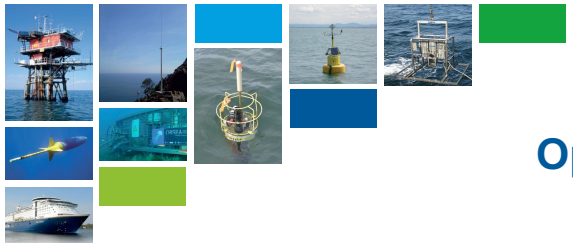


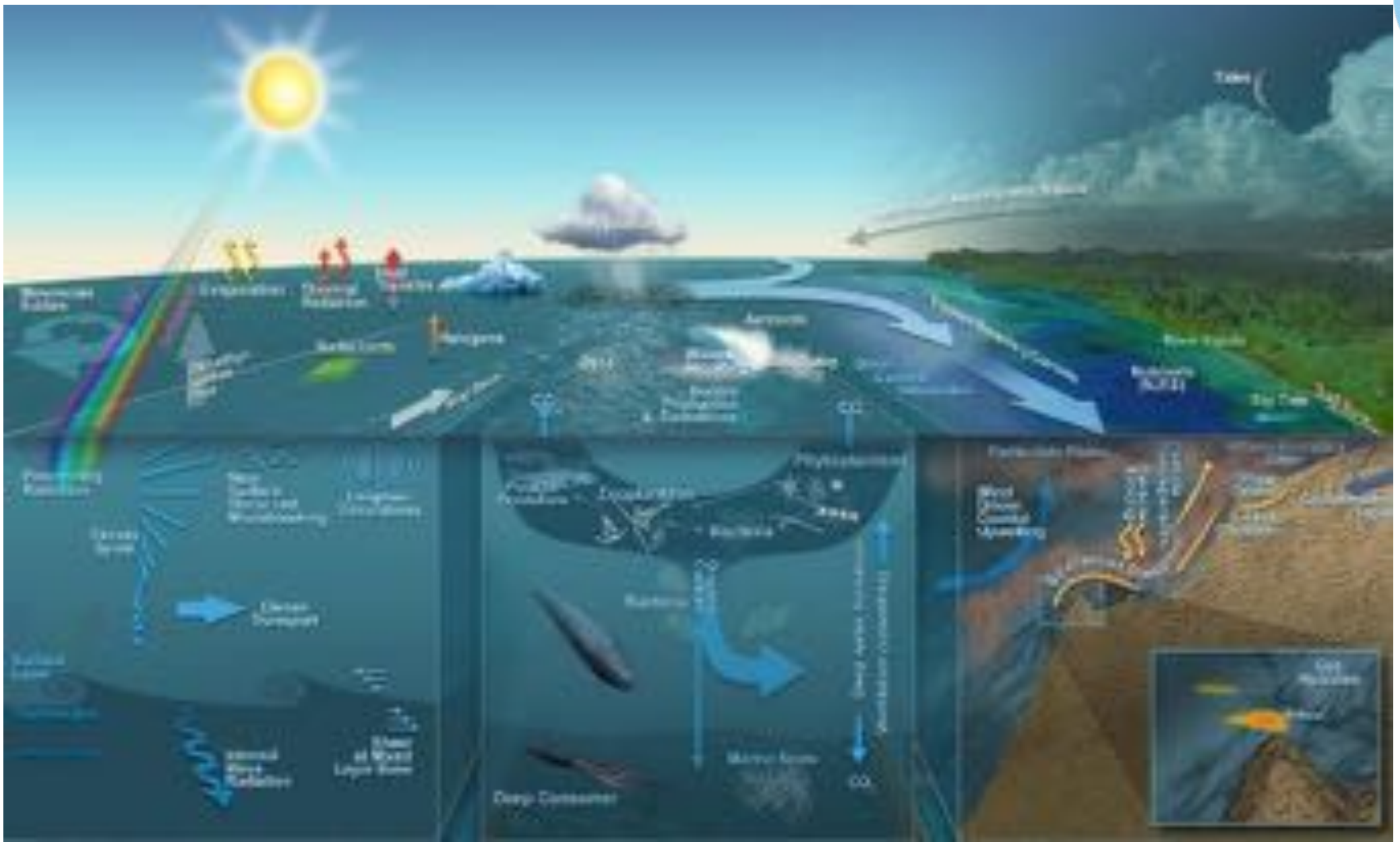
Malta Summer School 2018
Operational Oceanography for Blue Growth

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

Laurent Delauney - Ifremer
Laurent.delauney@ifremer.fr

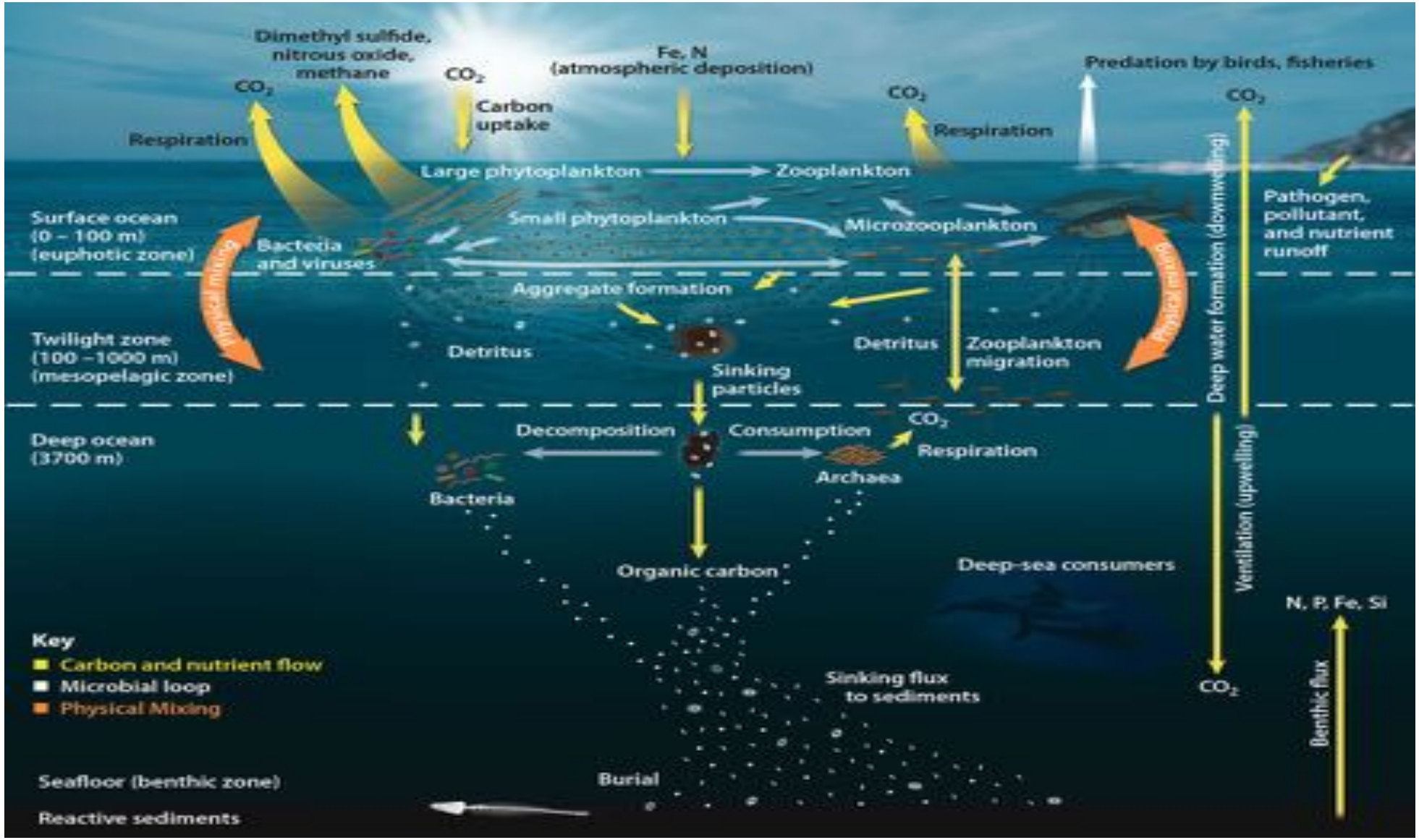
Ifremer

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

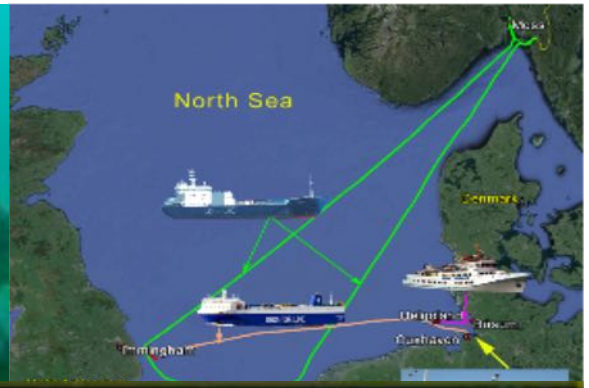
(http://www.jcommops.org)

Everybody is concerned to solve this challenge…

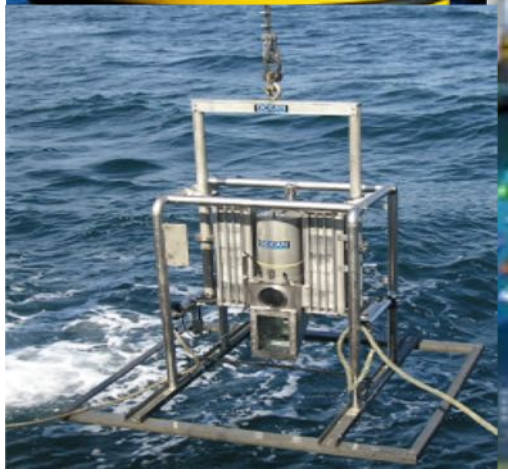
Science

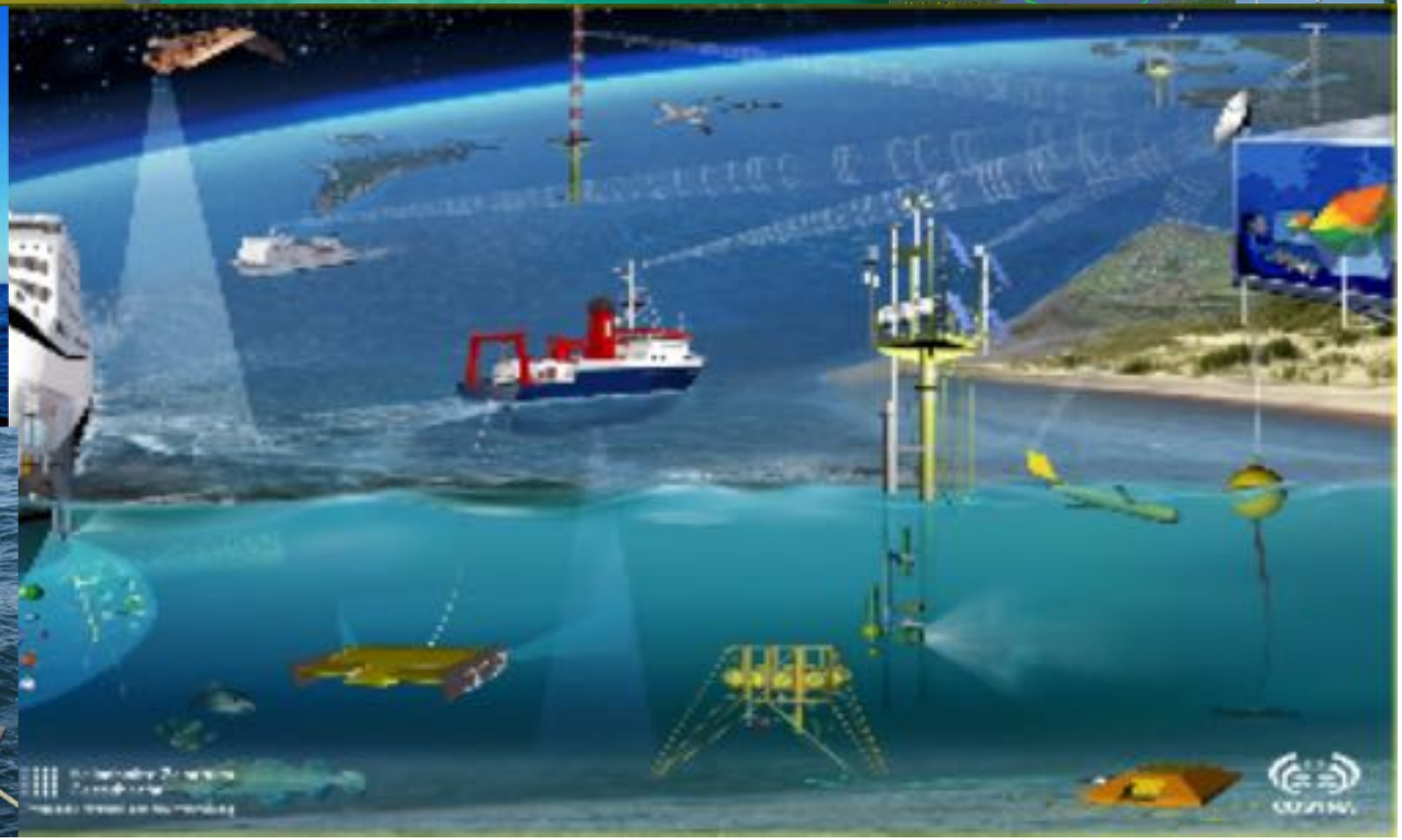
Technology

Us & others : politics, behaviour & education …


North Sea


Waverider





Coastal Monitoring E.g. in France

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

A need of crucial to federate…

Oceanographic systems for *In situ* monitoring

THE CHALLENGES :

Energy,

Maintenance, Metrology,

Data stream,

Biofouling,

Resources for operation…

Oceanographic systems for *in situ* monitoring

Coastal Monitoring

Buoys and Systems on Pier

3 months Maintenance => sensors !

Oceanographic systems for *in situ* monitoring

Costal Monitoring

Compact transportable system

3 months Maintenance =>
Sensors and batteries !

Low Energy => Batteries
Low Data stream => GSM

Oceanographic systems for *in situ* monitoring

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^3)

(ESONET)

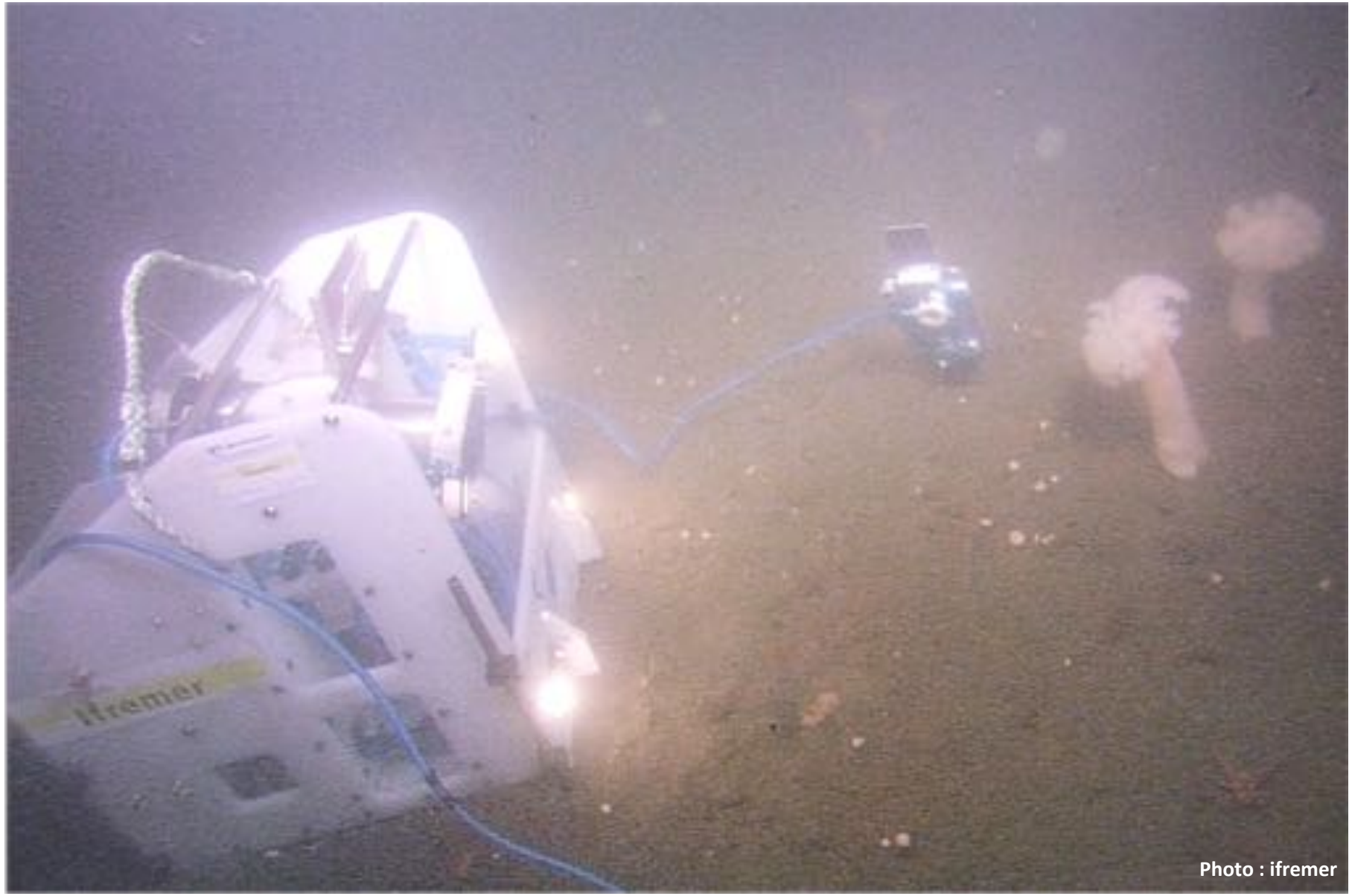
Oceanographic systems for *in situ* monitoring

Seafloor observatory : NEPTUNE Canada

800 km loop – 40 to 2500m deep

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

Oceanographic systems for *in situ* monitoring



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.

Oceanographic systems for *in situ* monitoring

Projet NOSS : NKE, Telecom Bretagne, SHOM, ifremer

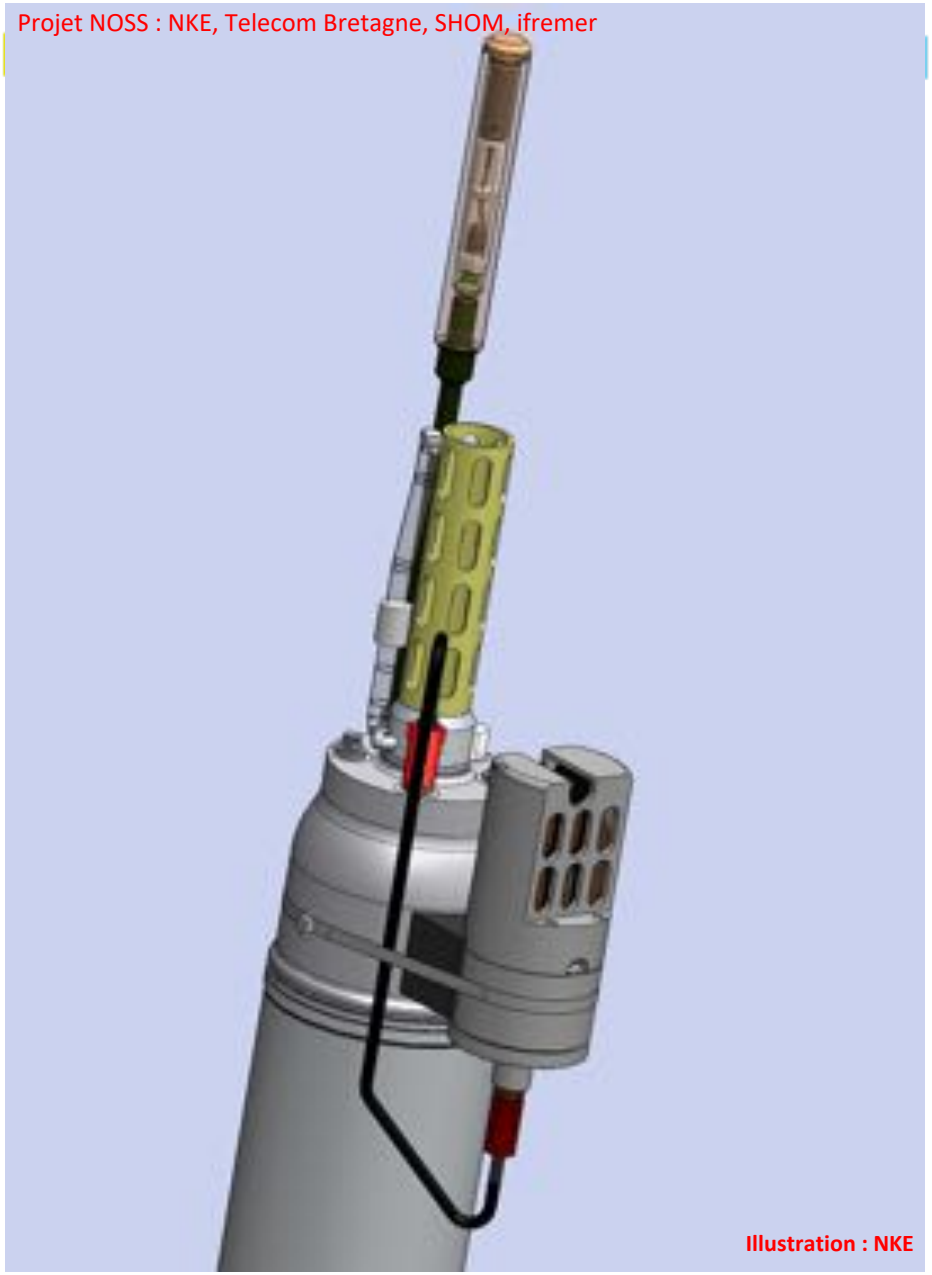


Illustration : NKE

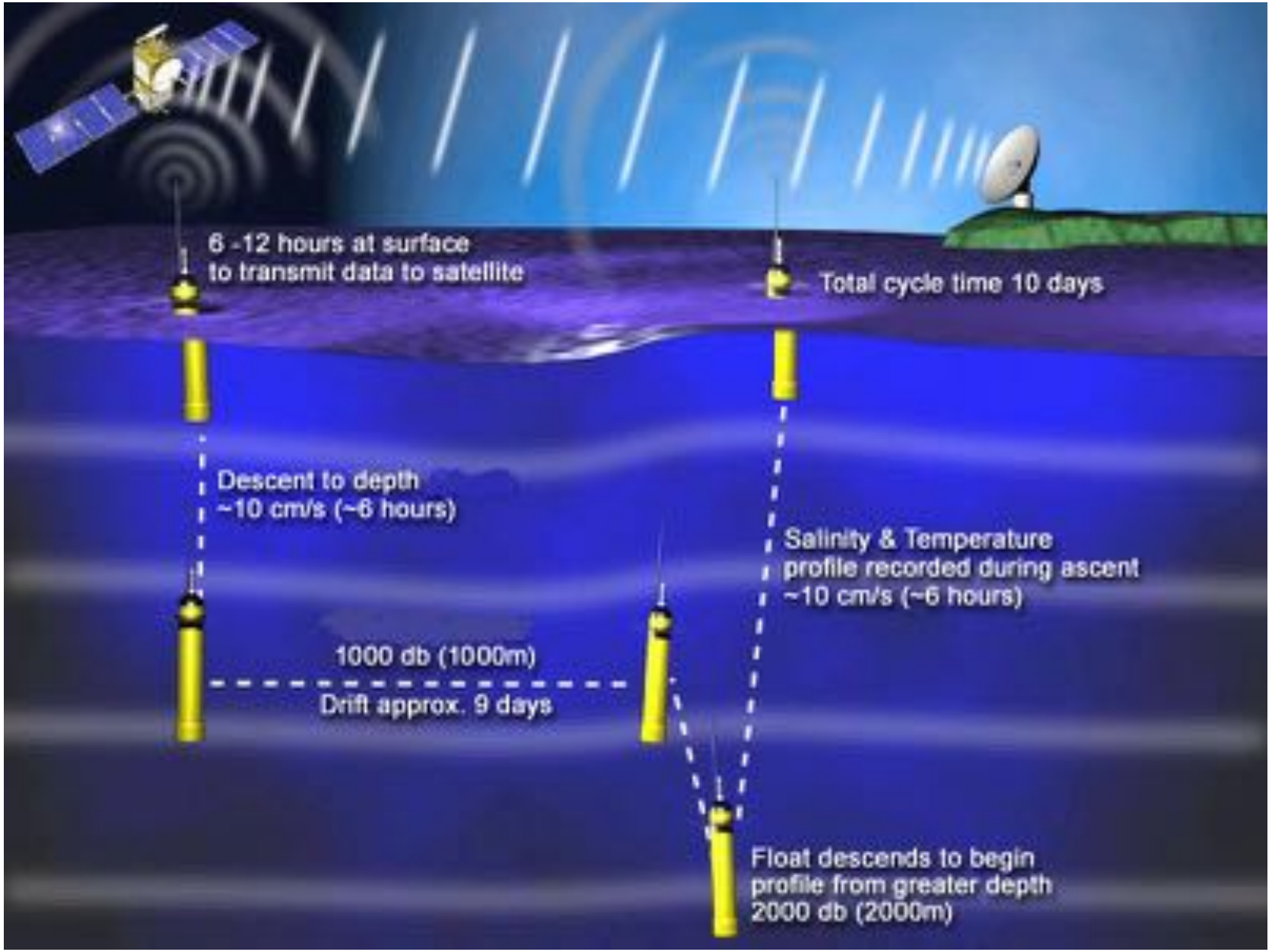
Illustration : NKE

Profiling Floats
(0 – 2500m)

Very Low Energy,
NO maintenance,
3 years life

Low Real Time Data stream => satellite.

Oceanographic systems for *in situ* monitoring



Profiling Floats
(0 – 2500m)

Very Low Energy,
NO maintenance,
3 years life

Low Real Time Data stream => satellite.

Oceanographic systems for *in situ* monitoring

AUV

(Autonomous underwater Vehicle)

Moderate Energy,

NO maintenance, normally few days deployment

No Real Time Data stream when underwater

GSM link when on surface

Oceanographic systems for *in situ* monitoring

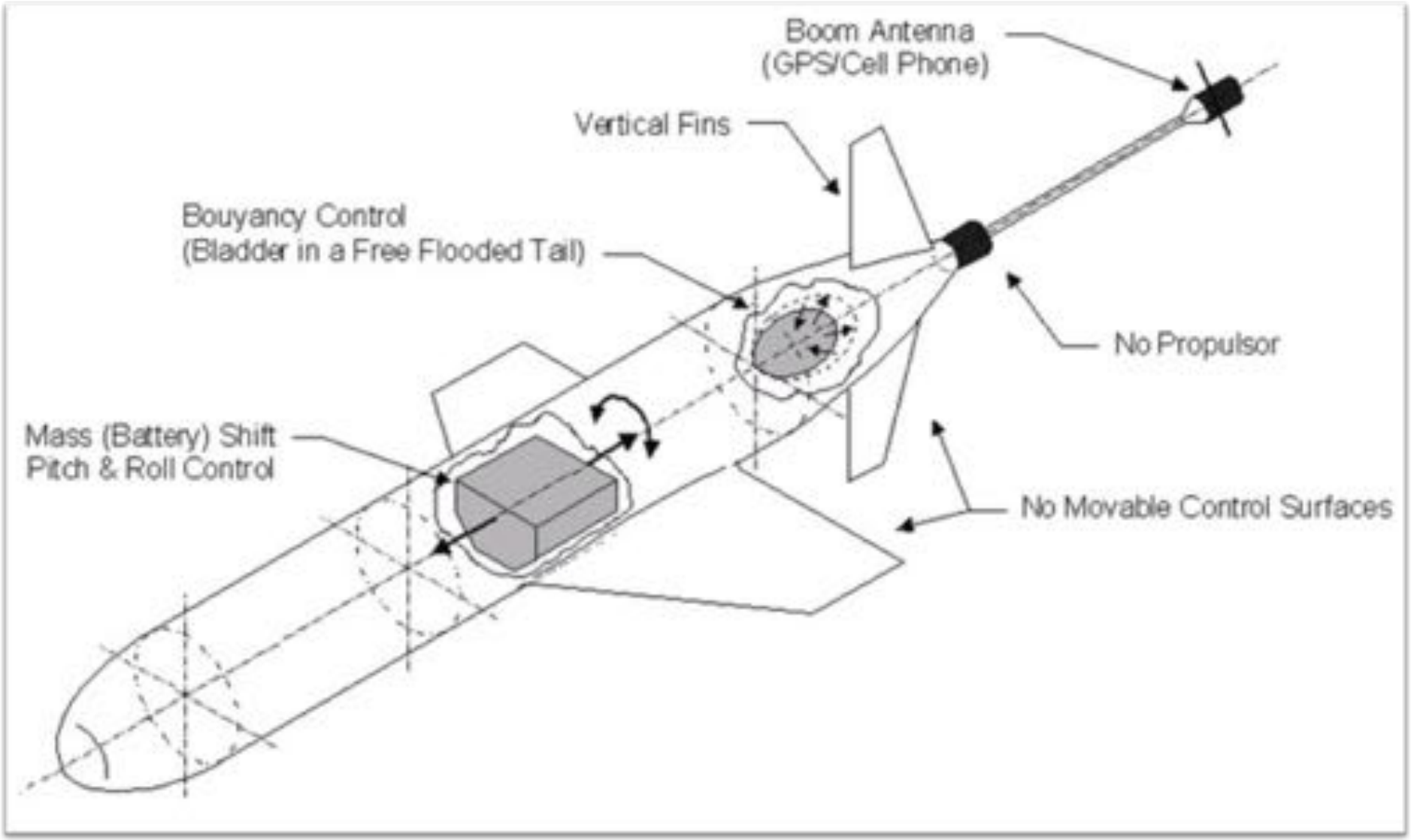
Gliders

Low Energy,

NO maintenance,

normally few days deployment

Oceanographic systems for *in situ* monitoring



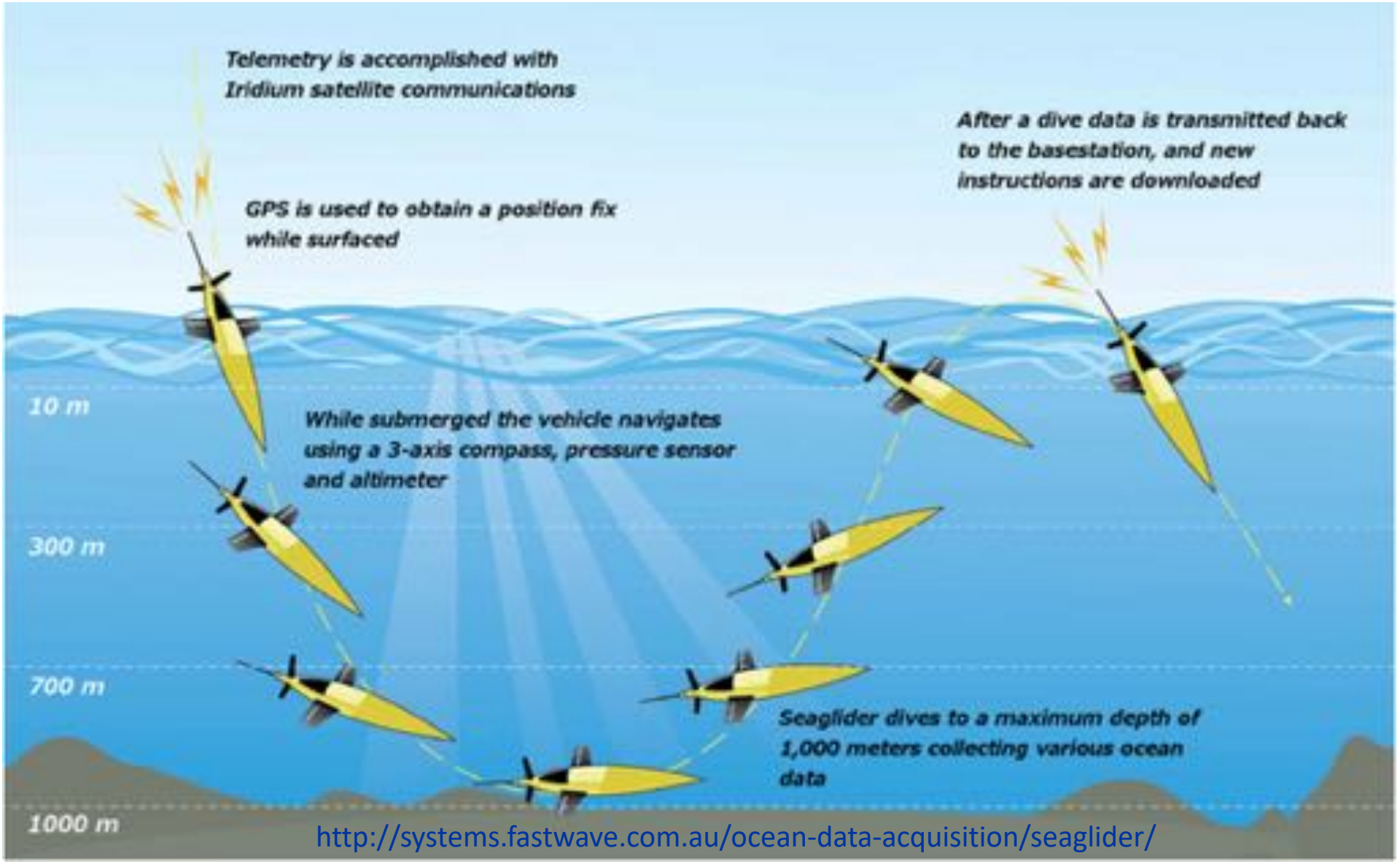
Gliders

Low Energy,

NO maintenance,

normally few days deployment

Oceanographic systems for *in situ* monitoring



http://systems.fastwave.com.au/ocean-data-acquisition/seaglider/

Gliders

Low Energy,

NO maintenance,

normally few days deployment

Scientific Drones

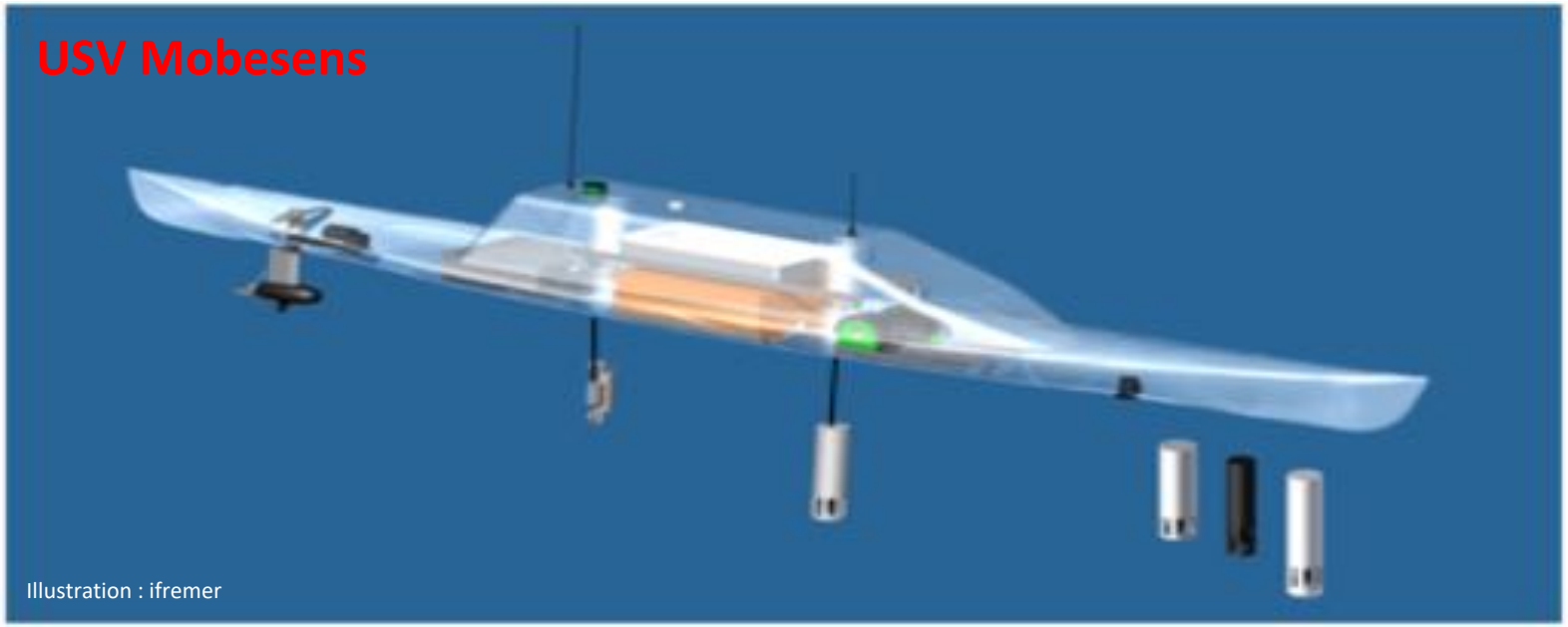


Illustration : ifremer

Photo : ifremer

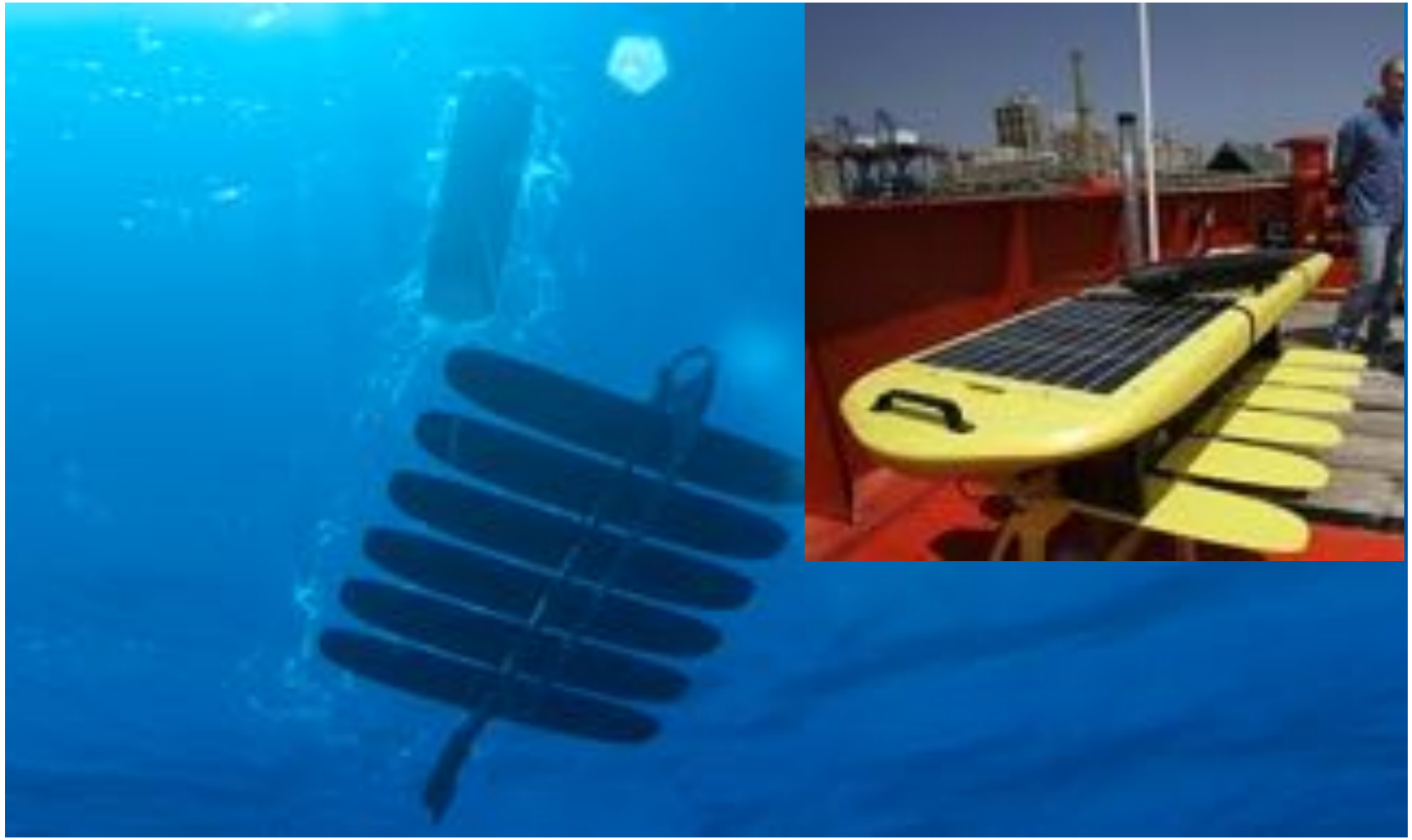
Medium energy

NO maintenance

Few hours/day deployment

Medium Data stream

=> GSM, Satellite

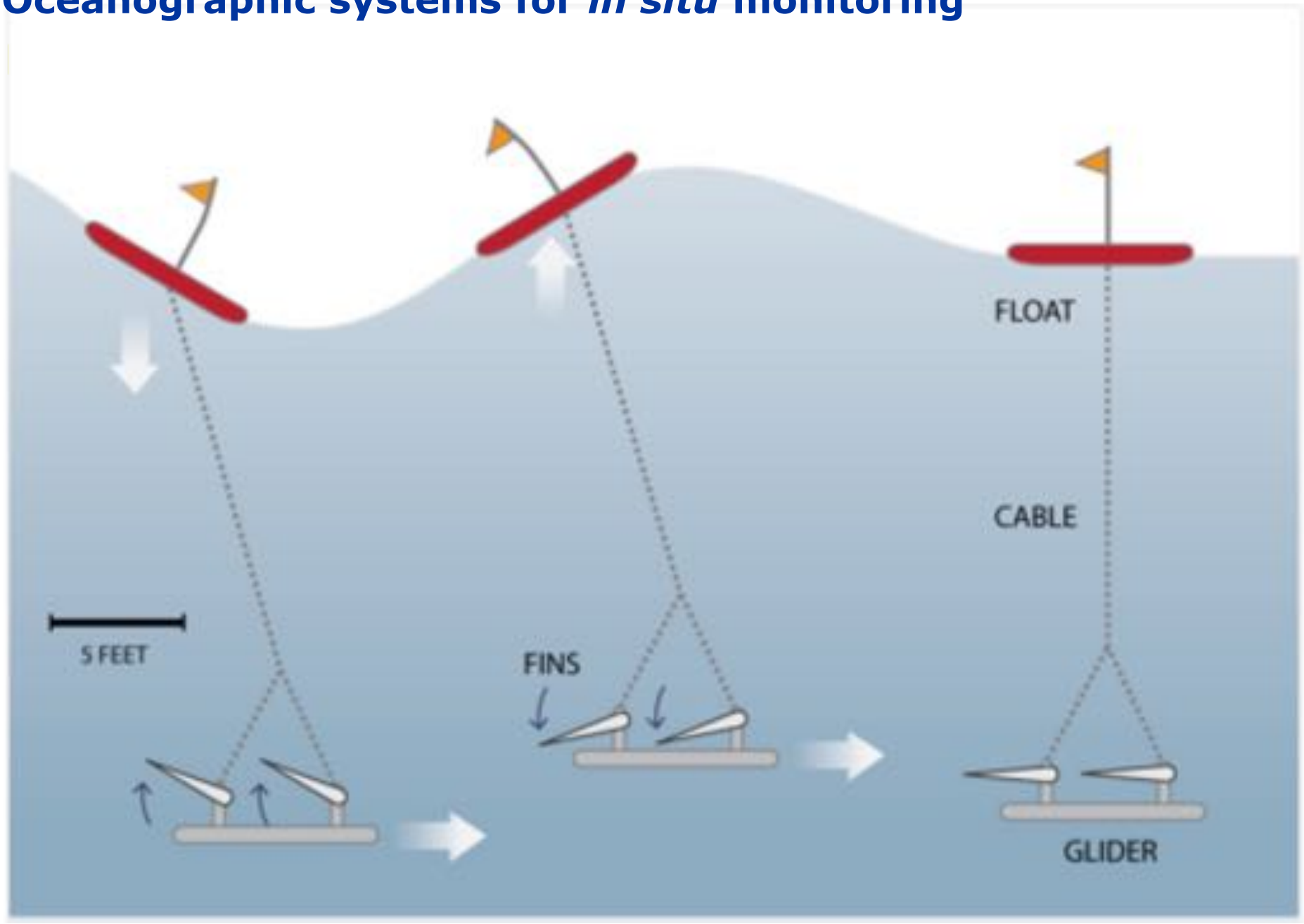


Scientific Drones

The Wave-Glider from Liquid robotic.

Sunnyvale, Californie, USA

Oceanographic systems for *in situ* monitoring



Scientific Drones

The Wave-Glider from Liquid robotic.

Sunnyvale, Californie, USA

Oceanographic systems for *in situ* monitoring

Scientific Drones

The Wave-Glider from Liquid robotic.

Sunnyvale, Californie, USA

Oceanographic systems for *in situ* monitoring

Fishing vessel

Voluntary Observing Ship (VOS)

Recopesca project

3 or 6 months Maintenance

=> Sensors !

Oceanographic systems for *in situ* monitoring

Ferry Box

Voluntary Observing Ship (VOS)

1 week to 1 month

(everytime ship is in harbour).

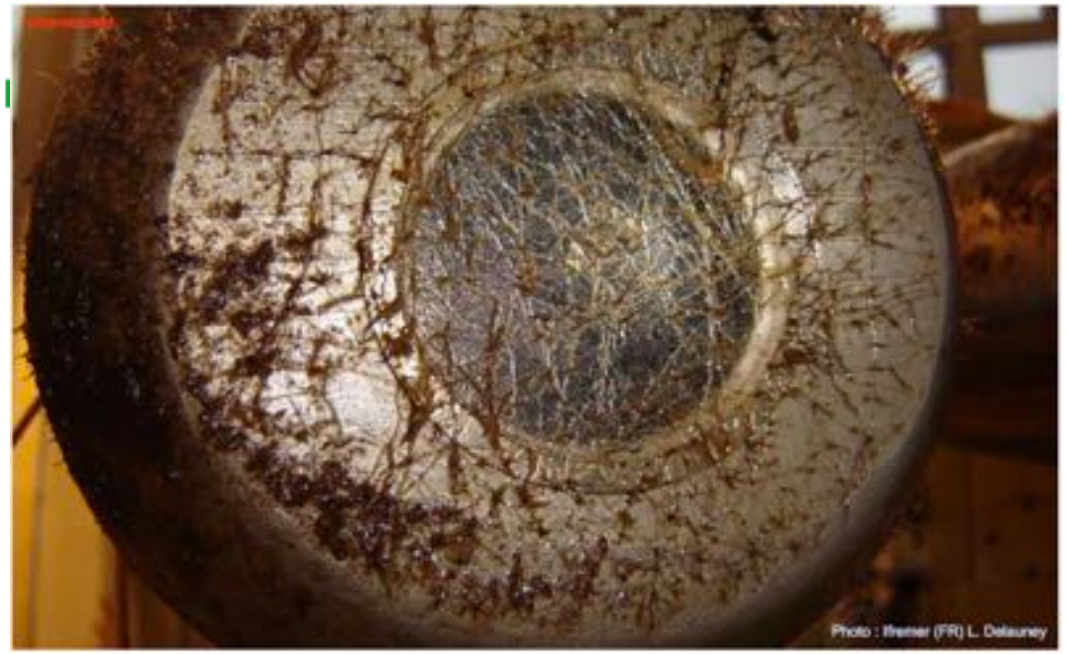
Maintenance => Sensors,

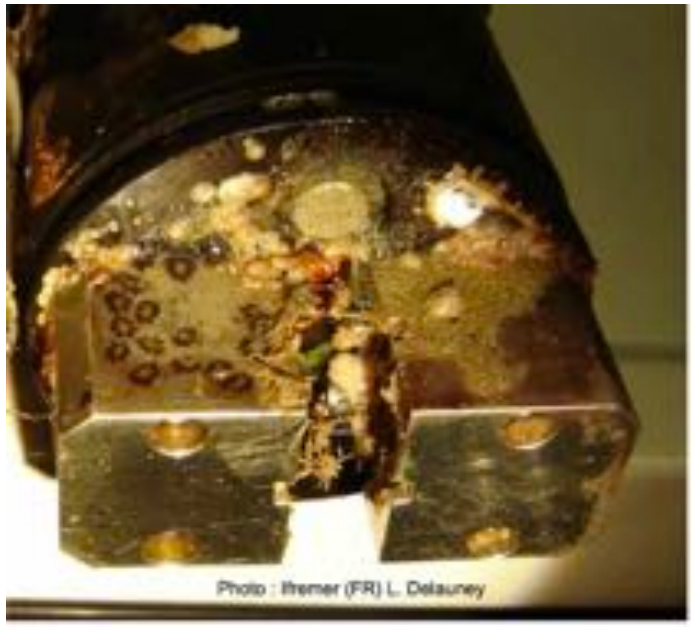
Reagents

Biofouling

Protection for marine *in situ* sensor

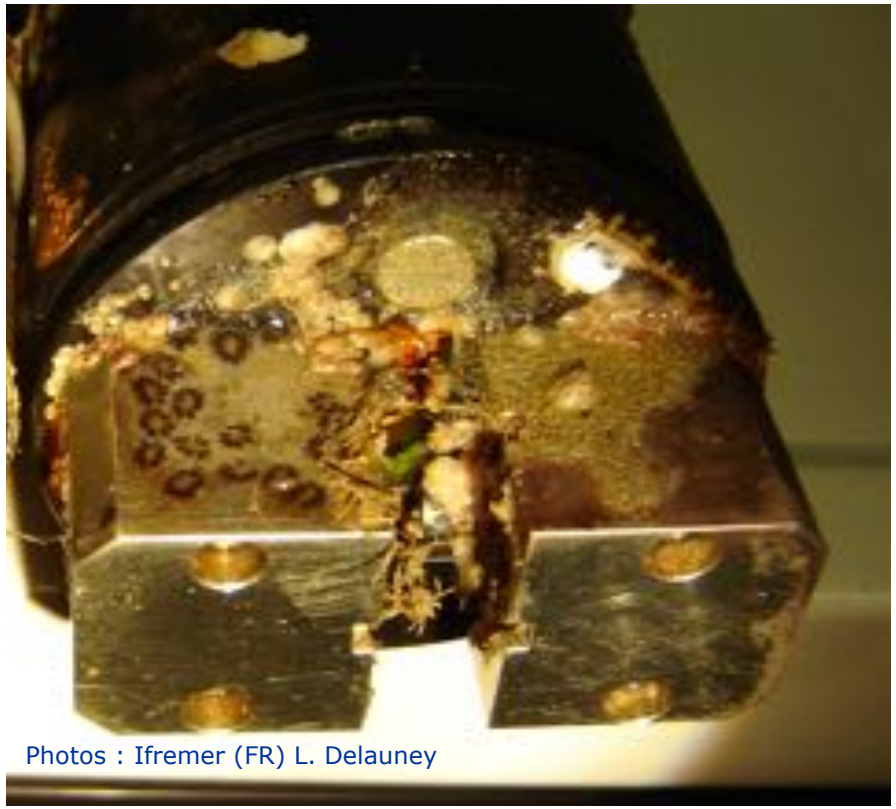
A tough medium





Biofouling and design

Photos : Ifremer (FR) L. Delauney



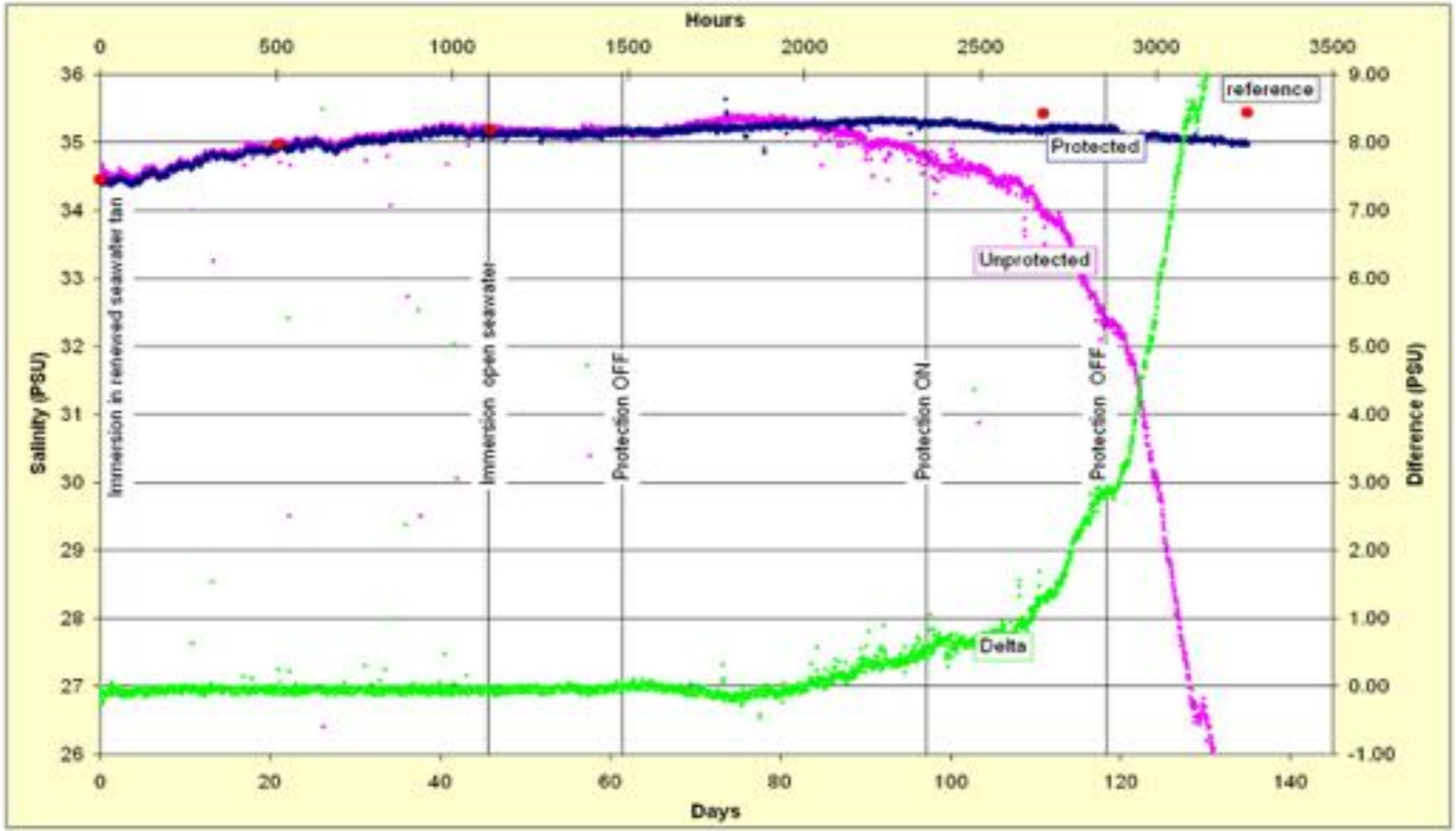
Photos : Ifremer (FR) L. Delauney

40 days ◆ August - October 2005 ◆ Helgoland - DE

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

Sensor deviation example : conductivity

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 SweepTM

Wipers

Biofouling

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**

Biofouling

Mechanical Protection

ZEBRA-TECH (NZ) – Opto Shutter

Biofouling

Copper Biofouling protection

Fluorimeter Seapoint + Hobilabs Hydroshutter

- **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.**

Biofouling

Projet NOSS : NKE, Telecom Bretagne, SHOM, ifremer

Illustration : NKE

Illustration : NKE

Biocide diffusion

Seabird conductivity sensor

⇒ TBT rings

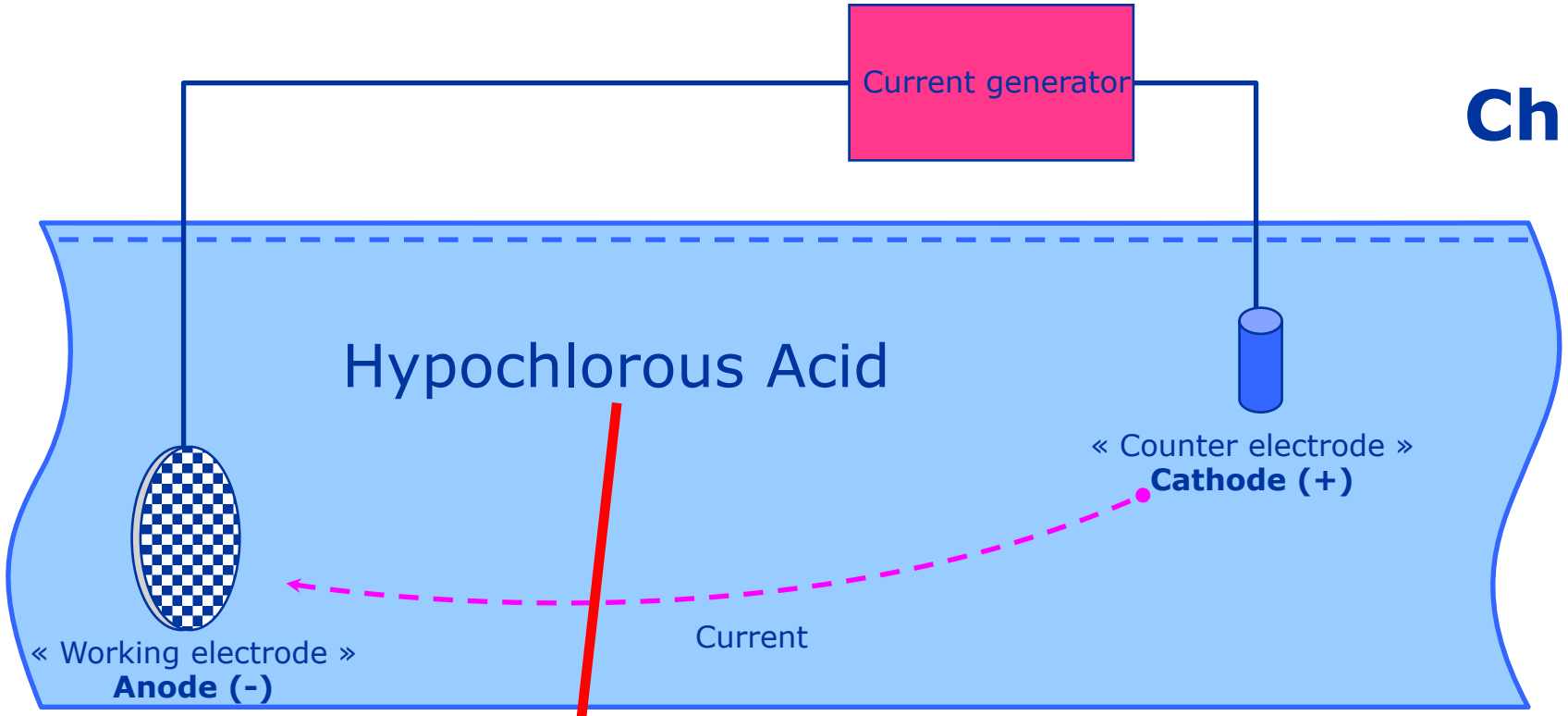
An idea,

Producing the

biocide in the sea:

=> Seawater electrolysis

Chlorine Generation In Sea Water



Sea water electrolysis :

Hypochlorous Acid generation.

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

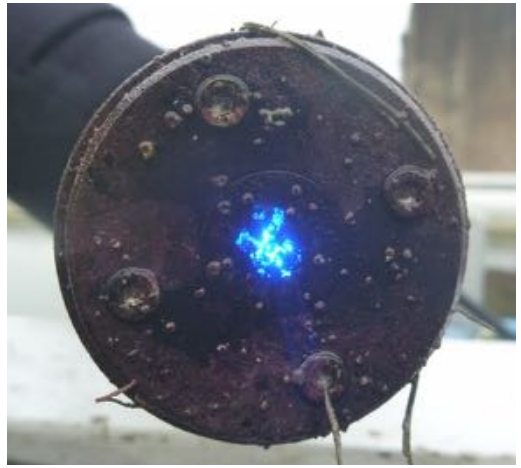
$$2H_2O + 2\,e^- \longrightarrow 2\,OH^- + H_2$$

Then in function of pH and Temperature :

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

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

Biofouling



Unprotected

Protected

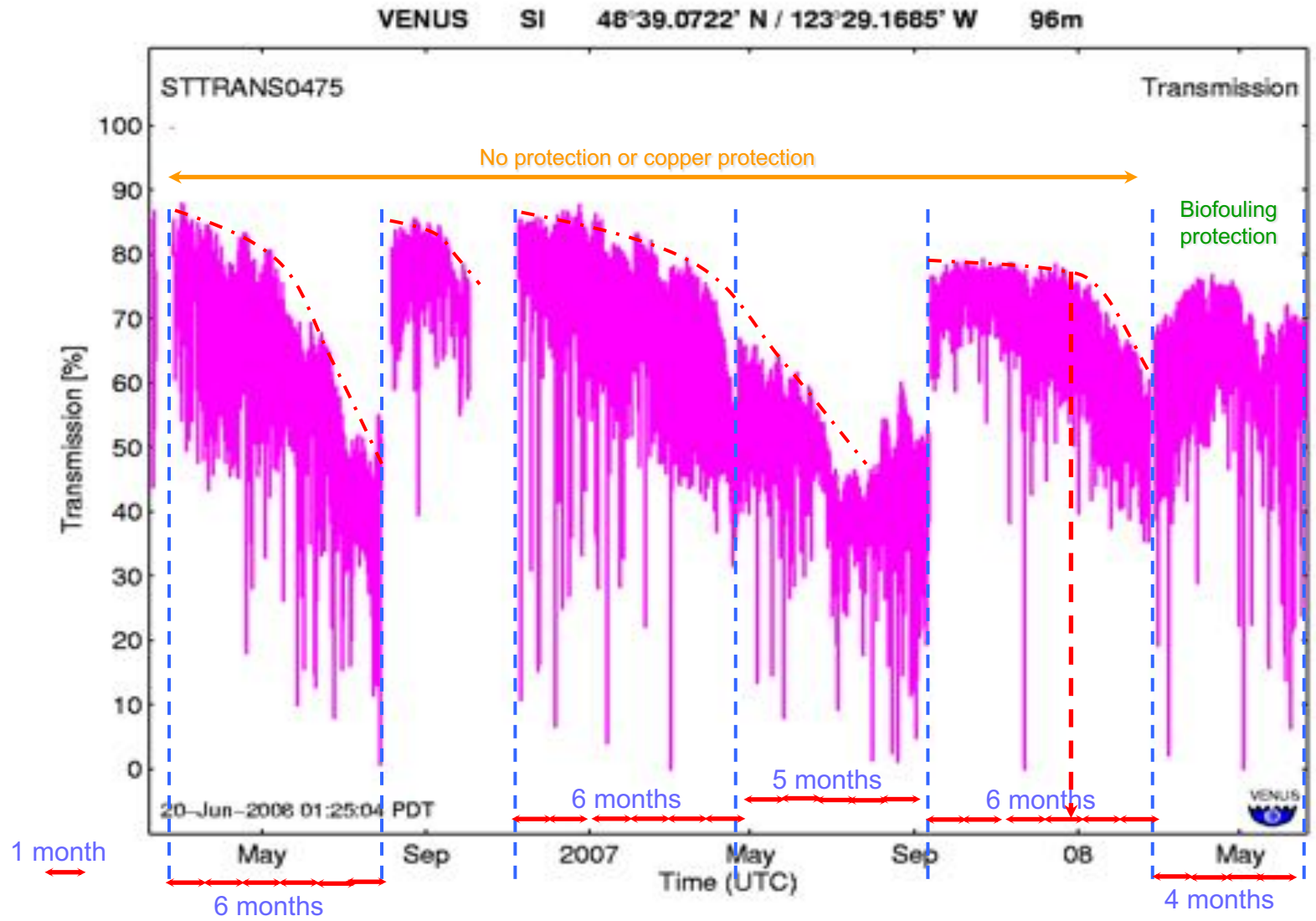
(Modified TriOS fluorometers)

Biofouling protection for sensors Surfacing chlorination (Ifremer)

Electrochlorination by **surface thin film electrode** on window:

18 months *in situ* test

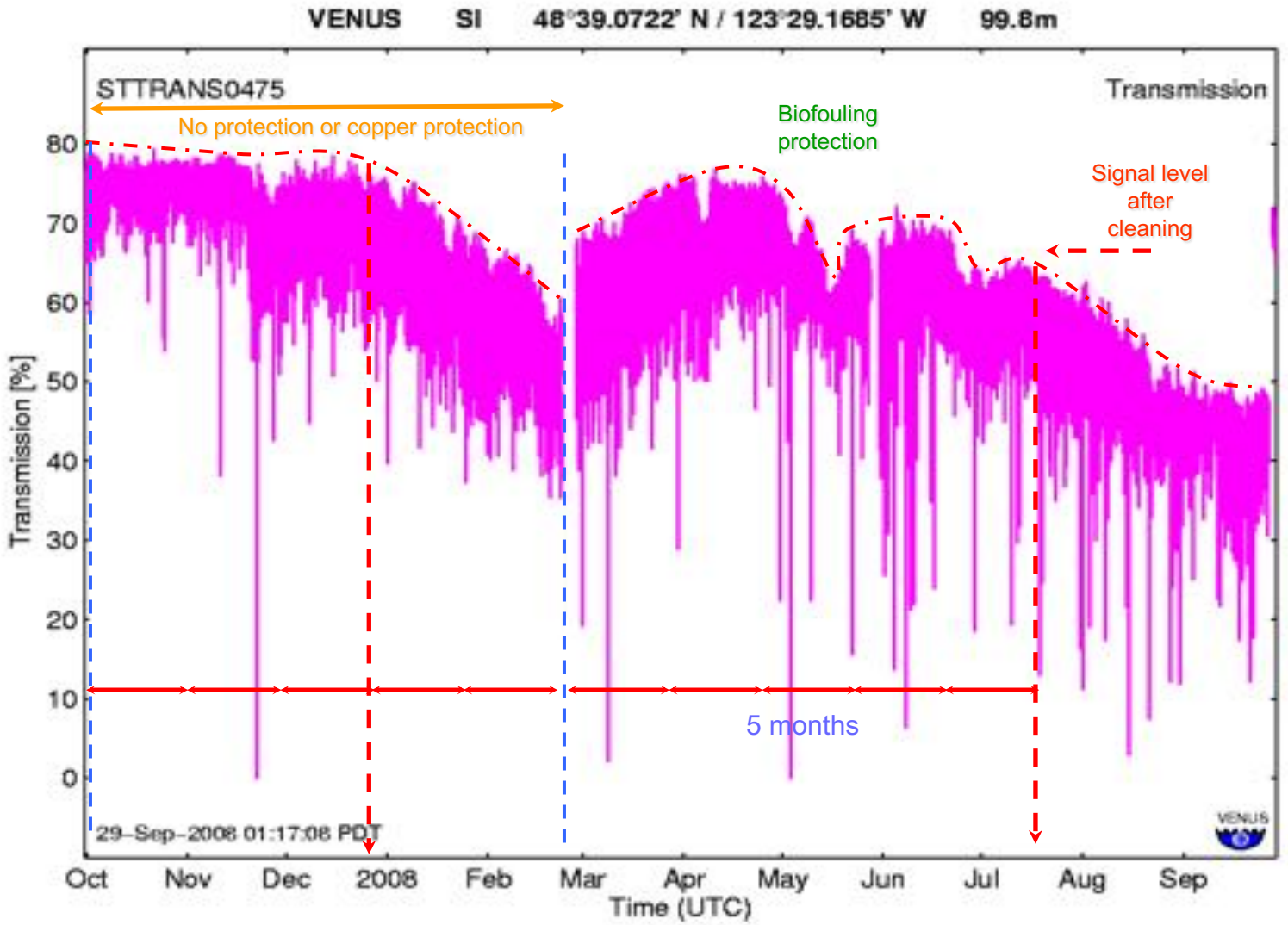
Biofouling



VENUS Observatory TRANSMISSOMETER

Ifremer Biofouling Protection
(VENUS Data)

Biofouling



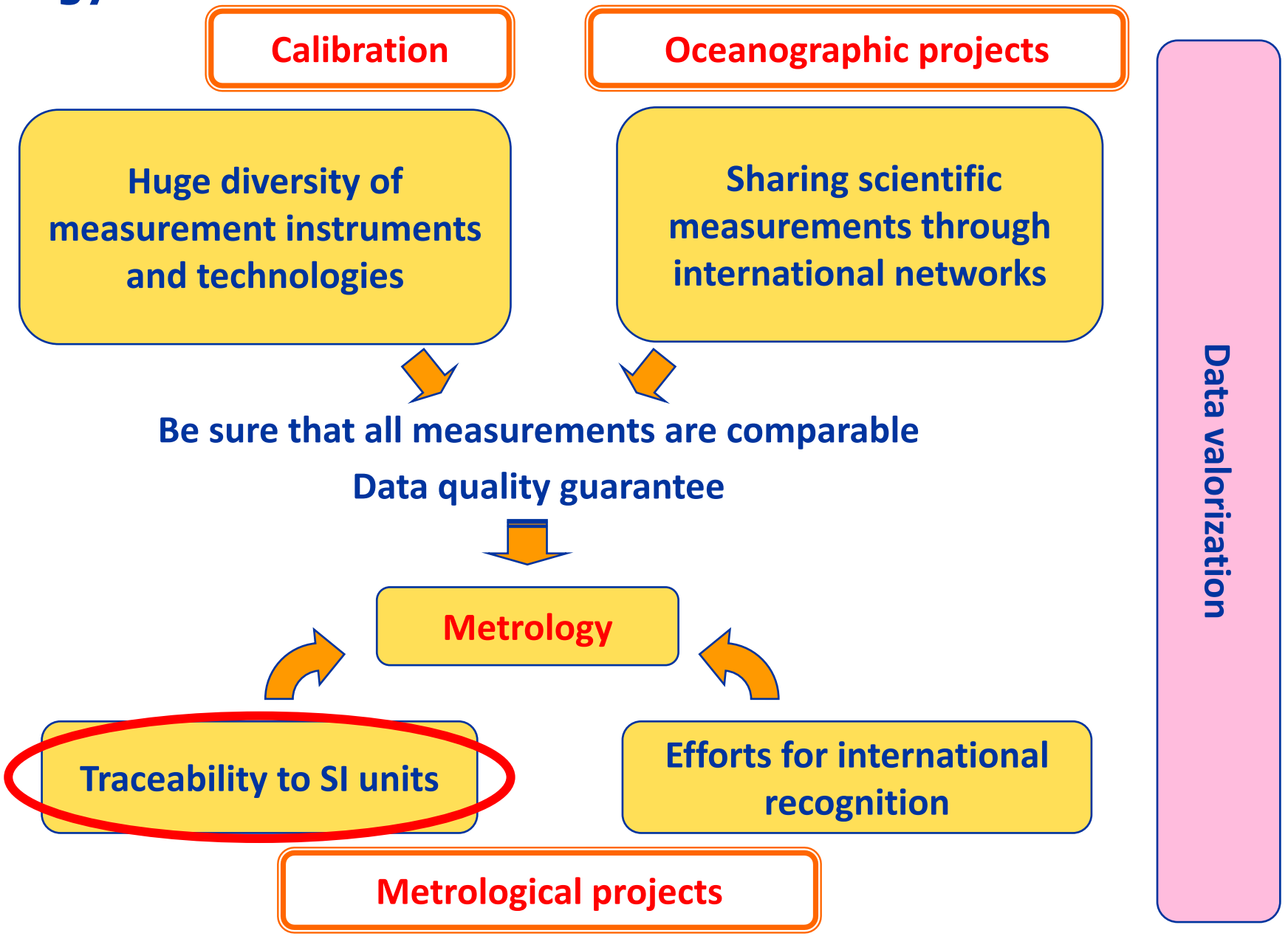
VENUS Observatory TRANSMISSOMETER

Ifremer Biofouling Protection
(VENUS Data)

Metrology

for marine monitoring

Metrology



Metrology

for marine monitoring

A science of prime importance needed for collaborative monitoring

Traceability ?

Trueness and U ?

Parameters							
Temperature	**Pressure**	**Current**	**O_2**	**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 APSO standard	Formazin solutions	Fluorophore solutions

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

Metrology

for marine monitoring

Projects and metrology

Oceanographic projects:

- **Argo, (ESONET), EMSODEV**
- **(Hypox)**

} D.Oxygen

- **ATLANTOS, (FIXO3)** Temp., Salinity, D.Oxygen, Turbidity,
- **(JERICO), JERICO-NEXT** Temp., Salinity, D.Oxygen, Fluorescence, Plancton imagery, pH, pCO_2

Projects on water measurement:

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

Metrological project:

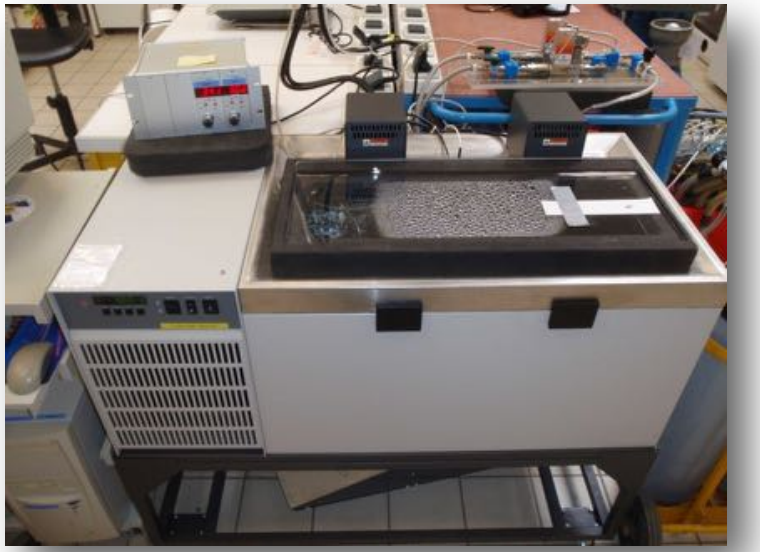
- **EMRP ENV05 Ocean** Salinity, D.Oxygen, Velocity, pH

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_2 analysis

Pressure sensor calibration

Salinometer

Metrology

for marine monitoring

Specific equipment,

rooms

and

skilled people

Conclusions

Challenges for the future

Sensor development status TRL	Short description	OS-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/ocean environment		
8	Actual system completed and "ocean 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

Information mining

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

A technological database on oceanographic systems

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 materia
	DO-OEM	AMT Analysenmesstechnik GmbH		-	-	-
	Flowthrough Oxygen Minisensor	PreSens Precision Sensing GmbH		-	-	-
	MacroQual	Coastal Leasing, Inc.		-	-	-
	Manta2 - Dissolved Oxygen Sensor Clark	Eureka Environmental		-	-	-
	Manta2 - Optical Dissolved Oxygen Sensor	Eureka Environmental		-	-	-
	Oxygen Optode 3830	Aanderaa Data Instruments Inc.		-	-	-
	Oxygen Optode 3835	Aanderaa Data Instruments Inc.		-	-	-

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

Information mining

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

A technological database on oceanographic systems

Information mining

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

A Technological database, evaluations reports on oceanographic technological systems

EGIM concepts

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

EGIM concepts

EGIM mechanical description

Length 790mm

Ø 750mm

GENERIC

***In situ* measurement**

module

COSTOF2
Communication & Storage Frond-end, 2nd 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

4000 m water depth version of the COSTOF2

Applications

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

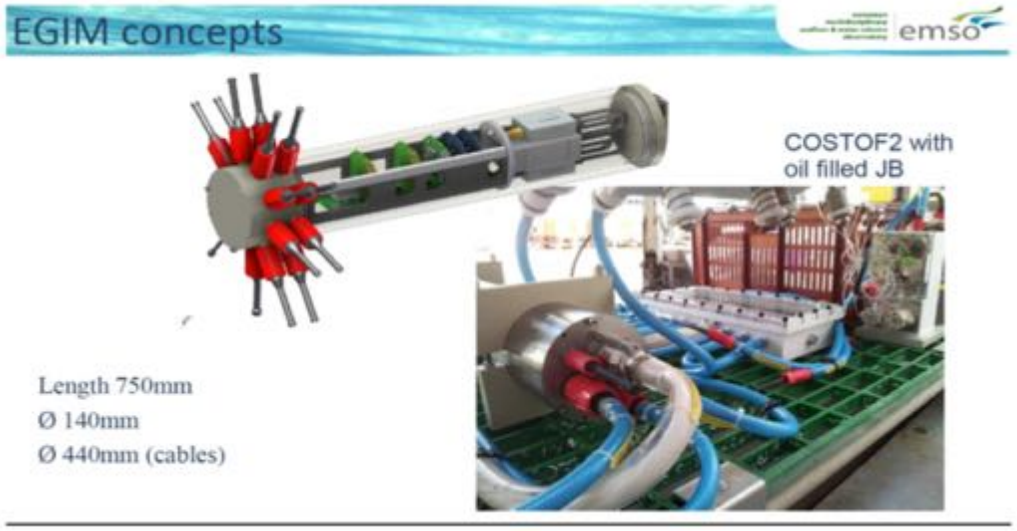
Operating characteristics

- 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 : 5.10^{-11} drift
- WiFi link for easy communication in air and underwater

GENERIC

***In situ* measurement**

module



Conclusions

⇒ 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…