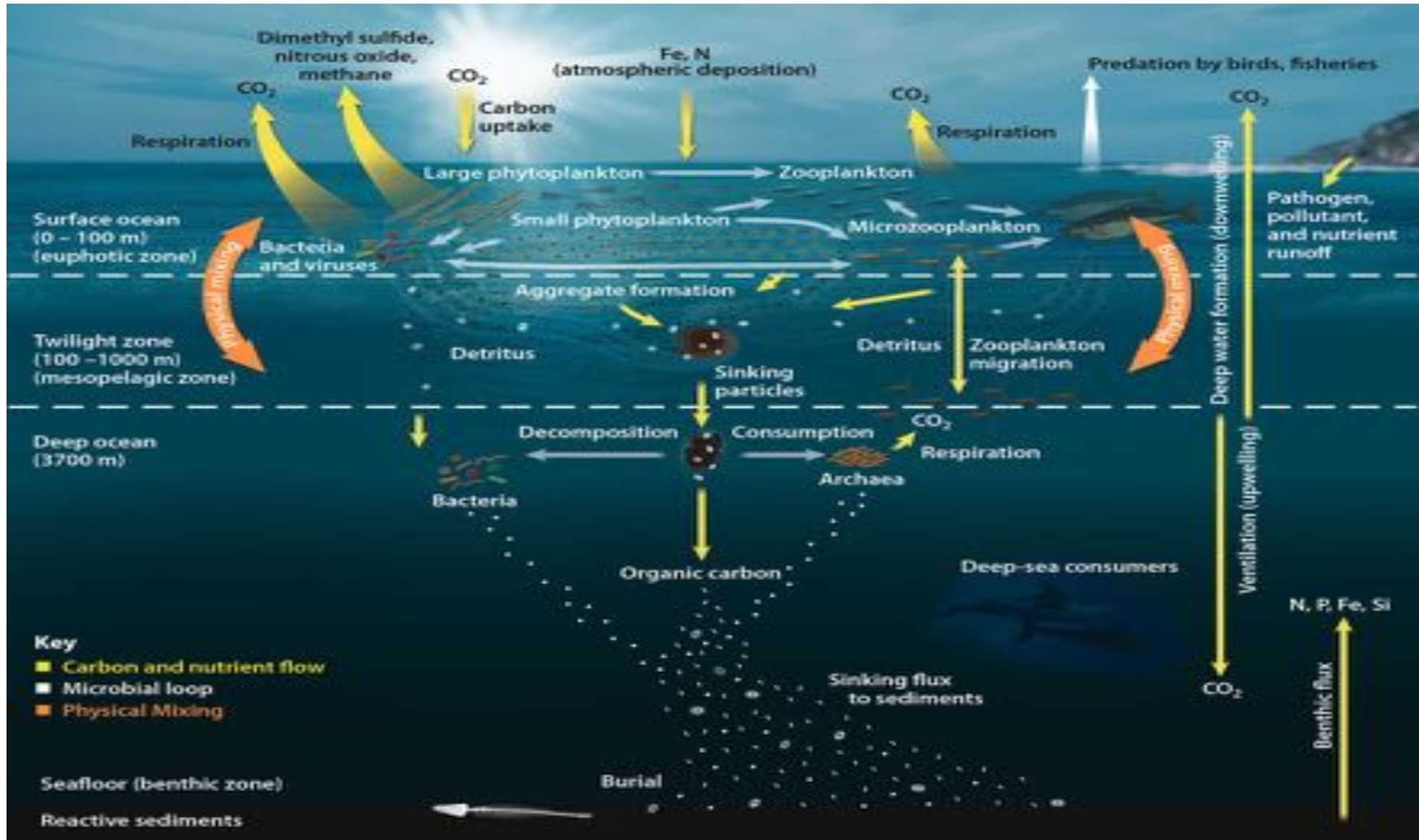
# Marine environment => A complex system to monitor



from OOI,  
Regional Scale  
Nodes (Delaney,  
2008)

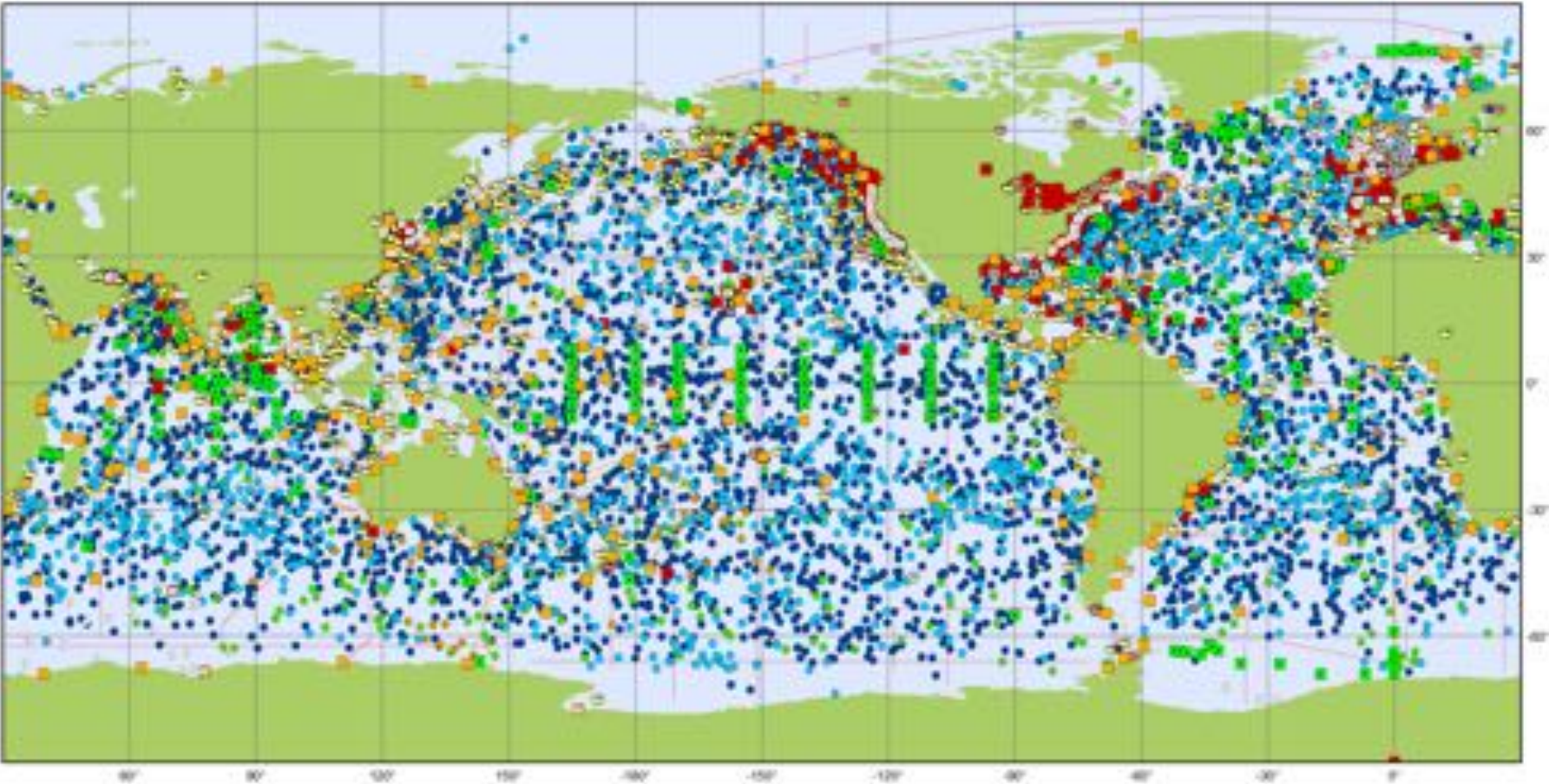


# An interdisciplinary challenge



From:  
Office of  
Biological and  
Environmental  
Research of the  
U.S. Department of  
Energy Office  
of Science.

# An interdisciplinary challenge



From:  
JCOMMOPS

(<http://www.jcommops.org>)

Main in situ Elements of the Global Ocean Observing System May 2018

Profiling Floats (Argo)	Data Buoys (DBCOP)	Timeseries (OceansITES)	Ship based Measurements (SOT)	Other Networks
<ul style="list-style-type: none"> <li>Core (3820)</li> <li>Deep (54)</li> <li>BioGeoChemical (303)</li> </ul>	<ul style="list-style-type: none"> <li>Surface Drifters (1499)</li> <li>Offshore Platforms (95)</li> <li>Ice Buoys (14)</li> <li>Moored Buoys (405)</li> <li>Tsunameters (36)</li> </ul>	<ul style="list-style-type: none"> <li>Interdisciplinary Moorings (337)</li> <li><b>Repeated Hydrography [GO-SHIP]</b></li> <li>Research Vessel Lines (61)</li> <li><b>Sea Level [GLOSS]</b></li> <li>Tide Gauges (252)</li> </ul>	<ul style="list-style-type: none"> <li>Automated Weather Stations (258)</li> <li>Manned Weather Stations (1850)</li> <li>Radiosondes (8)</li> <li>eXpendable BathyThermographs (37)</li> </ul>	<ul style="list-style-type: none"> <li>HF Radars (270)</li> <li>Animal Borne Sensors (53)</li> <li>Ocean Gliders (31)</li> </ul>

Generated by [www.jcommops.org](http://www.jcommops.org), 12/06/2008



# Everybody is concerned to solve this challenge...



Science

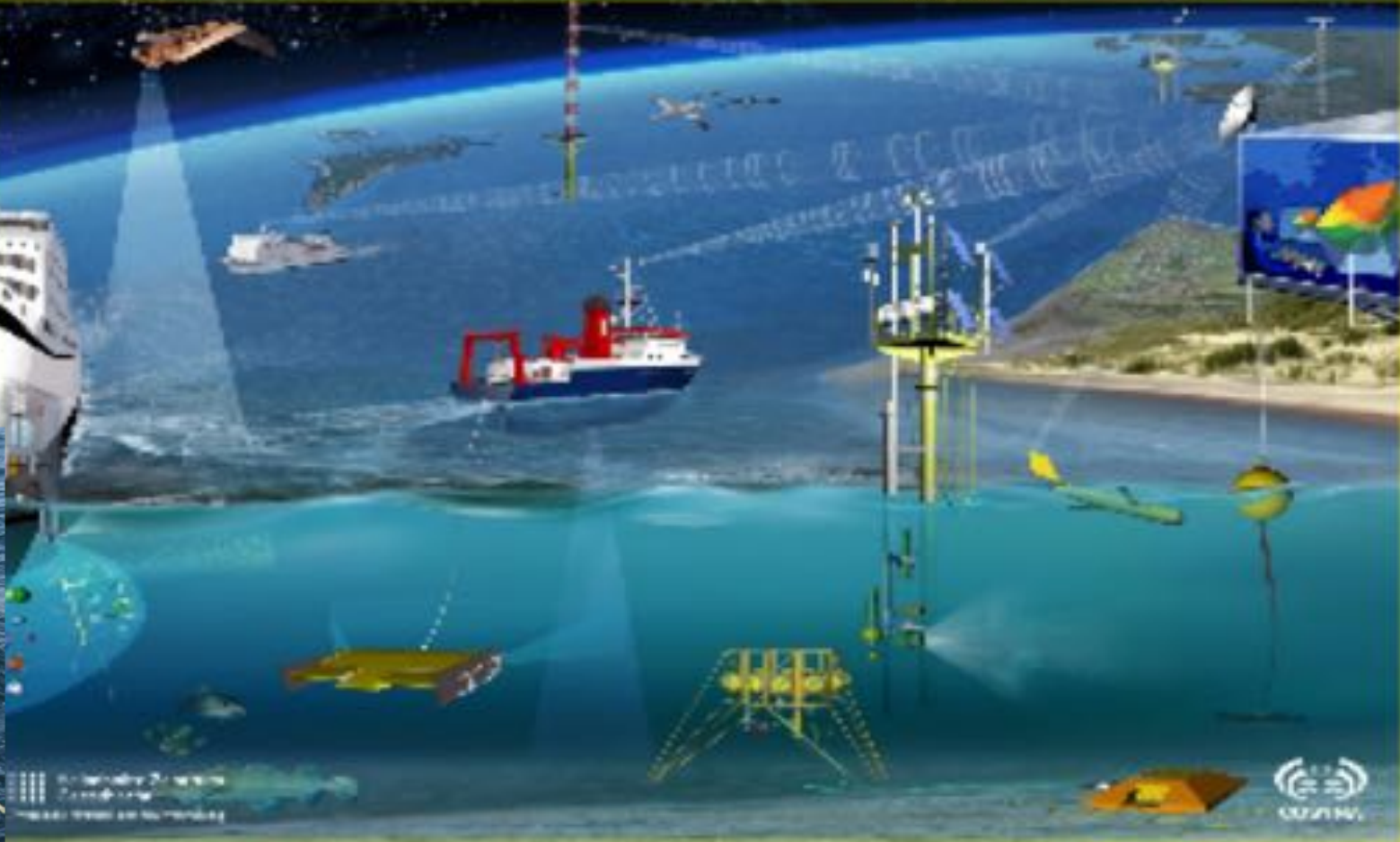
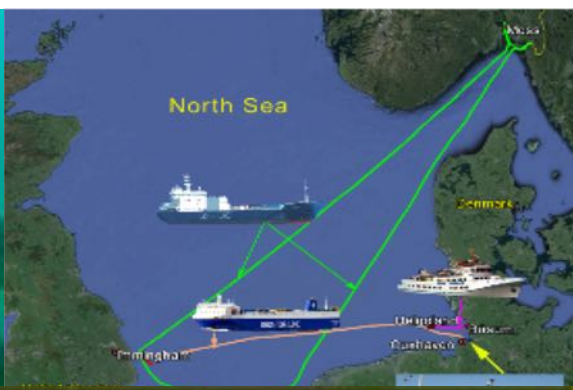


Technology



Us & others : politics, behaviour & education ...







# OBSERVATIONS *IN SITU*

Mesures temps-réel en septembre 2013



## Coastal Monitoring E.g. in France

=> A multitude of sites  
equipped with multiple  
different systems  
(Platforms, sensors, etc.)

A need of crucial to  
federate...

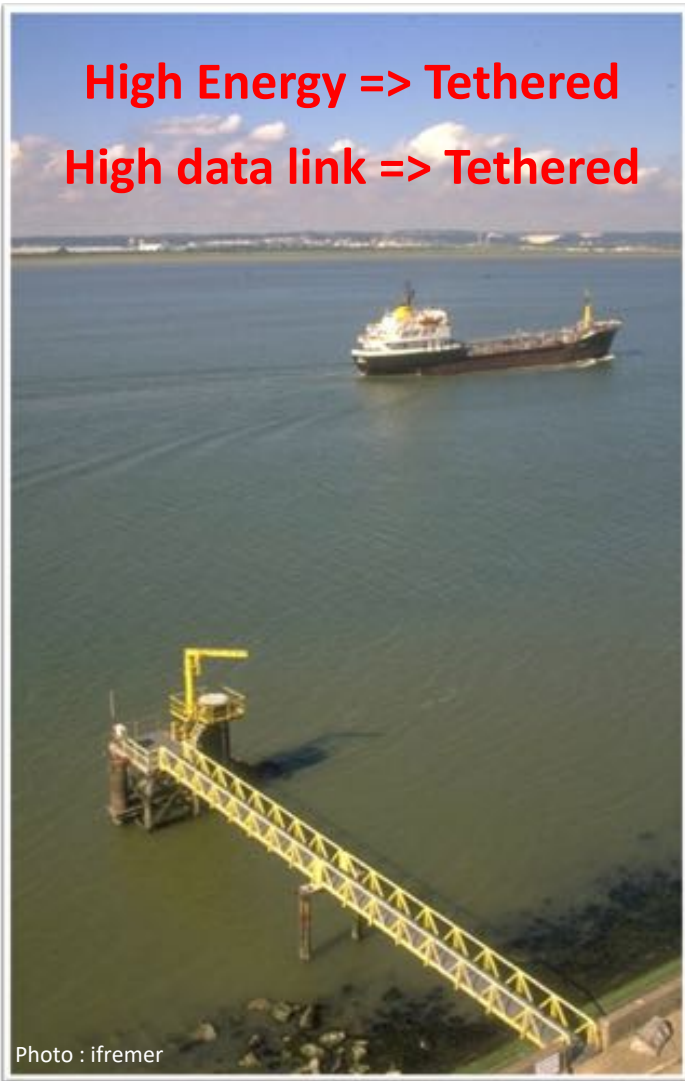
A decorative horizontal bar at the top left of the slide, consisting of a series of vertical bars in various colors (yellow, green, blue).

# Oceanographic systems for *In situ* monitoring

**THE CHALLENGES :**

***Energy,  
Maintenance, Metrology,  
Data stream,  
Biofouling,  
Resources for operation...***





## Coastal Monitoring Buoys and Systems on Pier

**3 months Maintenance => sensors !**



Photo : Ifremer (FR)



Photo : Ifremer (FR)

## Costal Monitoring Compact transportable system

**3 months Maintenance =>  
Sensors and batteries !**

**Low Energy => Batteries  
Low Data stream => GSM**





## Seafloor Observatories

### NEPTUNE Canada

Source:  
Juliane Richter et  
Birte Wagner/GEO  
Magazine



# Oceanographic systems for *in situ* monitoring



## Seafloor Observatories in EUROPE

JERICO-NEXT

EMSO ERIC

(FixO<sup>3</sup>)  
(ESONET)





# Oceanographic systems for *in situ* monitoring



## Seafloor observatory : NEPTUNE Canada

**800 km loop – 40 to 2500m deep**

**6 months Maintenance  
Energy on cable but limited !  
Data Ethernet high bandwidth**



## Seafloor observatory in Azores MOMAR-D – Tempo mini

1700m deep, hydrothermal sources

**Annual Maintenance  
Energy on Batteries**

**Very Low Real Time Data  
stream =>  
Acoustic link from bottom to  
surface then satellite.**

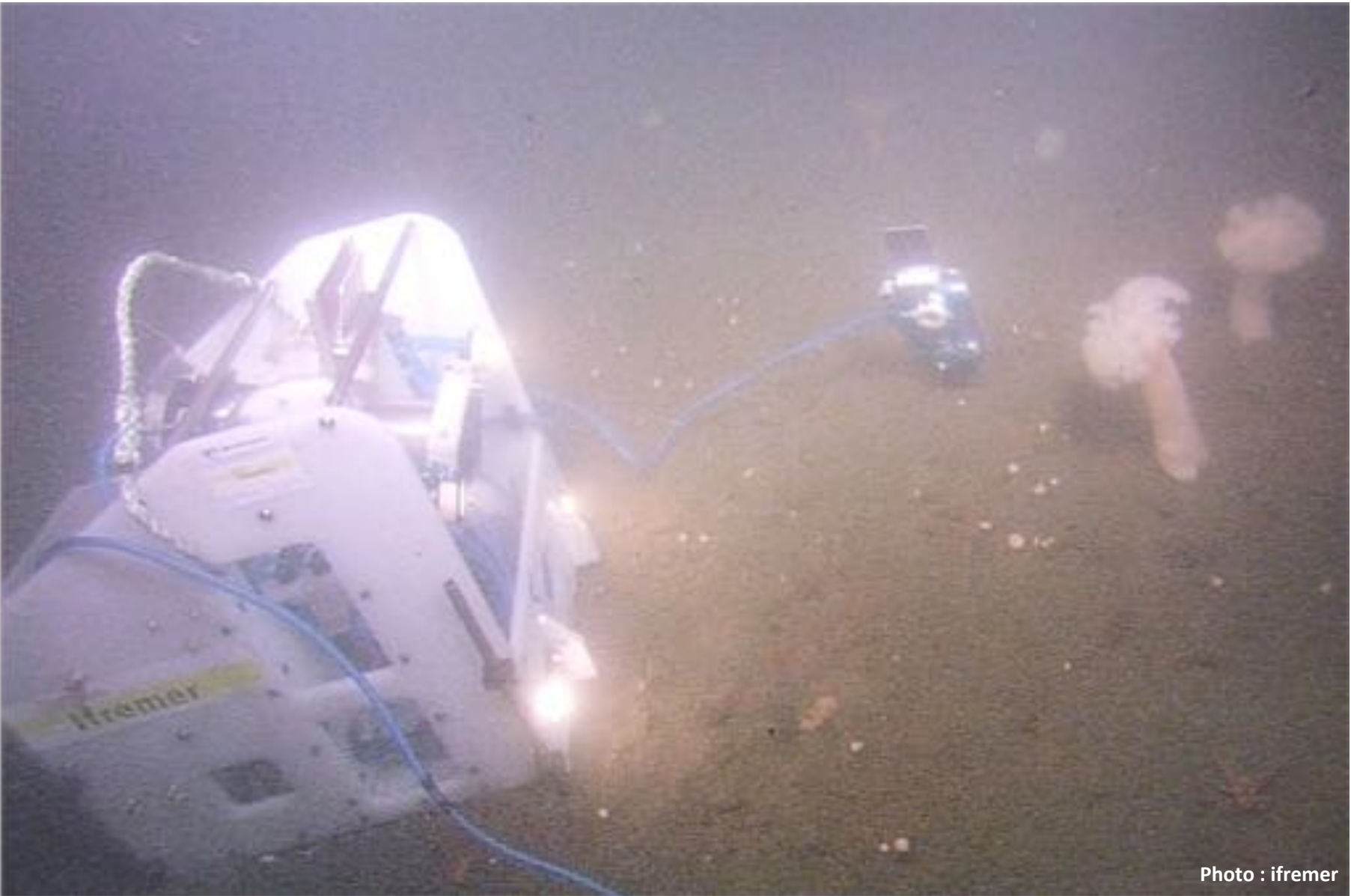


Photo : ifremer



# Oceanographic systems for *in situ* monitoring



Projet NOSS : NKE, Telecom Bretagne, SHOM, ifremer

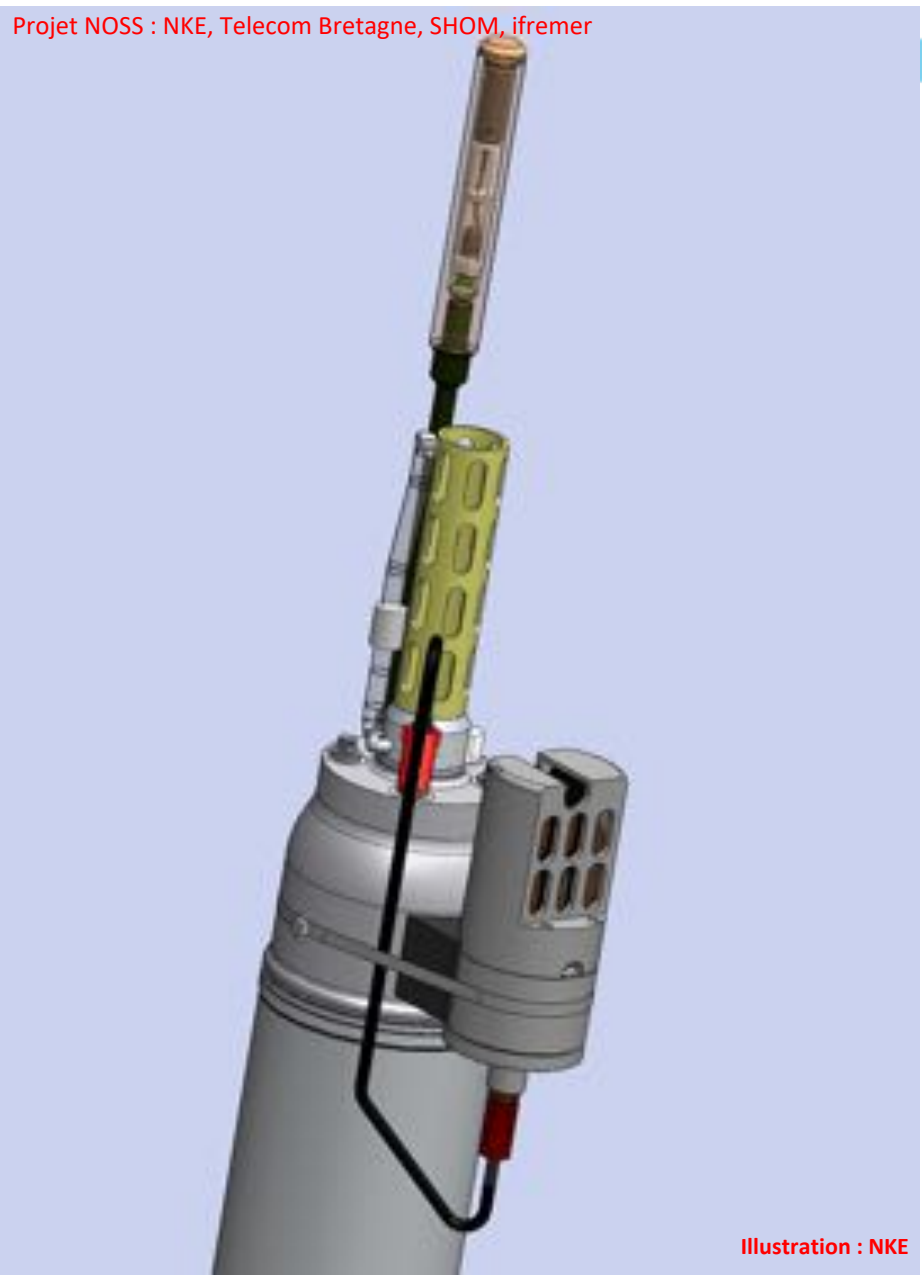


Illustration : NKE

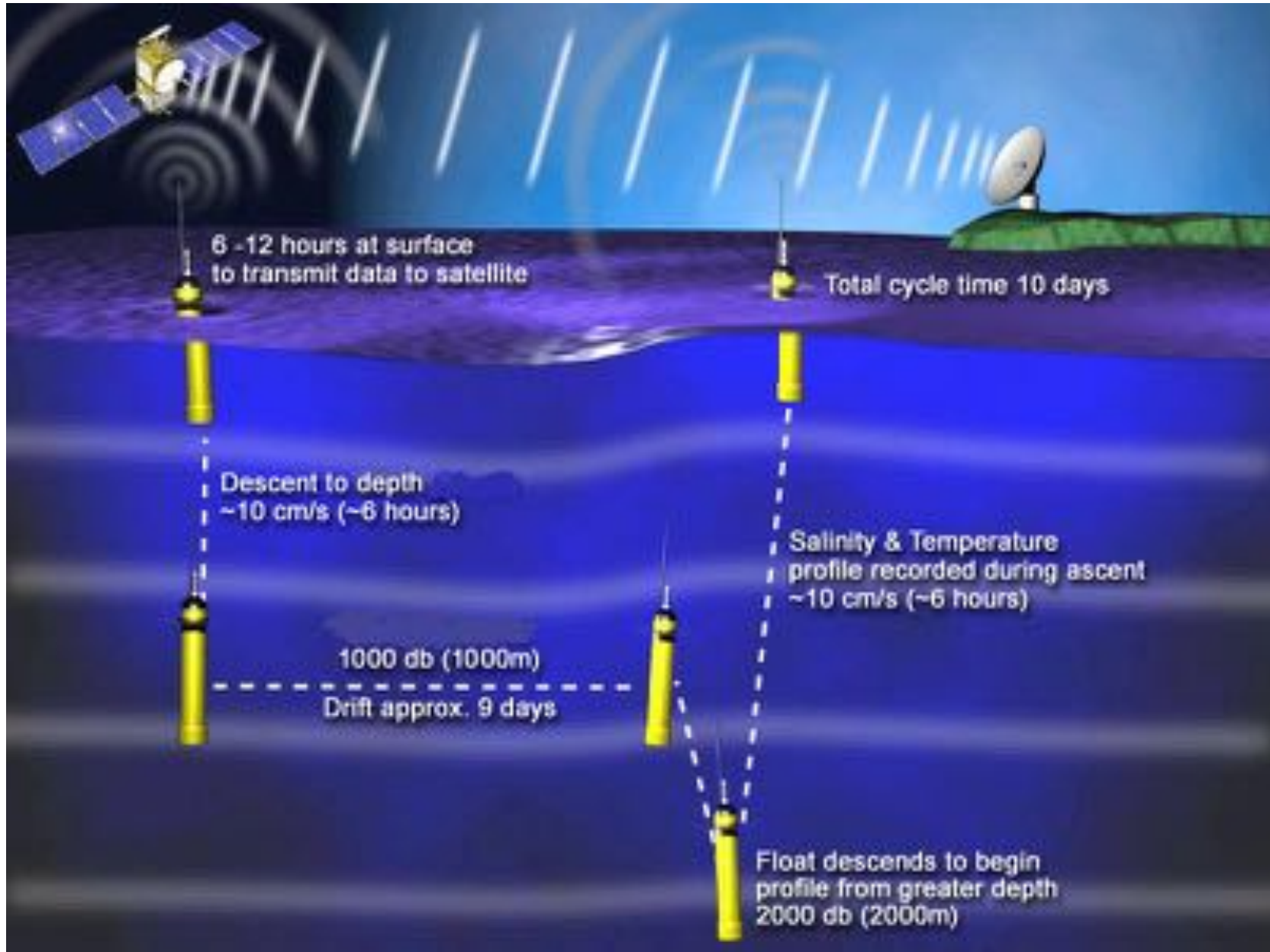


Illustration : NKE

## Profiling Floats (0 – 2500m)

**Very Low Energy,  
NO maintenance,  
3 years life**

**Low Real Time Data  
stream => satellite.**



## Profiling Floats (0 – 2500m)

**Very Low Energy,  
NO maintenance,  
3 years life**

**Low Real Time Data  
stream => satellite.**





AsterX (de la société ISE Ltd (Vancouver) sur cahier des charges de l'Ifremer)

Photo : ifremer

## AUV

(Autonomous underwater Vehicle)

**Moderate Energy,  
NO maintenance, normally  
few days deployment**

**No Real Time Data stream when  
underwater**

**GSM link when on surface**



No Real Time Data stream when underwater  
Moderate data stream when on surface => Satellite

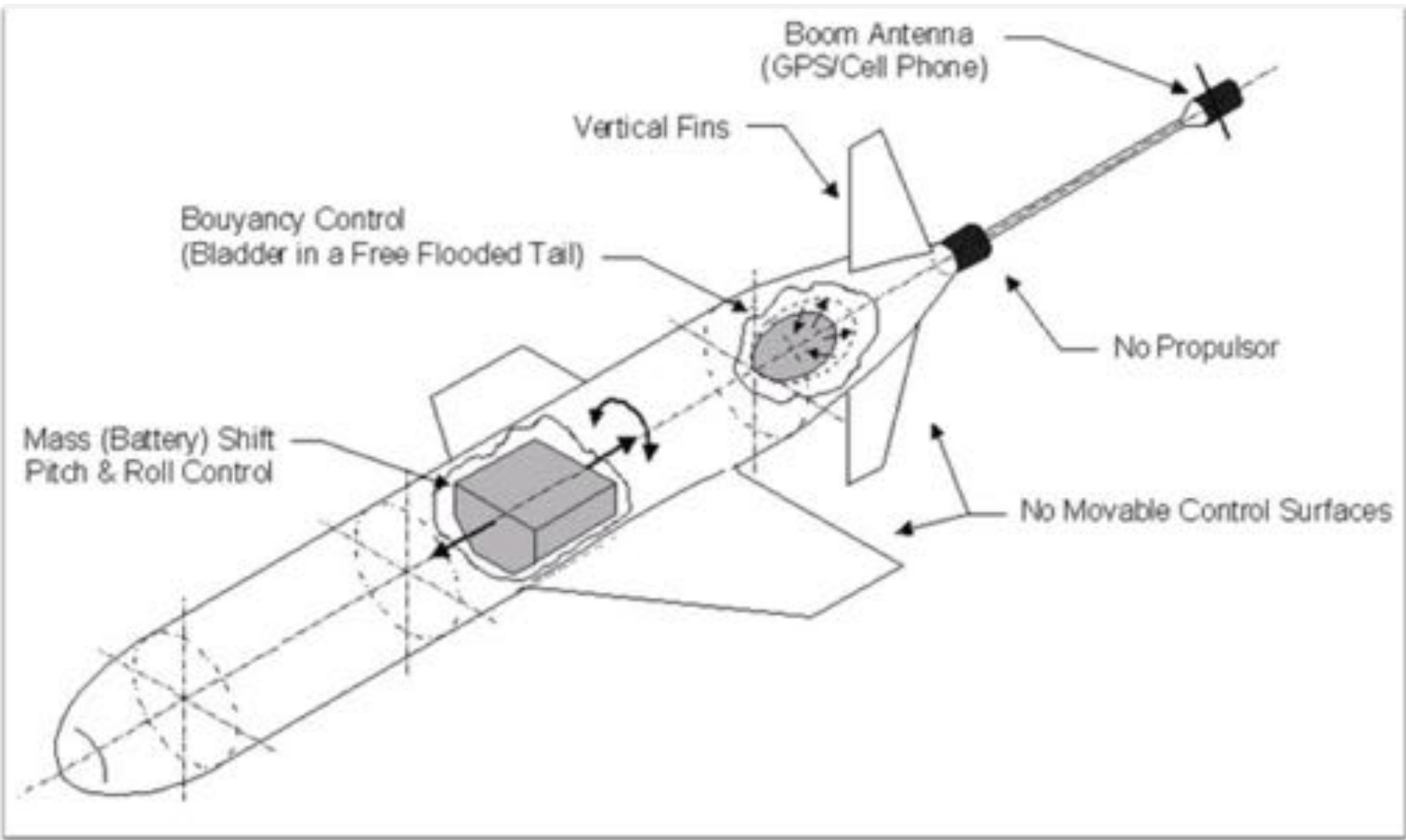


Photo : Site internet ACSA

## Gliders

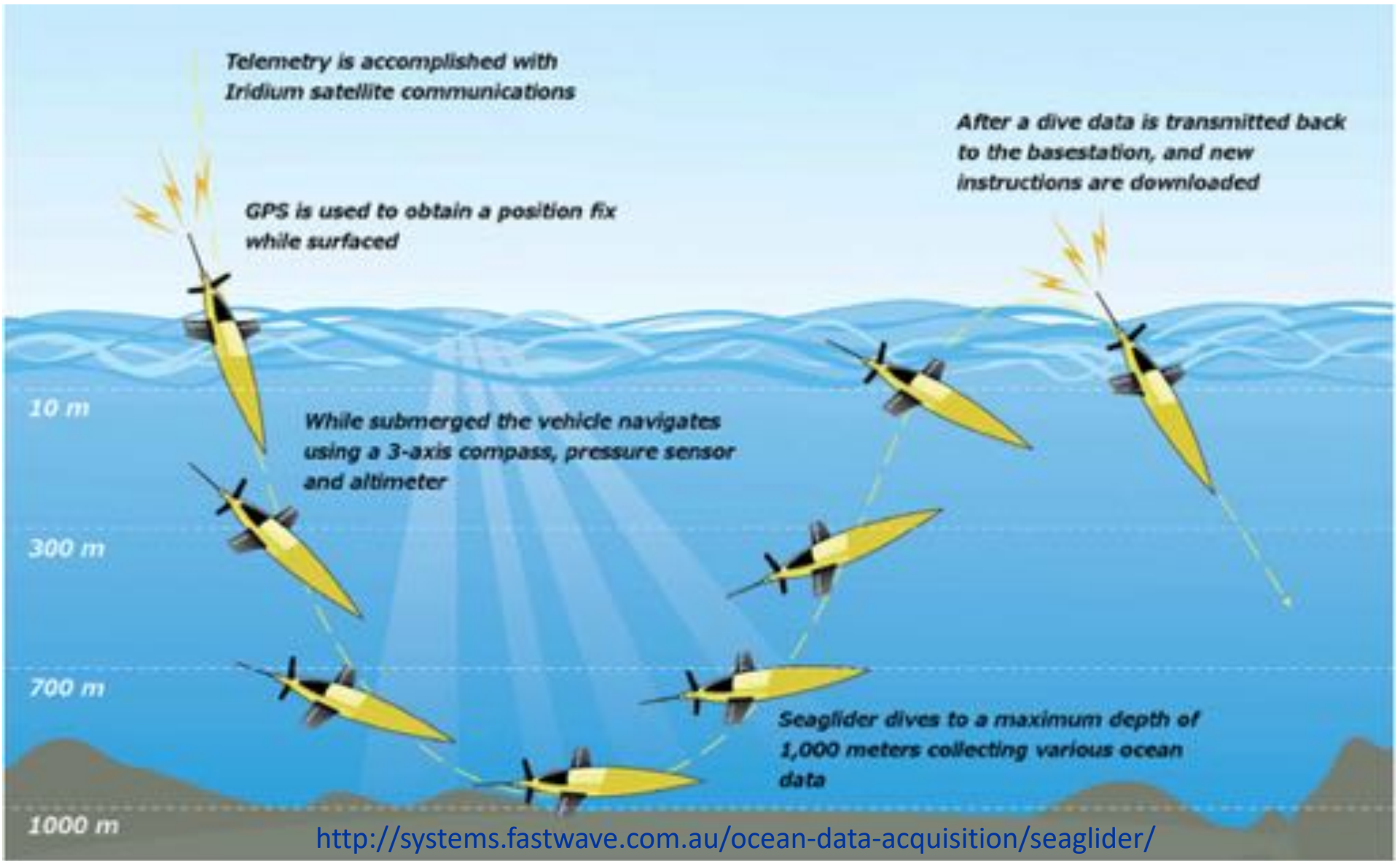
**Low Energy,  
NO maintenance,  
normally few  
days deployment**





## Gliders

**Low Energy,  
NO maintenance,  
normally few  
days deployment**



## Gliders

**Low Energy,**  
**NO maintenance,**  
**normally few**  
**days deployment**



**USV Mobesens**

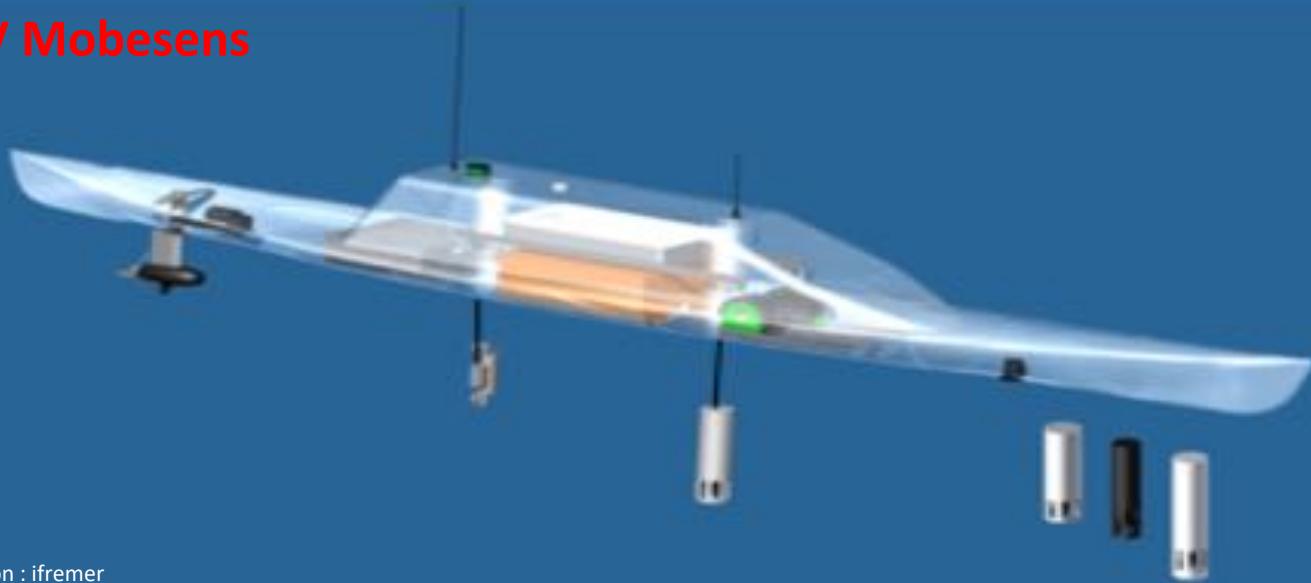


Illustration : ifremer

## Scientific Drones

**Medium energy**

**NO maintenance**

**Few hours/day deployment**

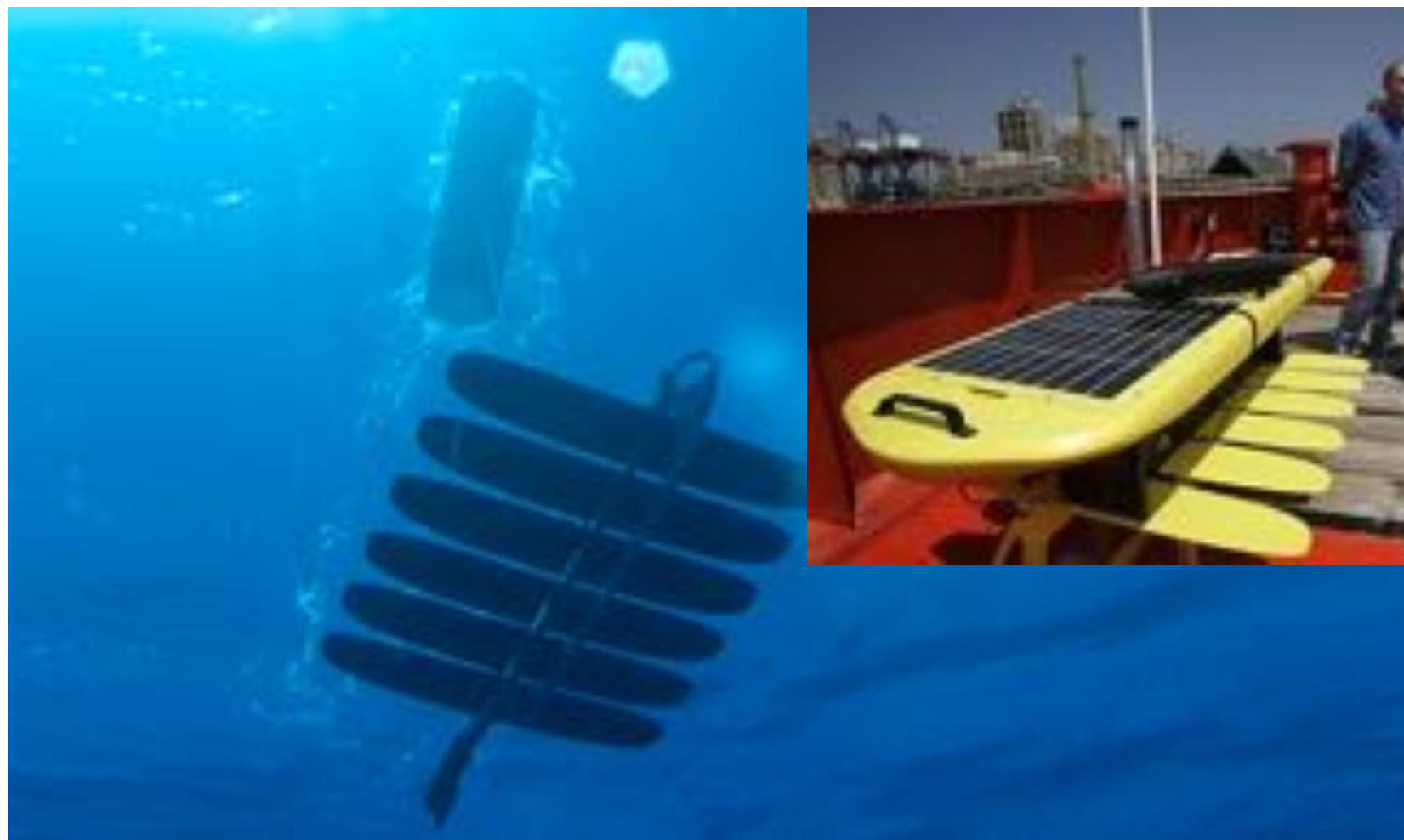
**Medium Data stream**

**=> GSM, Satellite**

**USV Vaimos**



Photo : ifremer



## Scientific Drones

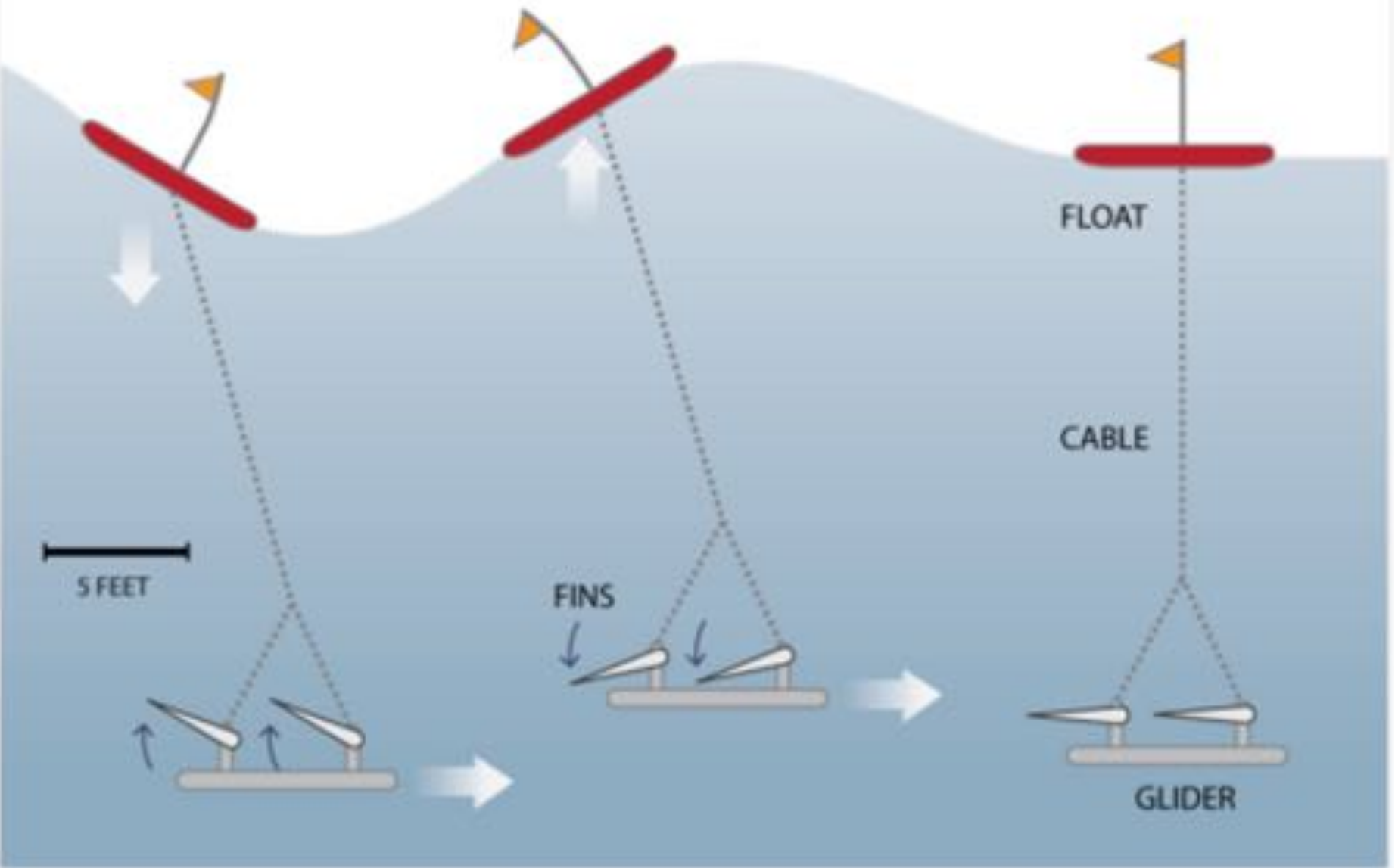
**The Wave-Glider from Liquid robotic.  
Sunnyvale, Californie, USA**



# Scientific Drones

**The Wave-Glider from Liquid robotic.**

Sunnyvale, Californie, USA



## Scientific Drones

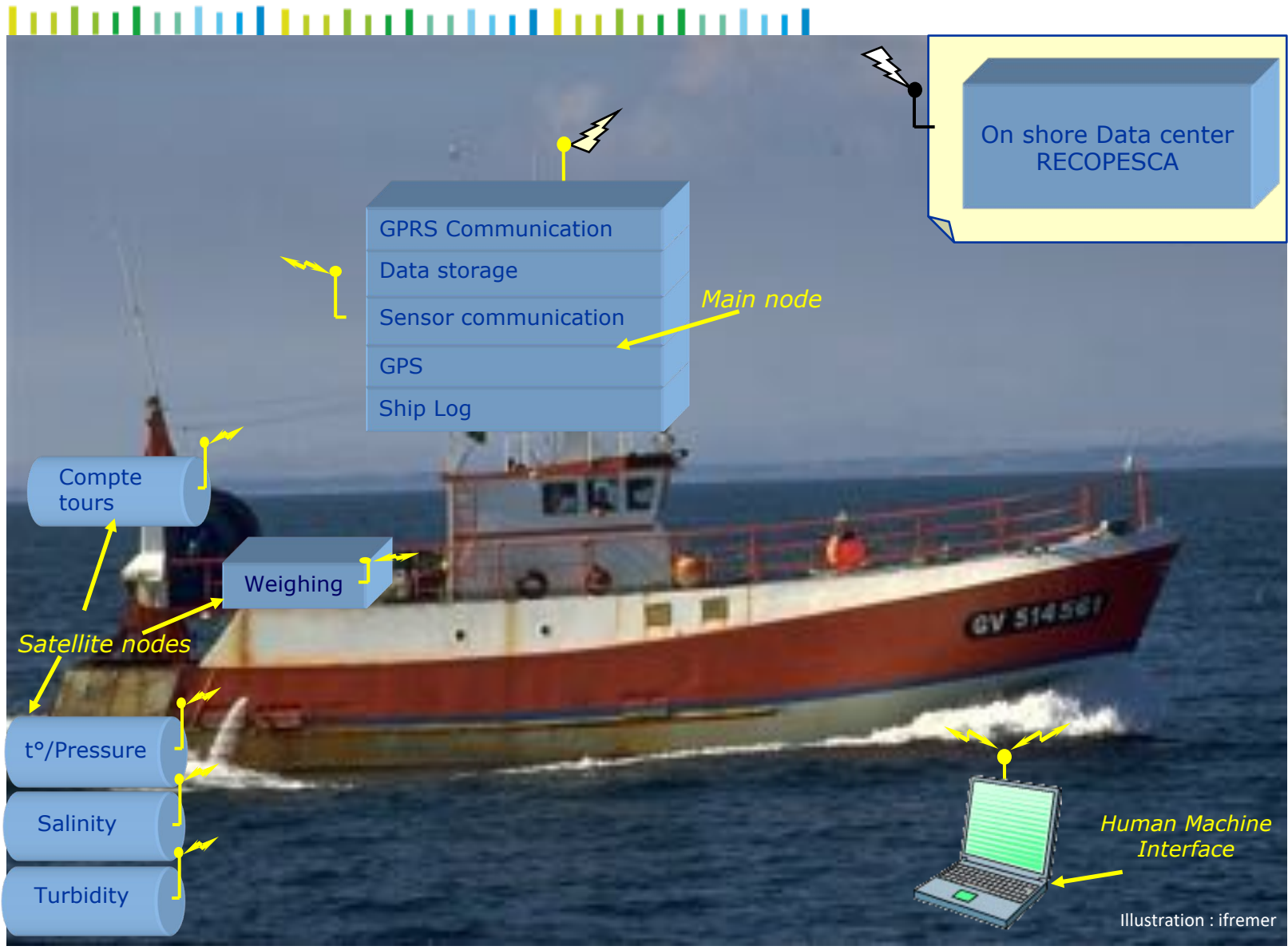
A video frame showing a Wave Glider underwater. The glider is a dark, elongated, cylindrical object with a small, glowing light on its top surface. It is positioned in the center of the frame, surrounded by blue water. The text "The Wave Glider®" is overlaid in white, sans-serif font across the middle of the image. The video player interface is visible at the top and bottom of the frame.

The Wave Glider®

**The Wave-Glider  
from Liquid  
robotic.**

Sunnyvale, Californie, USA





## Fishing vessel Voluntary Observing Ship (VOS) Recopesca project

**3 or 6 months Maintenance  
=> Sensors !**



## Ferry Box Voluntary Observing Ship (VOS)

**1 week to 1 month  
(everytime ship is in harbour).**

**Maintenance => Sensors,  
Reagents**

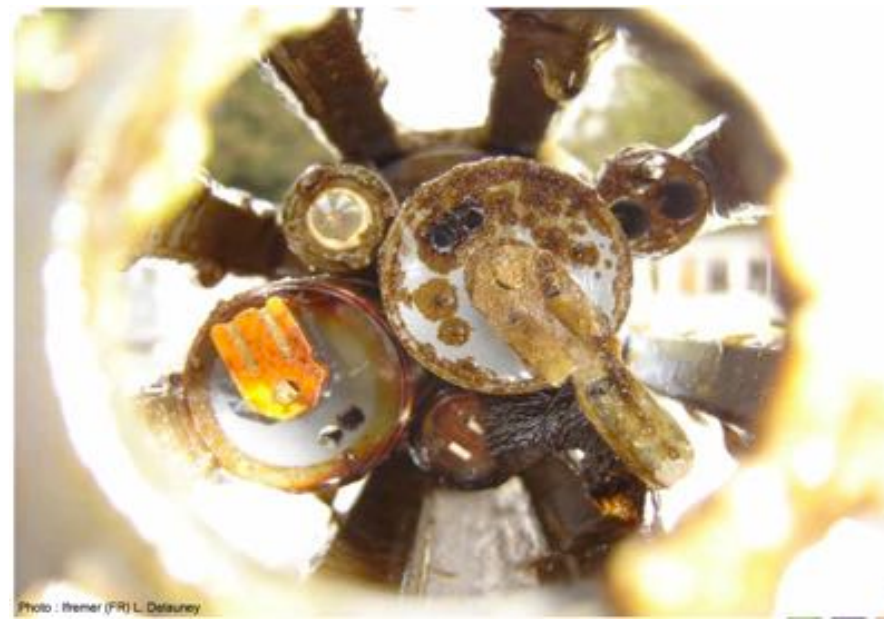
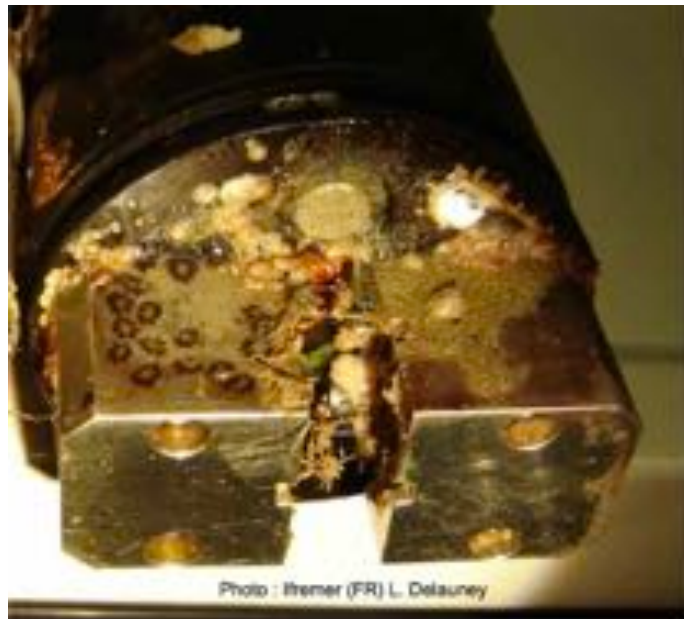
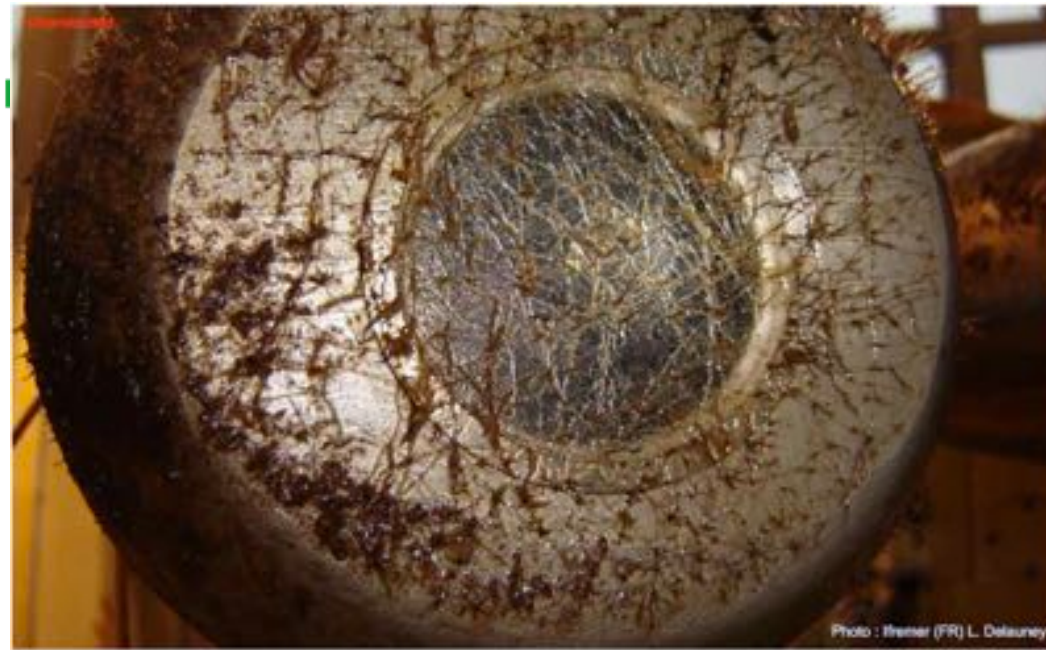


A decorative horizontal bar at the top left of the slide, consisting of a series of vertical bars in yellow, green, and blue.

# Biofouling

## Protection for marine *in situ* sensor

# A tough medium





## Biofouling and design



Photos : Ifremer (FR) L. Delauney



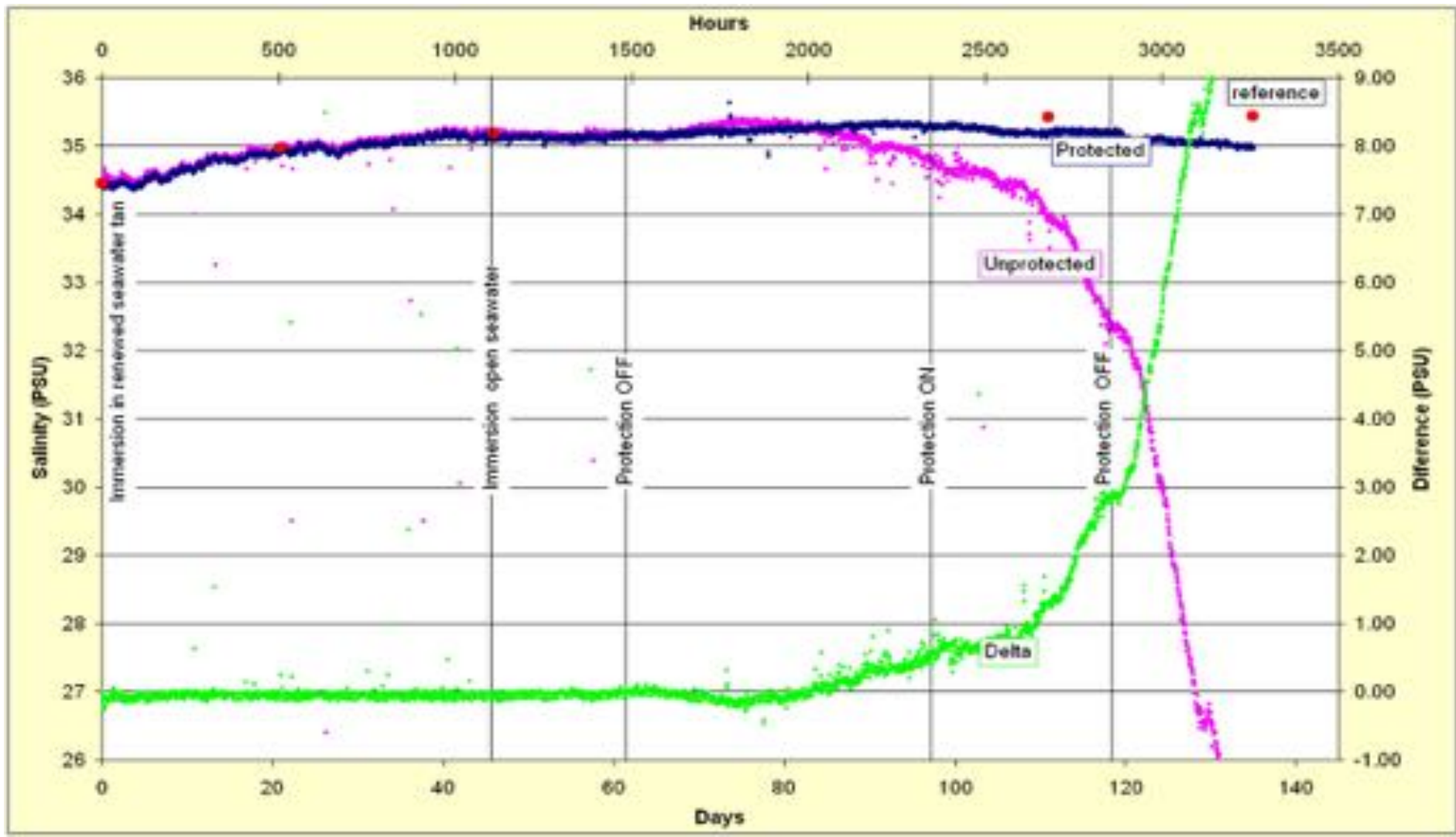
Photos : Ifremer (FR) L. Delauney

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

40 days ♦ August - October 2005 ♦ Helgoland - DE



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



Conductivity Measurement - TPS35 Micrel Instrument

## Objectives of a biofouling protection

- Coastal observatories: protection for 1 month in severe conditions and for 3 months in average condition.
- Deep sea observatories, protection for at least 12 months (many years needed).
- The protection system should/must be
  - compatible with energy supply
  - adaptable quite easily on existing instrumentation.
  - no effect on the measurements produced



## Existing “on shelf” biofouling protection for oceanographic sensors

## Mechanical Protection

YSI 6600 EDS (Extended Deployment System) - Clean Sweep™

### Wipers





Photos courtesy of MScience Pty Ltd, Australia



Photo courtesy of USGS, Santa Cruz



Photo courtesy of NIWA, New Zealand



## Mechanical Protection

ZEBRA-TECH (NZ) – **Hydro Wiper**





## Mechanical Protection

ZEBRA-TECH (NZ) – Opto Shutter

## Copper Biofouling protection

Fluorimeter Seapoint +  
Hobilabs Hydroshutter



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.



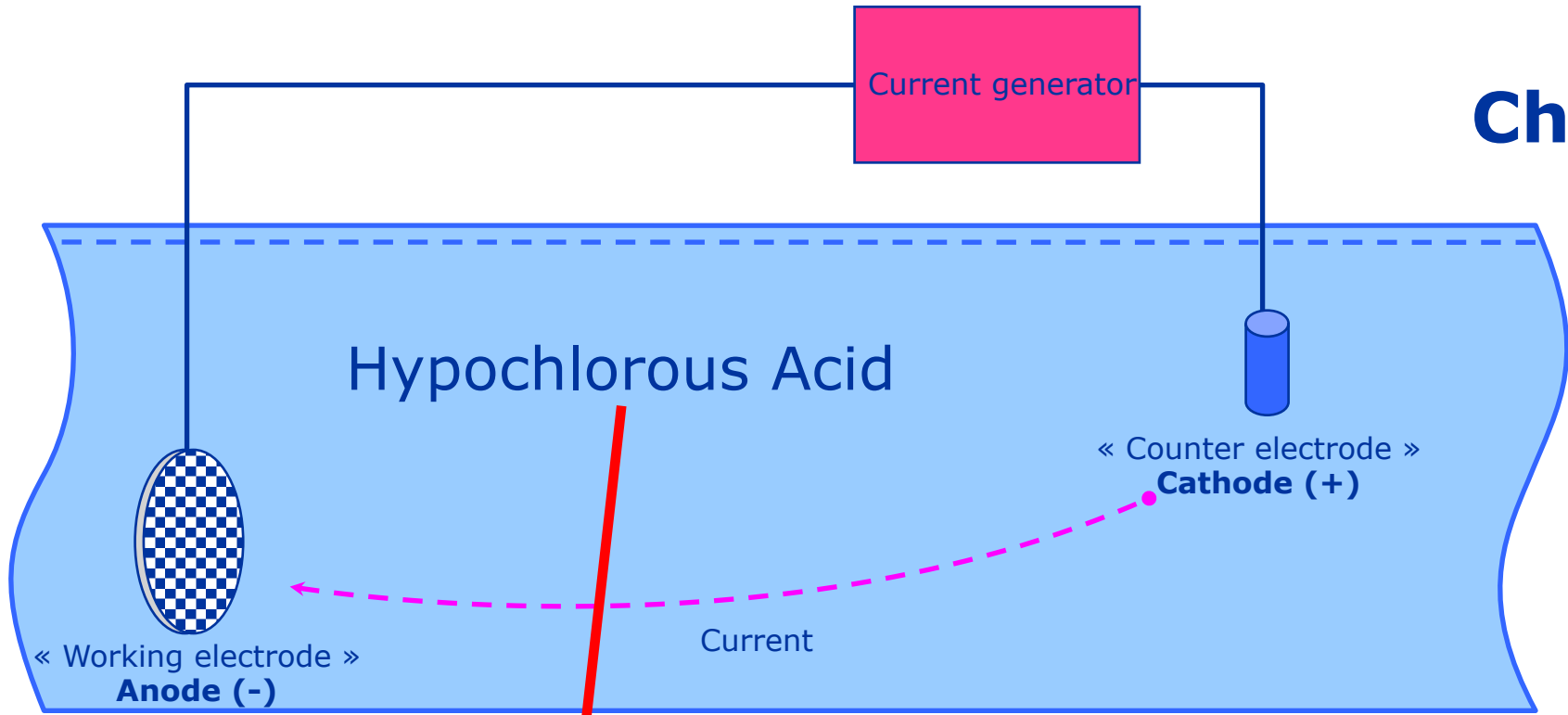
## Biocide diffusion

Seabird conductivity sensor

⇒ TBT rings

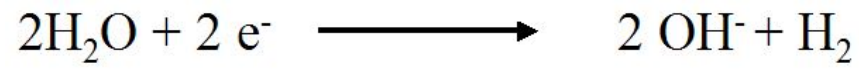


**An idea,  
Producing the  
biocide in the sea:  
=> Seawater electrolysis**

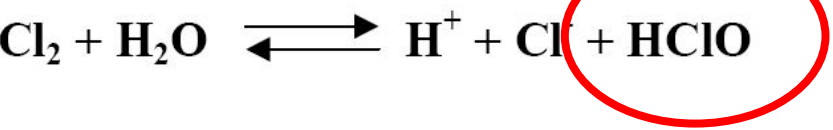


## Chlorine Generation In Sea Water

Sea water electrolysis :  
Hypochlorous Acid generation.



Then in function of pH and Temperature :



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



## Biofouling protection for sensors Surfacing chlorination (Ifremer)

Electrochlorination by **surface thin film electrode** on window:  
**18 months *in situ* test**



**Unprotected**



**Protected**



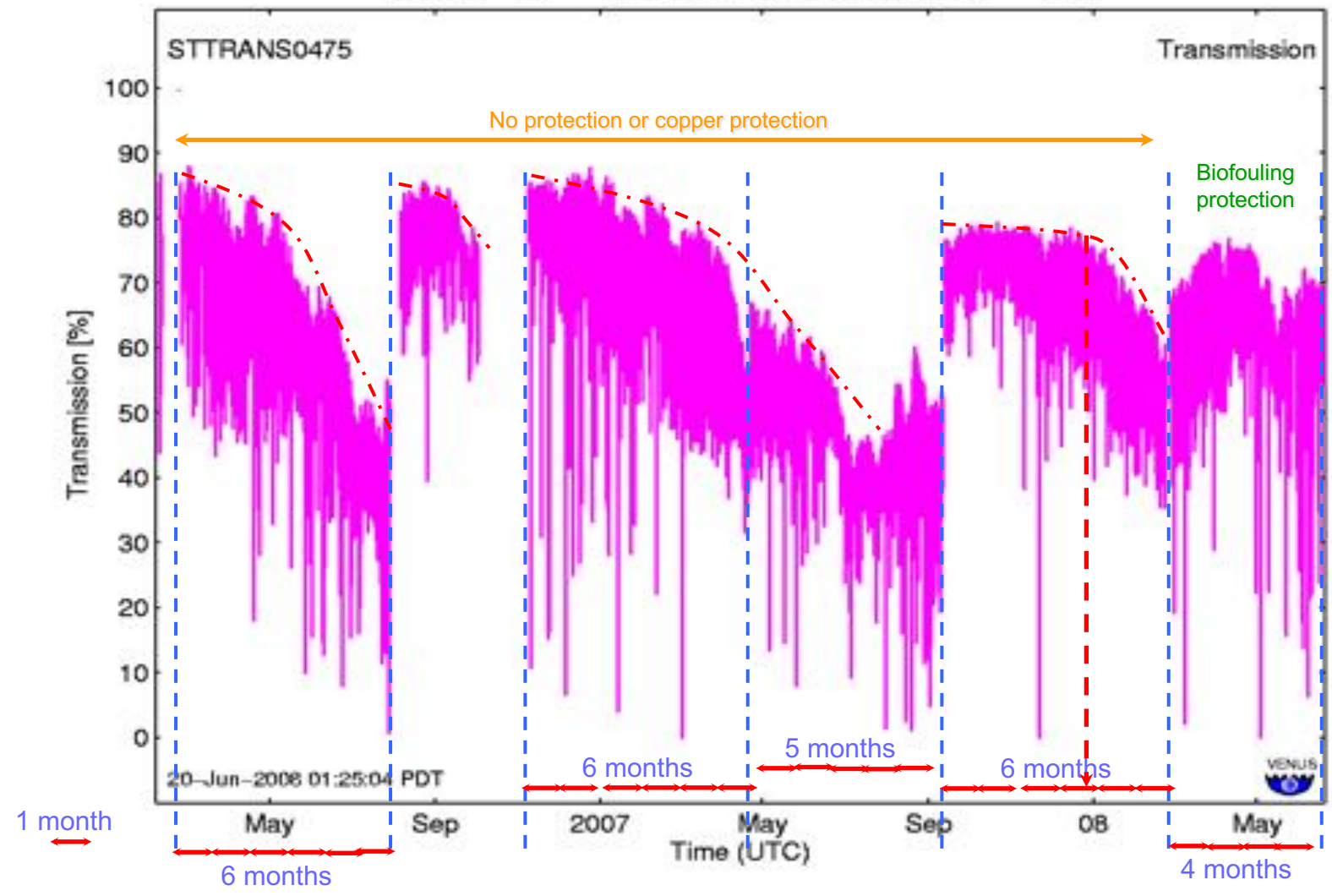
(Modified TriOS fluorimeters)



# Biofouling

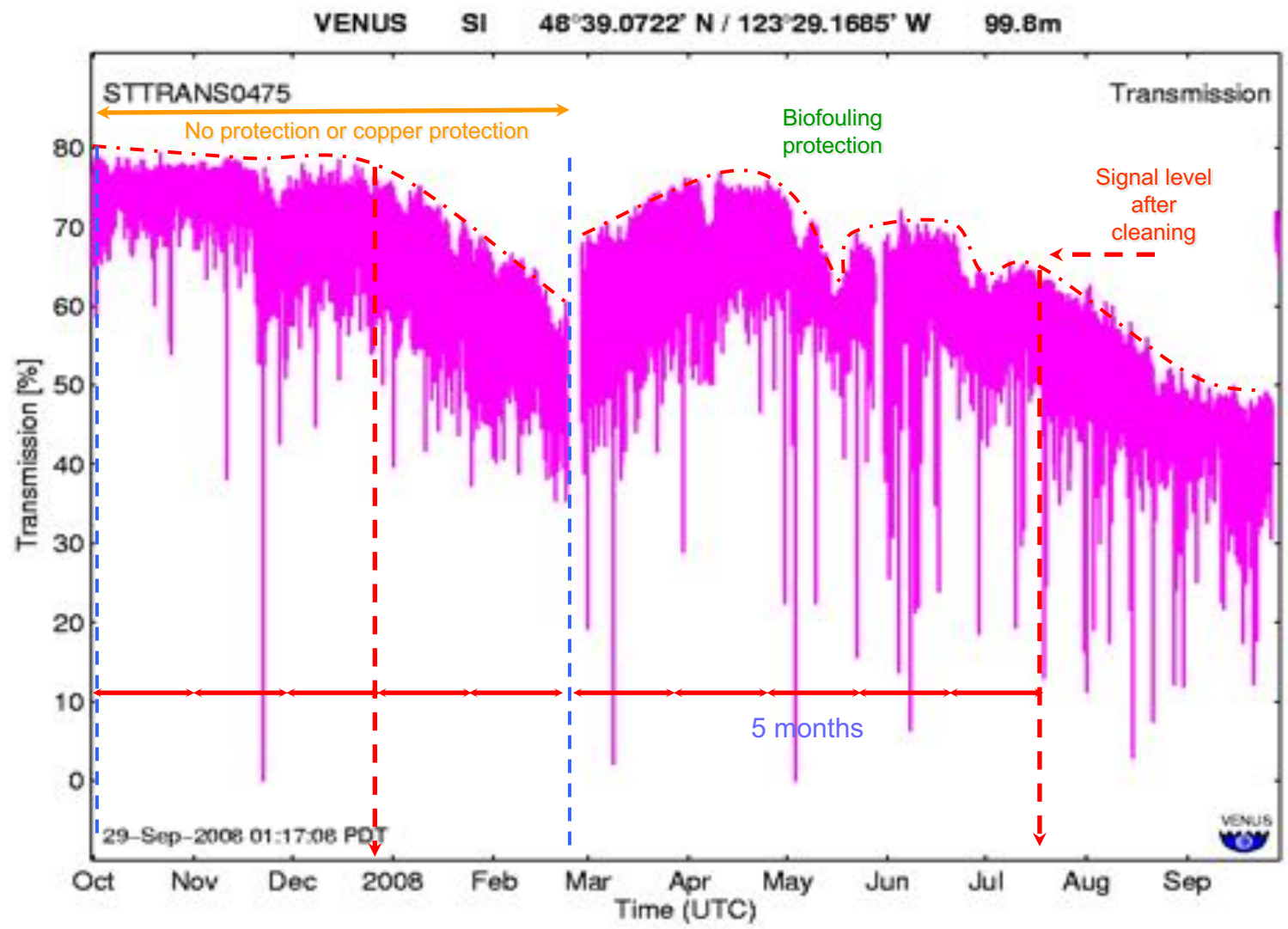


VENUS SI 46°39.0722' N / 123°29.1685' W 96m



## VENUS Observatory TRANSMISSOMETER

Ifremer Biofouling Protection (VENUS Data)



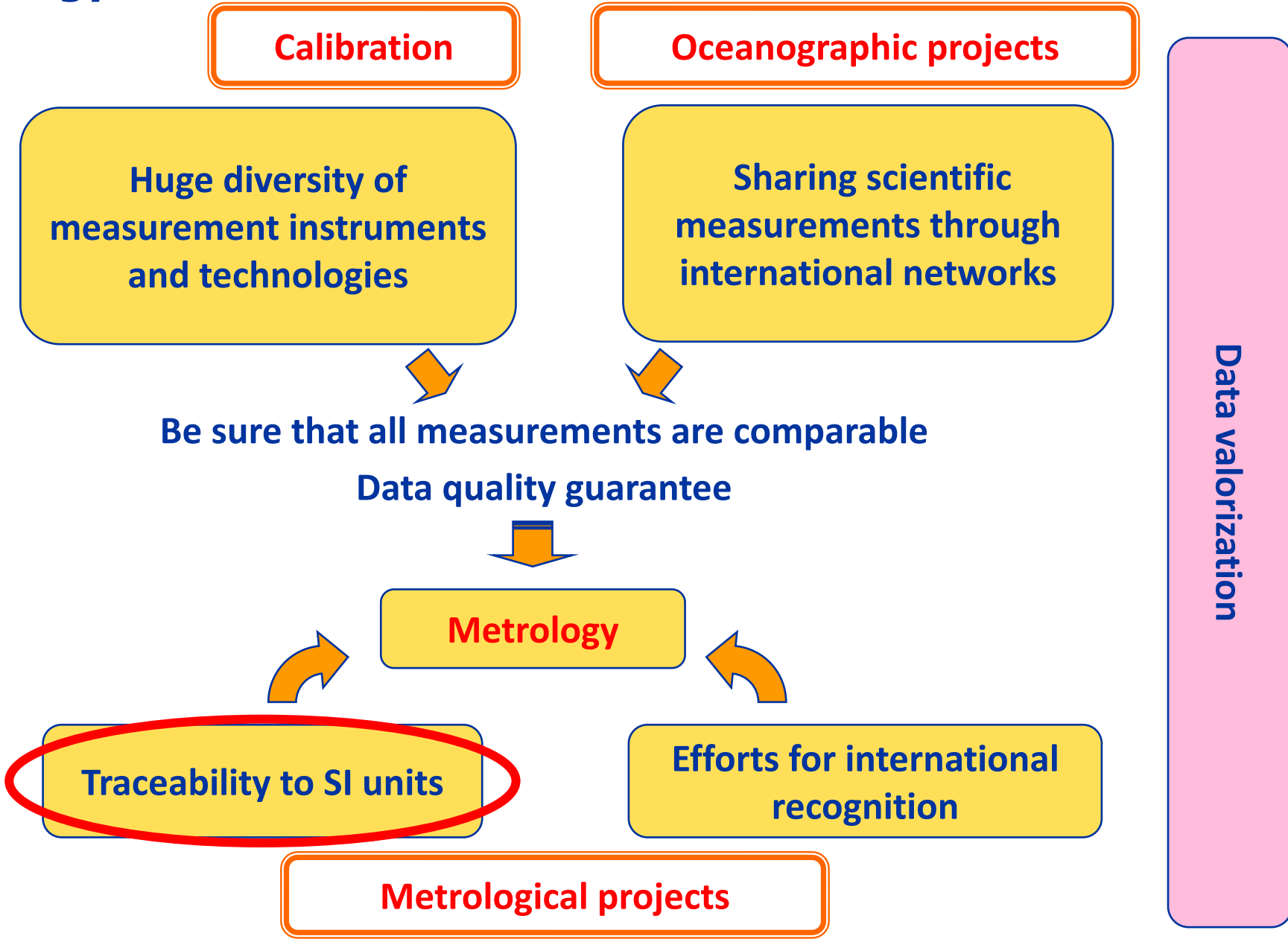
## VENUS Observatory TRANSMISSOMETER

### Ifremer Biofouling Protection (VENUS Data)

A decorative horizontal bar chart at the top left of the slide, consisting of a series of vertical bars in yellow, green, and blue.

# Metrology for marine monitoring



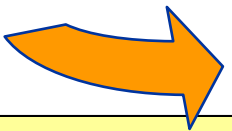


# Metrology

for marine monitoring

A science of prime importance needed for collaborative monitoring

## Traceability ?



Trueness and U ?

Parameters							
Temperature	Pressure	Current	O <sub>2</sub>	pH	Salinity	Turbidity	Fluorescence
YES	YES	YES / NO (sensor technology)	YES -> NO	YES -> NO	NO	NO	NO
Regulated bath + Pt25 reference thermometer	Relative pressure balance	Towing canal	Regulated bath + Winkler titration	Standard pH solution	Salinometer calibrated by APISO standard	Formazin solutions	Fluorophore solutions

# Metrology

for marine monitoring

No norm in technology

- No representativeness (substance matrix, ...)
- No relation to SI units
- Not universal in regard to the different technologies



No reference material or No reference method

# Projects and metrology



## Oceanographic projects:

- Argo, (ESONET), EMSODEV
  - (Hypox)
  - ATLANTOS, (FIXO3)
  - (JERICO), JERICO-NEXT
- } D.Oxygen
- Temp., Salinity, D.Oxygen, Turbidity,  
Temp., Salinity, D.Oxygen, Fluorescence,  
Plancton imagery, pH, pCO<sub>2</sub>

## Projects on water measurement:

- Aquaref consortium
- Temp., Salinity, D.Oxygen, Turbidity, pH,  
Fluorescence

## Metrological project:

- EMRP ENV05 Ocean
- Salinity, D.Oxygen, Velocity, pH

## Metrology prospection

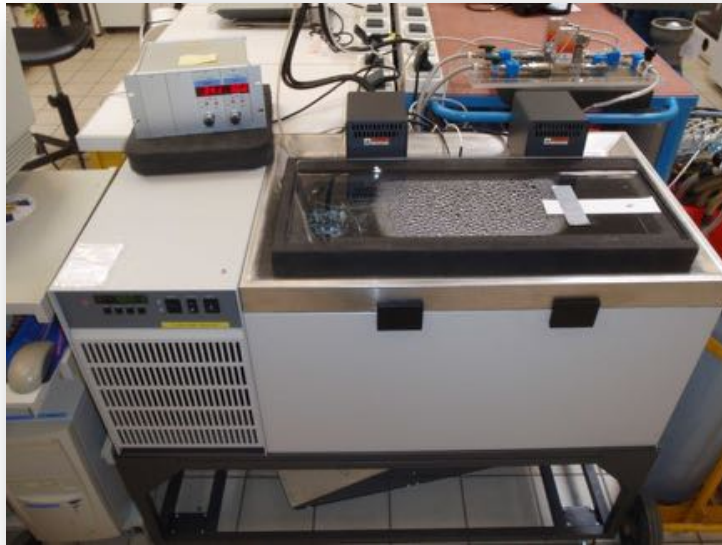
Temp., Salinity, D. Oxygen, Turbidity, Fluorescence, Current

# Metrology

for marine  
monitoring

A big  
collaborative  
work at a  
European and  
even World  
scale





Dissolved Oxygen bench



Winkler sampling  
for O<sub>2</sub> analysis

# Metrology

for marine  
monitoring



Pressure sensor calibration



Salinometer

Specific equipment,  
rooms  
and  
skilled people



# Conclusions

## Challenges for the future

Sensor development status	TRL	Short description	DS-TRL	Short description
1		Basic principles observed and reported		
2		Technology concept and/or application formulated	1	Proof-of-concept development
3		Analytical and experimental critical function and/or characteristic proof-of-concept		
4		Component and/or breadboard validation in laboratory environment		
5		Component and/or breadboard validation in relevant environment	2	Research Prototyping
6		System/subsystem model or prototype demonstration in a relevant environment		
7		System prototype demonstration in a space/real environment		
8		Actual systems completed and "occur mission qualified" through test and demonstration	3	Commercial product
9		Actual system proven through successful mission operations	4	Mission proved

**Sensor development duration =  
10 years ?**

## TRL : Technology Readiness Levels

Assessment of sensor performance  
C. Waldmann, M. Tamburri, R. D. Prien, and P. Fietzek -  
Ocean Sci., 6, 235–245, 2010



# ESONET YELLOW PAGES

A Tool for Interoperability and Standardization



HOME FIND A SENSOR FIND A HARDWARE COMPONENT FIND A DEEP SEA SERVICE FIND A MANUFACTURER MY EYP

WHAT ARE YOU LOOKING FOR?

e.g. Deepquest 800, Deepquest or underwater connector

Welcome to the Esonet Yellow Pages, a Tool for Interoperability and Standardization



The ESONET Yellow Pages aim to organize the information concerning on-the-shelf products for the development and maintenance of Deep-Sea Observatories, which are provided by the private sector. This includes a range of equipments, from simple, isolated sensors or parts, to communication systems or even integrated Observatories.



ESONET Yellow Pages also aims to foster the feedback from the scientific community in what concerns the experience with a specific product, addressing reliability for long-term operations and the use in real deep sea or coastal conditions.

RANDOM MANUFACTURERS (WORD)



Information mining

ESONET Yellow pages  
(<http://www.esonetyellowpages.com>)


A technological database  
on oceanographic  
systems

## Information mining

ESONET Yellow pages  
(<http://www.esonetyellowpages.com>)








A technological  
database on  
oceanographic  
systems

HOME FIND A SENSOR FIND A HARDWARE COMPONENT FIND A DEEP SEA SERVICE FIND A MANUFACTURER MY EYP



Esonet Yellow Pages > Sensors > DO sensors

**DO sensors** → found 20 sensors [How to use this table](#)

Picture	Model	Manufacturer	ESONET reference	Depth rating	Max. pressure	Housing material
	<a href="#">DO-OEM</a>	<a href="#">AMT Analyzertechnik GmbH</a>		-	-	-
	<a href="#">Flowthrough Oxygen Minisensor</a>	<a href="#">ProGera Precision Sensing GmbH</a>		-	-	-
	<a href="#">MacroQuel</a>	<a href="#">Coastal Leasing, Inc.</a>		-	-	-
	<a href="#">Manta2 - Dissolved Oxygen Sensor Clark</a>	<a href="#">Eureka Environmental</a>		-	-	-
	<a href="#">Manta2 - Optical Dissolved Oxygen Sensor</a>	<a href="#">Eureka Environmental</a>		-	-	-
	<a href="#">Oxygen Optode 3830</a>	<a href="#">Aanderaa Data Instruments Inc.</a>		-	-	-
	<a href="#">Oxygen Optode 3835</a>	<a href="#">Aanderaa Data Instruments Inc.</a>		-	-	-

10 Page 1 of 2 Displaying 1 to 10 of 20 items

# ACT TECHNOLOGIES DATABASE - SENSOR TYPE

The ACT Technology Database is a continuously updated catalogue of instrumentation used for coastal and ocean science and observations, designed to help you identify technologies available to meet your specific needs. Search by environmental parameters, sensor types or manufacturers.



PHYSICAL

BIOLOGICAL

CHEMICAL

PLATFORM

HARDWARE

SENSOR TYPE

MANUFACTURER

METEOROLOGICAL

HYDROPHONES

GROUNDWATER

FLUOROMETER

DISSOLVED OXYGEN

CTD

CONDUCTIVITY/SALINITY

AUV

NUTRIENT

TEMPERATURE

TRANSDUCER

TURBIDITY

PAGE 1 OF 1



## Information mining

Alliance for Coastal  
Technology  
(<http://www.act-us.info>)

A Technological  
database, evaluations  
reports on  
oceanographic  
technological systems

**ALLIANCE FOR COASTAL TECHNOLOGIES**  
SUPPORTING INNOVATION TO BETTER UNDERSTAND, PREDICT AND MANAGE COASTAL, OCEAN AND GREAT LAKES ENVIRONMENTS.



- EVALUATIONS reports
- WORKSHOP reports
- TECHNOLOGIES database

Home About Tech Database Workshops Evaluations The Sensor Contact



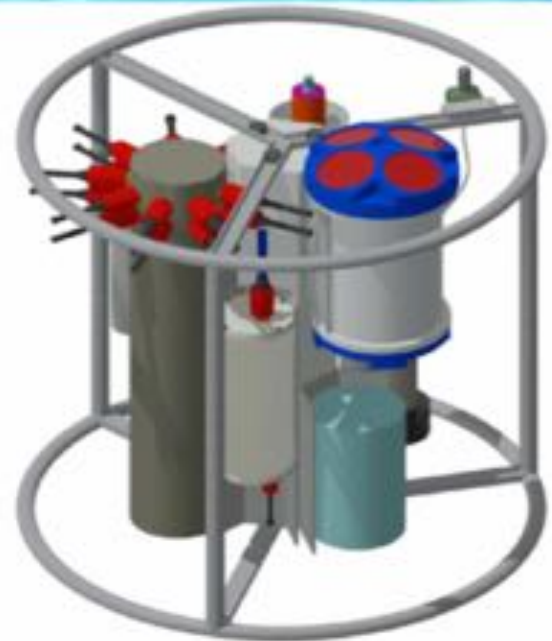
Main purpose : Get long term data series on EMSO nodes

- Be shipped and prepared for a deployment
- Be deployed from an oceanographic vessel or from a small boat
- Be put in place using a submarine vehicle or by divers or installed on a mooring
- Run in both autonomous or cabled configuration
- Get the data from the 6 generic parameters (possibly optional parameters)
- Performs the data time stamping
- Performs the data storage, and backup
- Performs the data transmission
- Enable a real time communication between the sensor and the scientist
- Be lifted on board the vessel
- Capabilities to autonomous retrieval on an acoustic order

# GENERIC *In situ* measurement module

## EGIM mechanical description

Length 790mm  
Ø 750mm



## COSTOF2

### Communication & Storage Front-end, 2<sup>nd</sup> generation

- ◆ Designed for marine observation platforms
- ◆ Serves of up to 16 sensors
- ◆ Ultra-low power AND High bandwidth
- ◆ Suited for cabled or non-cabled monitoring environments

#### ◆ Applications

- All subsea monitoring applications, including
- Oil & Gas environment & production monitoring
  - Geohazard monitoring
  - Climate change monitoring
  - Multidisciplinary monitoring

#### ◆ Operating characteristics

- Max operating depth: 6000 m
- Ethernet or RS232/485/422 or 1-wire sensors
- Power supply: up to 3A per sensor
- Embedded web server
- 0,5 mW in sleep mode with TCXO
- Embedded atomic clock :  $5 \cdot 10^{-11}$  drift
- WiFi link for easy communication in air and underwater



4000 m water depth version of the COSTOF2

## GENERIC

## *In situ* measurement module

### EGIM concepts



COSTOF2 with  
oil filled JB



Length 750mm  
Ø 140mm  
Ø 440mm (cables)

- ⇒ **Metrology** concepts should be part of sensor development from scratch : **Accredited metrology lab**
- ⇒ **Interdisciplinary** : chemical/biology, physic/biology, nanotechnology/biology...
- ⇒ Integration of a diversity of sensors on-board several types of platforms => **SWE, IoT, Smart sensors.**
- ⇒ Sensor **transduction interface** phenomena **modelling** (response time, drifting, etc.)
- ⇒ **Biofouling protection / Long term** reliability.
- ⇒ *In situ* **sample preparation** systems to develop for **Biosensors** application.
- ⇒ **Nanotechnology**, surface **functionalization**, RDNA and Metabarcoding are actually technology ruptures for oceanographic monitoring...