R&D Webinar - BIODHYL Project Outcomes

Enhanced biocolonisation knowledge and optimisation of offshore renewable energy systems monitoring

With the financial support of:

Recommendations for biofouling measurement protocol

Recommendations for biofouling measurement protocol: Presentation at the OMAE conference 2026 @ Tokyo

STRENGTH OF A MULTIDISCIPLINARY APPROACH TO ENHANCE BIOFOULING CHARACTERIZATION: FROM COMPREHENSIVE REQUIREMENTS OF ENGINEERING AND ENVIRONMENTAL ANALYSES
OMAE2026-181349

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Recommendations for biofouling measurement protocol: *Summary*

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1. Context & Motivation

2. How to characterize biofouling in a representative way: Use representative samples

3. Refine biofouling characteristics of offshore sites

4. Key learnings to built a consistent and reliable data base on biofouling for engineering purpose

More context in: *Aurélie Portas, Jean-François Briand, Guillaume Damblans & Nolwenn Quillien (27 Feb 2026): A review of biofouling characteristics and issues for offshore renewable energy industry, Biofouling, DOI: 10.1080/08927014.2026.2630946*

Context & Motivation:

Brief history of practices to account for biofouling in offshore structures design

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norsok standard

N-003 (1999)

Design

- Hydrodynamic actions
- Weight
- Added mass
- Fluid structure instability

BUREAU VERITAS

NI-624 & NI572

Design

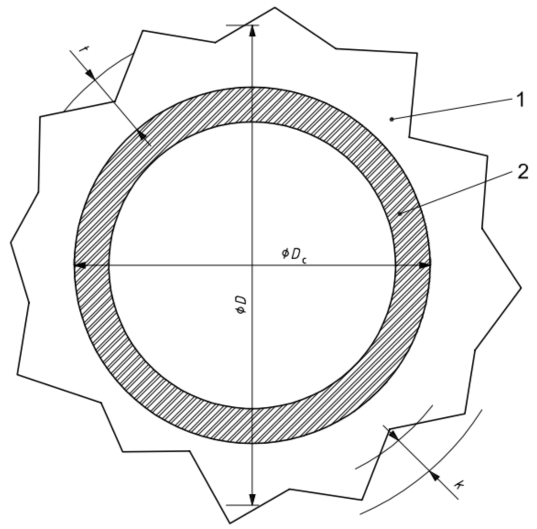
- Accounted for in fatigue analysis
- **Characterized by Th and density**

ISO API

ISO 19902
API-RP-2SIM

Inspection recommendations

- Visual inspections
- **Mean Th** from perimeter measurements
- e=k/D : peak to valley



DNV

OS-E301

Modelling
Formulas to derive hydrodynamic coefficients

Default values:

- North Sea: WD=0-40m → **Th=100mm**
- **ρ_{mg} = 13 kN.m^{-3}**
- In-situ measurements recommended

Modelling well described for idealized material BUT…

How to characterize equivalent parameters on alive and heterogeneous organisms, in a representative manner?

Recommendations for biofouling measurement protocol

Use representative samples: Material & geometry influence

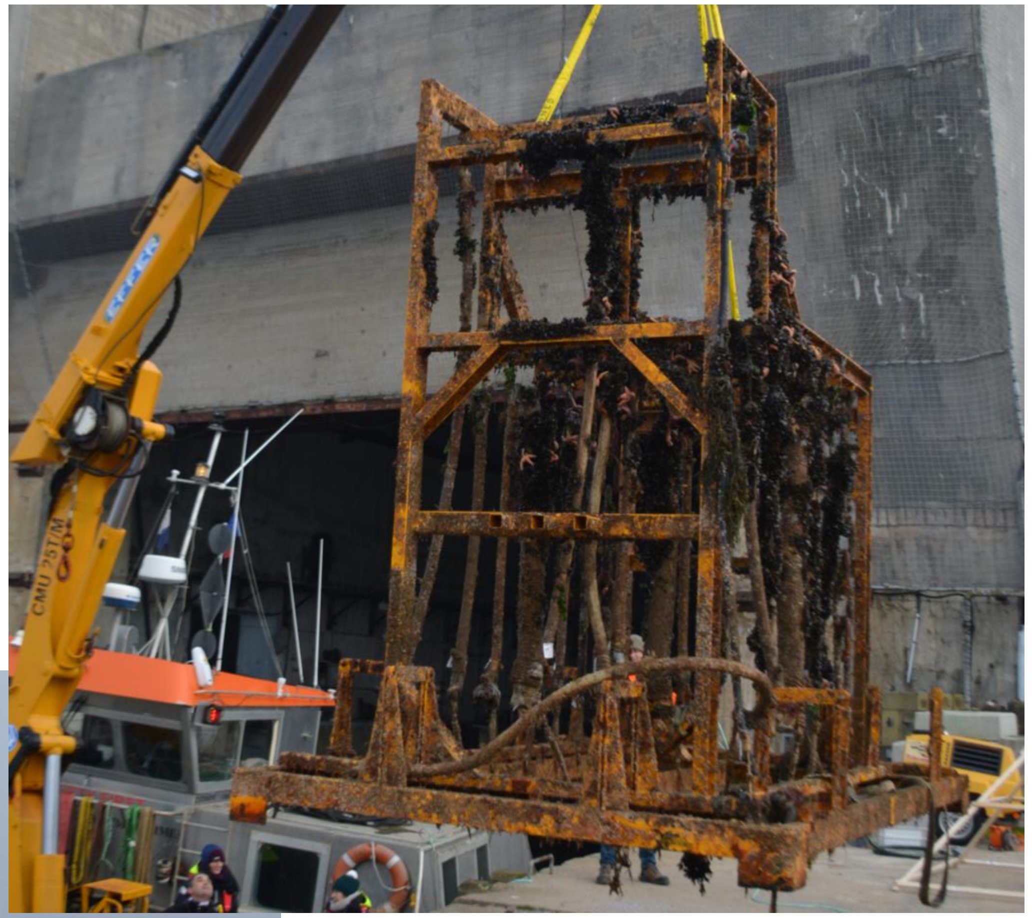
OBJECTIVES

Identify the impact of:

- Material ?
- Diameter ?
- Length ?
- Shape (plate vs cylinder) ?

Protocol

- Etel site: marine environment protected from wave
- 30 samples deployed
- 7 diameters (from 14mm to 120mm)
- 7 materials: PET, PA, PA/PE, PE, PVC, steel, HDPE
- 2 length : 1m and 1.5 & 2.5m
- 2 geometries: plate & cylinder
- 18 months of colonisation
- Dedicated measuring tools & protocols (fibre rope)



Recommendations for biofouling measurement protocol:
Use representative samples: Material & geometry influence

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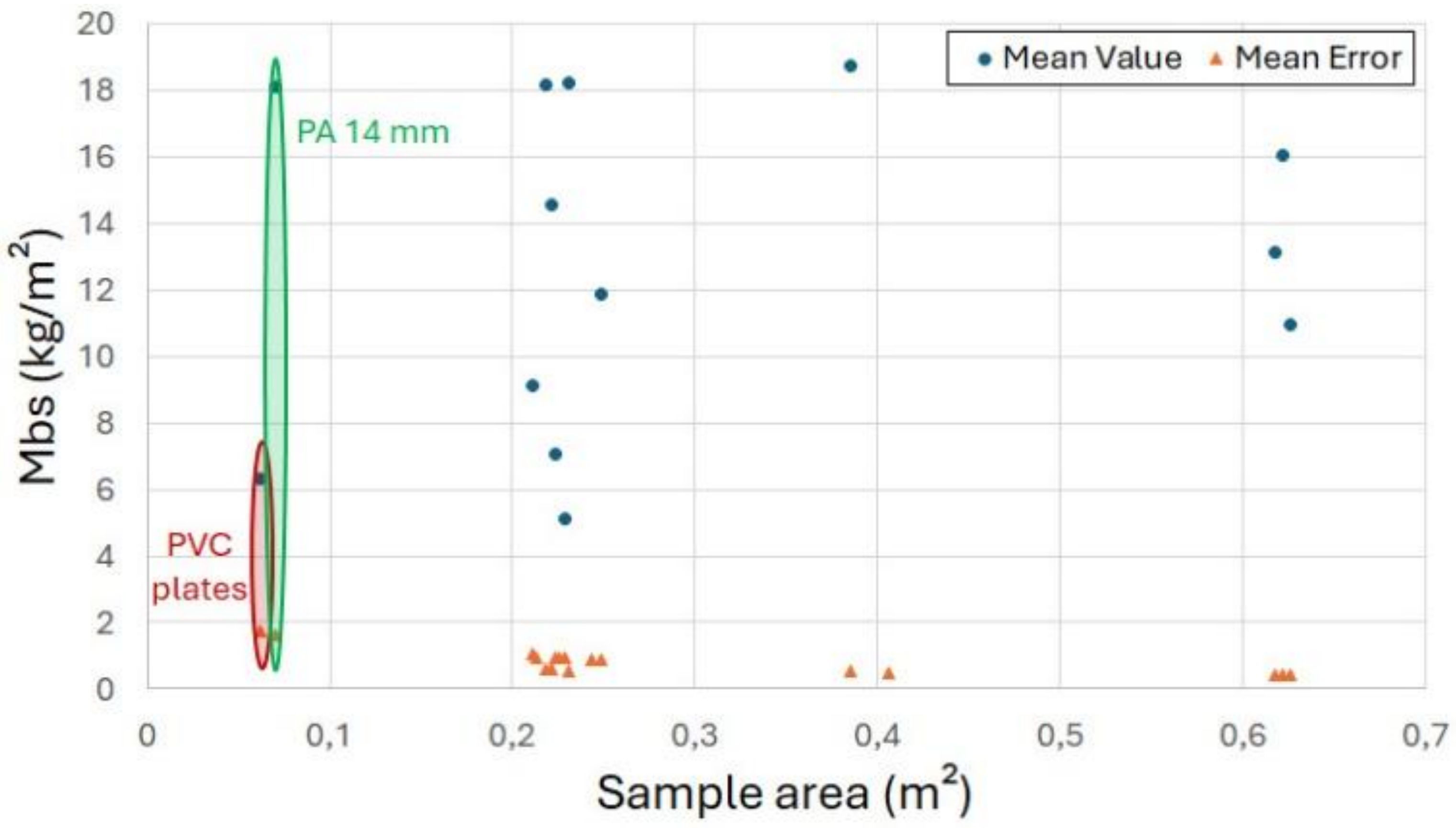
Key learnings

Based on engineering parameters ***(m, V, Th)***

- No clear influence of diameter nor lenght
- Influence of shape highlighted: PVC plates oriented towards North show lower amount than PA rope
- PE plate & chain induce lower amount than other materials
- Biovolume generally overestimated using mean Th
- More complicated to perform measurements on cylindrical samples
- No clear difference between different fibre ropes (PET, PA, Deltaflex) & HDPE tube (electrical cable)

Design : need long-term data
→ Are 18 months representative enough for 25 years?

PA	Diameter (mm)	14	48	120
Mean Vbs (cm^3/m^2)	Mean	9 068	11 637	9 263
	RMS	NA	9 387	1 162
	Error	37	44	74



Recommendations for biofouling measurement protocol:
Use representative samples: Material & geometry influence

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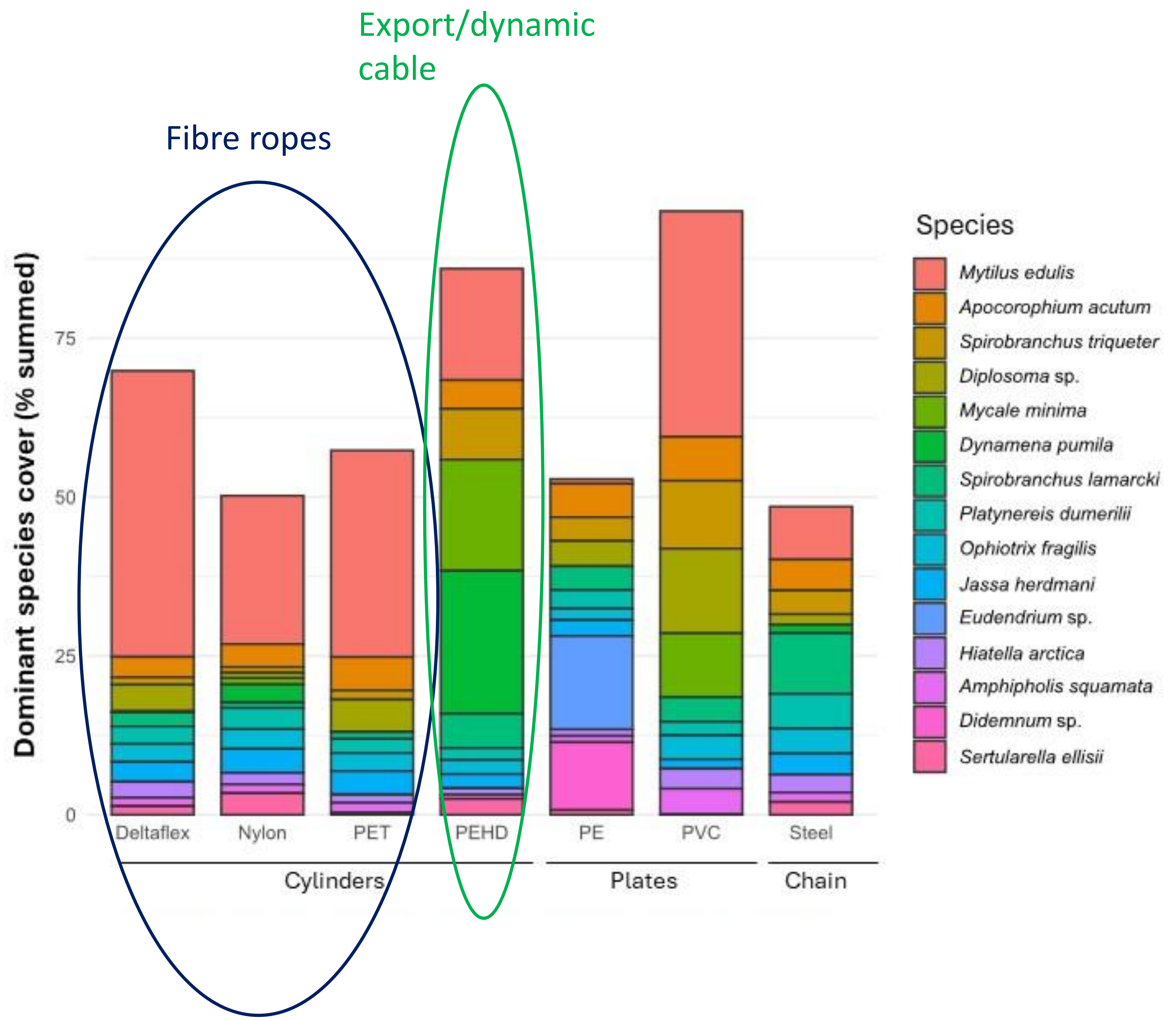
Key learnings

Add biological analysis:

- Morpho-taxonomic analysis revealed that:
  - Same communities (species group & distribution) are observed on PA, PET & PA/PE (Deltaflex)
  - Different colonisation are observed on HDPE tubes (export cable)
  - Different colonisation between PE & PVC plates (not used in offshore application)

→We can expect different stabilized colonization on HDPE vs fibre ropes:
Deploy both!

→Do not use PVC plate for characterization (actual practice)



Refine biofouling characteristics of offshore sites: An ambitious observation plan

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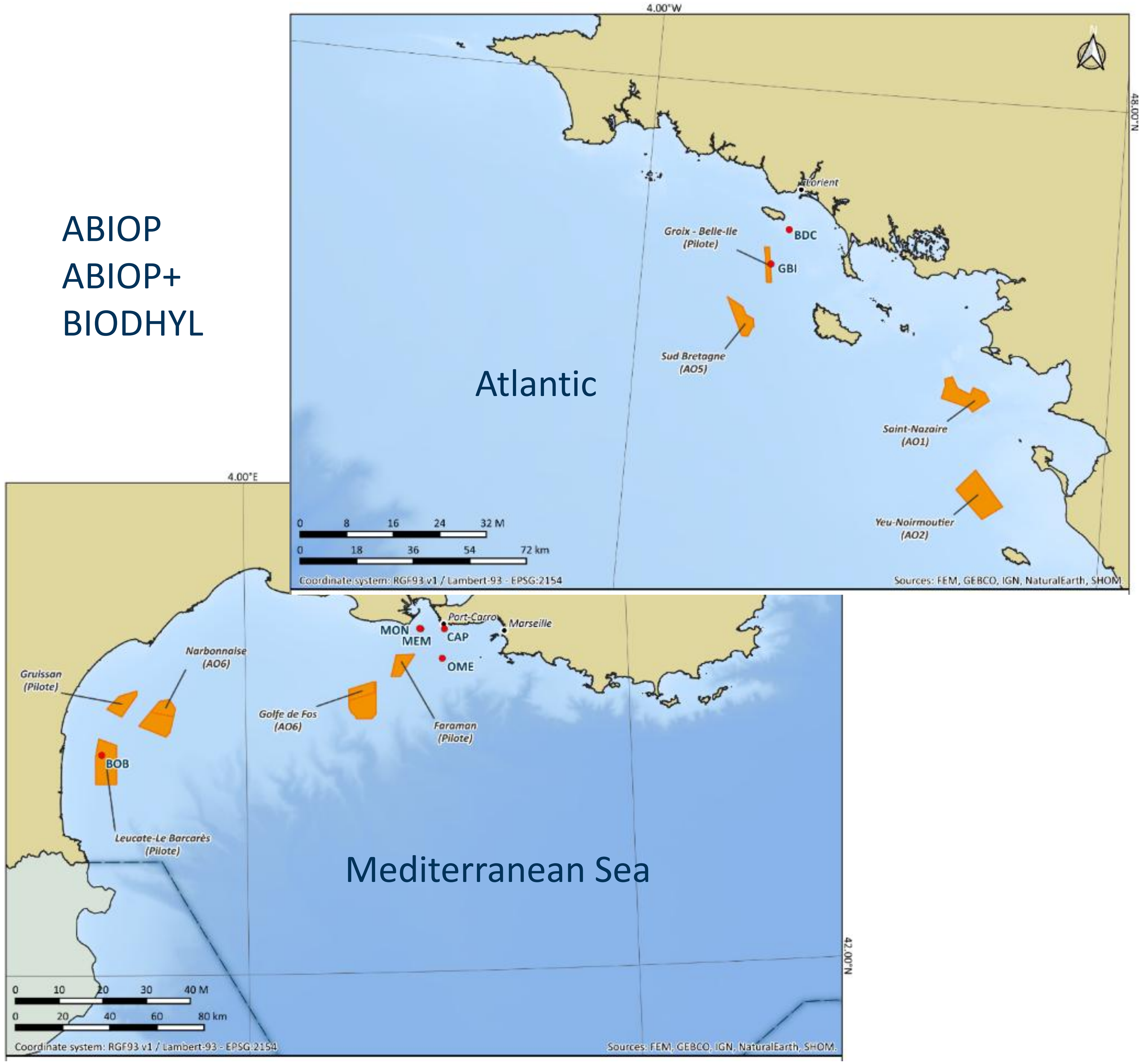
OBJECTIVES

Investigations conducted through 3 R&D projects since 9 years to identify the influence on biofouling properties of:

- Fine spatial scale effect (wind farm width)
- Marine areas
- Water depth
- Time
- Understanding of physico-chemical explanatory variables for future prediction
- Better understand the reef effect: Use biofouling as a passive e-DNA vector of upper layers of trophic model

- Refine biofouling characteristics measurements for reliable and representative modelling

ABIOP
ABIOP+
BIODHYL

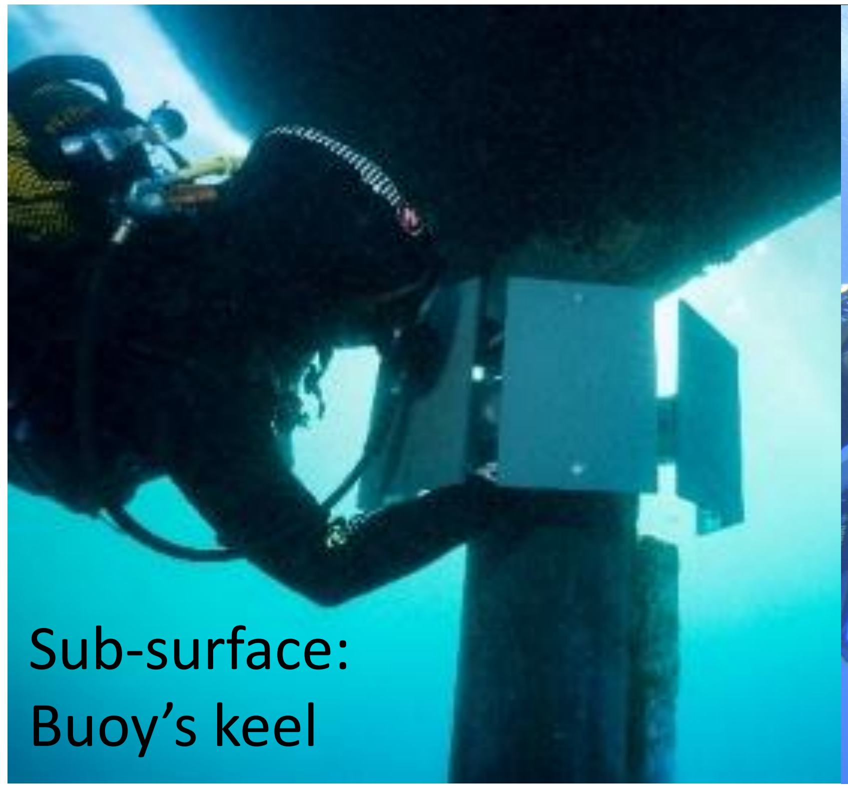


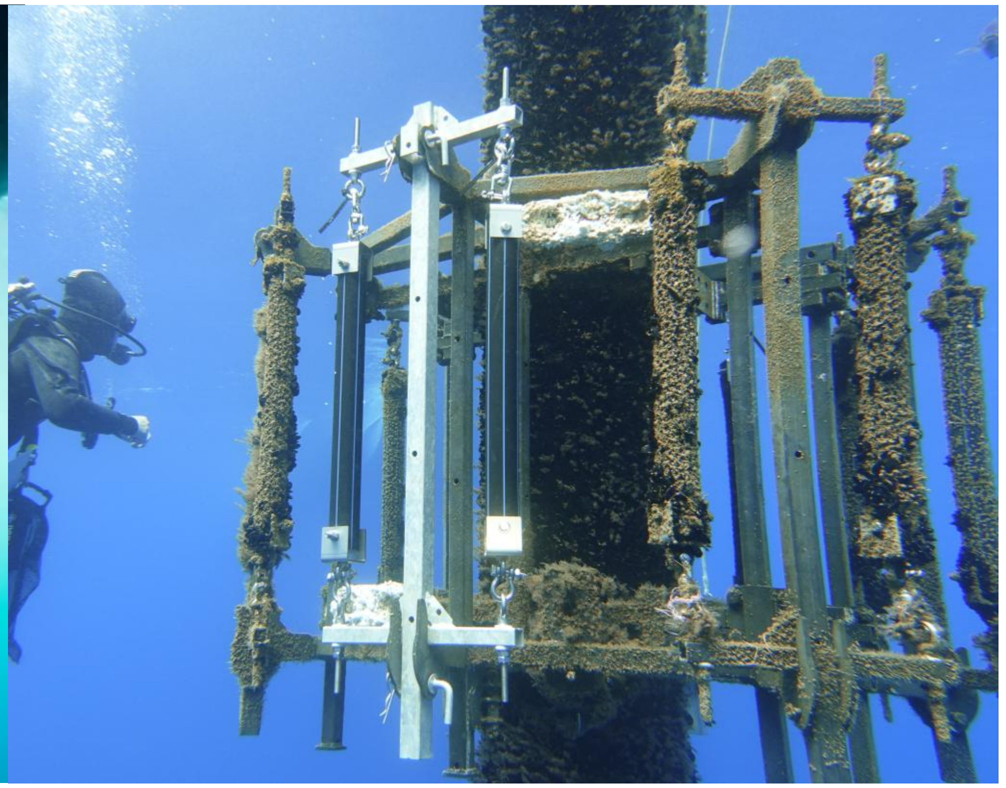
Refine biofouling characteristics of offshore sites: Key learnings

Key learnings

Issues related to offshore sites and periodic recovering:

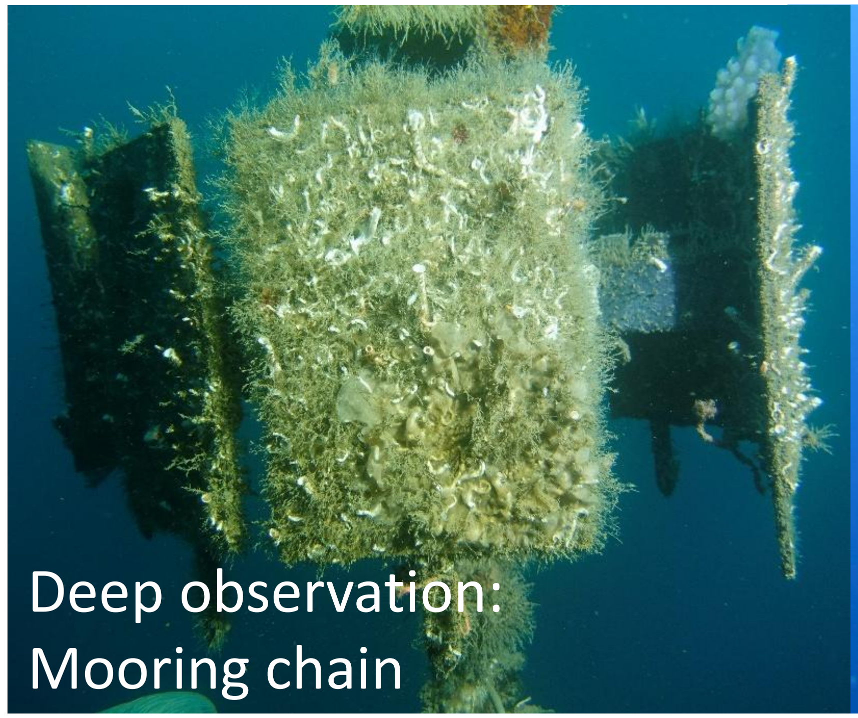
- Design of supporting structures to be reinforced
- Deep observations require specific and conservative designs for safety reason
- Specific sample hang-off system ensuring sustainment and easing sample recovery
- Cylinder sample (rope, tube) induces more complex and heaviest supporting systems

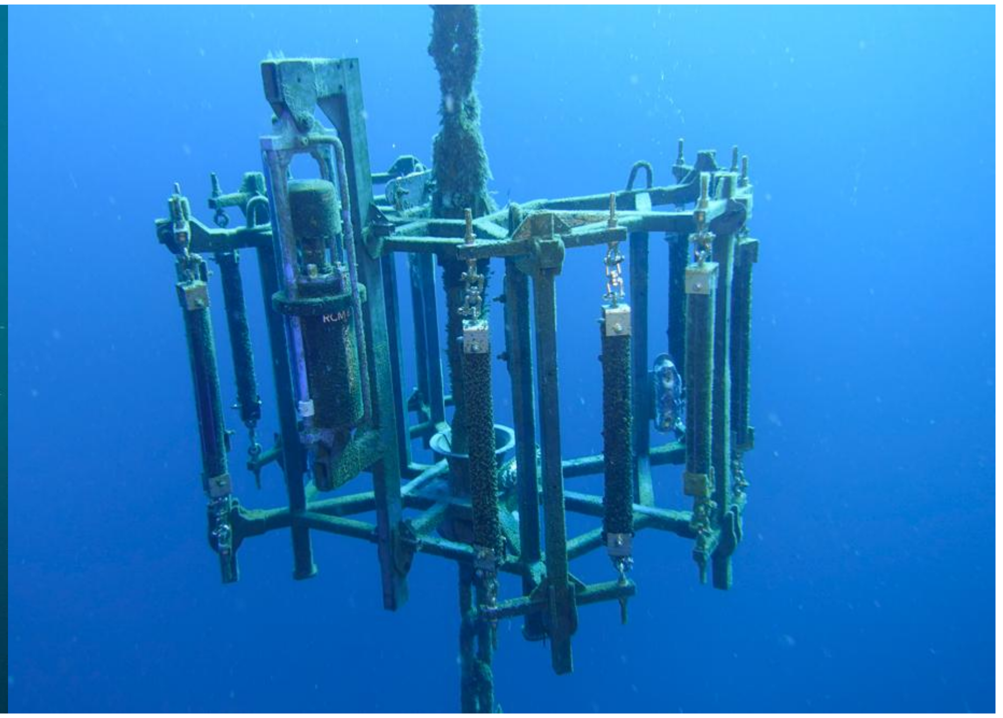




Plate

Cylinder





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Key learnings

Alive species behaviour representative only in their natural environment.

→ The measurement protocol and data use should be coherent with the physics to account for and the conditions of the final application

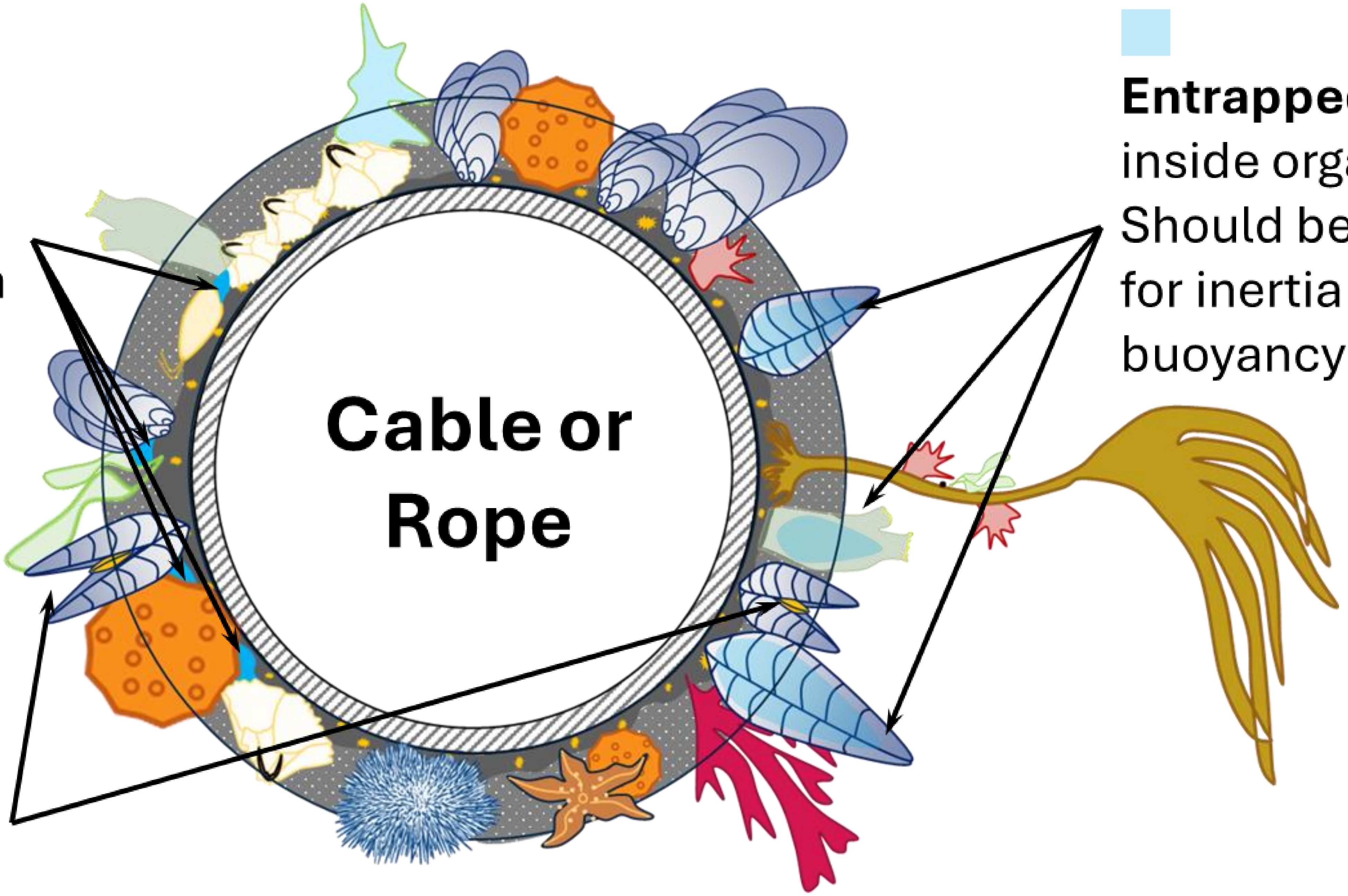
Mussel filtering activity: regularly opened in water

Mass in air measurement *(10s drying)*:
Closed mussels,
Sponges or solitary ascidia release water…

Recommendations for biofouling measurement protocol: Refine biofouling characteristics of offshore sites: Key learnings

Interstitial water
(between organisms):
Identical to entrapped water + no influence on flow dynamic

Released water
(opened organisms):
Entrapped and interstitial water may change in time



Entrapped water
inside organisms:
Should be considered for inertia but **NOT** for buoyancy!

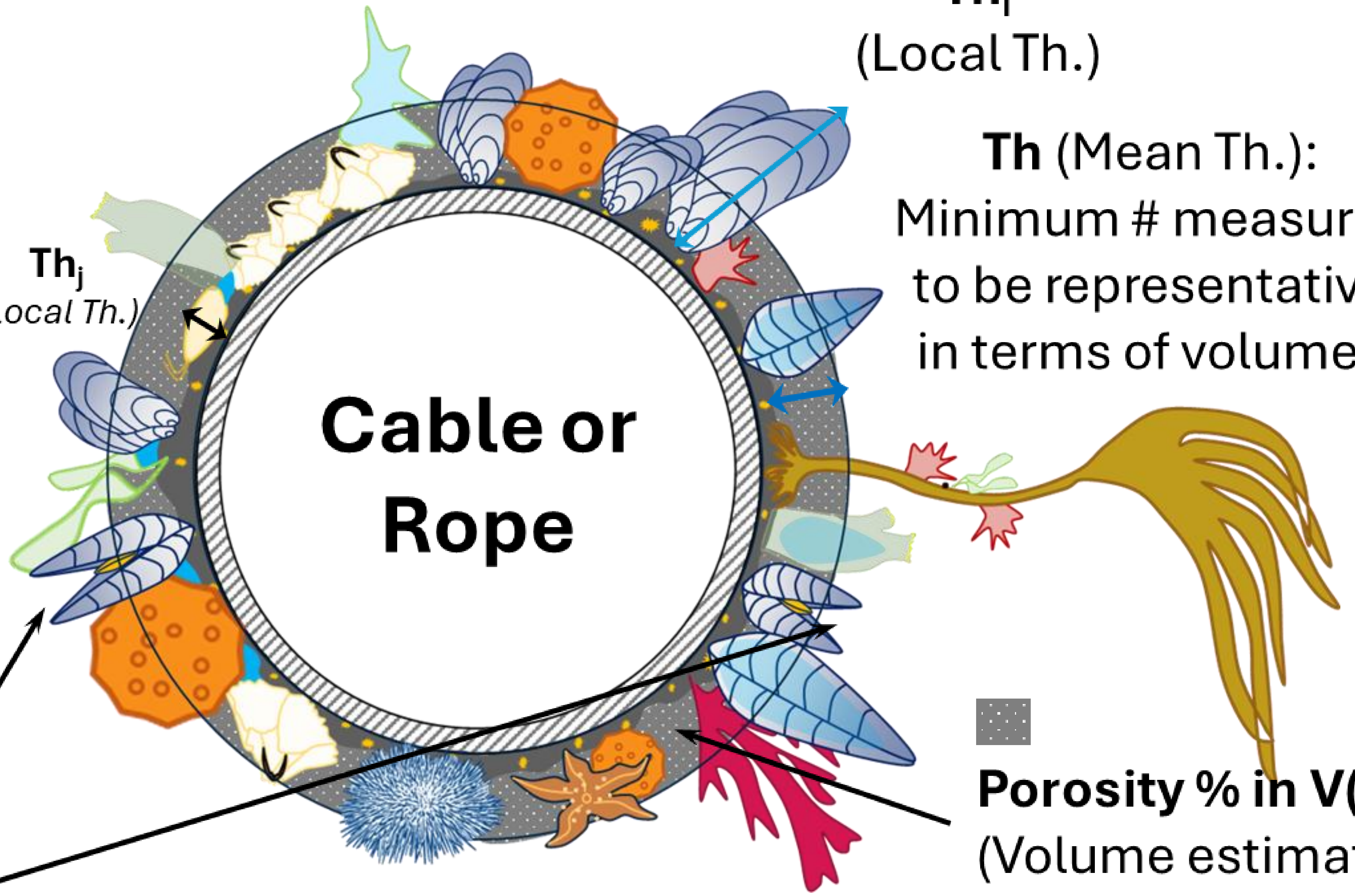
Recommendations for biofouling measurement protocol:
Refine biofouling characteristics of offshore sites: Key learnings

First layers:
Homogeneous layer w.o interaction with external flow → increased diameter

⬇

kr:
Relative to D or Dh?
How to define $k_r = f(Thi; Dh)$?

Th_j
(Local Th.)



Th_i
(Local Th.)

Th (Mean Th.):
Minimum # measures to be representative in terms of volume?

Released water (opened organisms):
Varying displaced volume

Porosity % in V(th)
(Volume estimated from Th): relevancy of the relations m, m_{sw}, V & ρ ?

Recommendations for biofouling measurement protocol:
Refine biofouling characteristics of offshore sites: Key learnings

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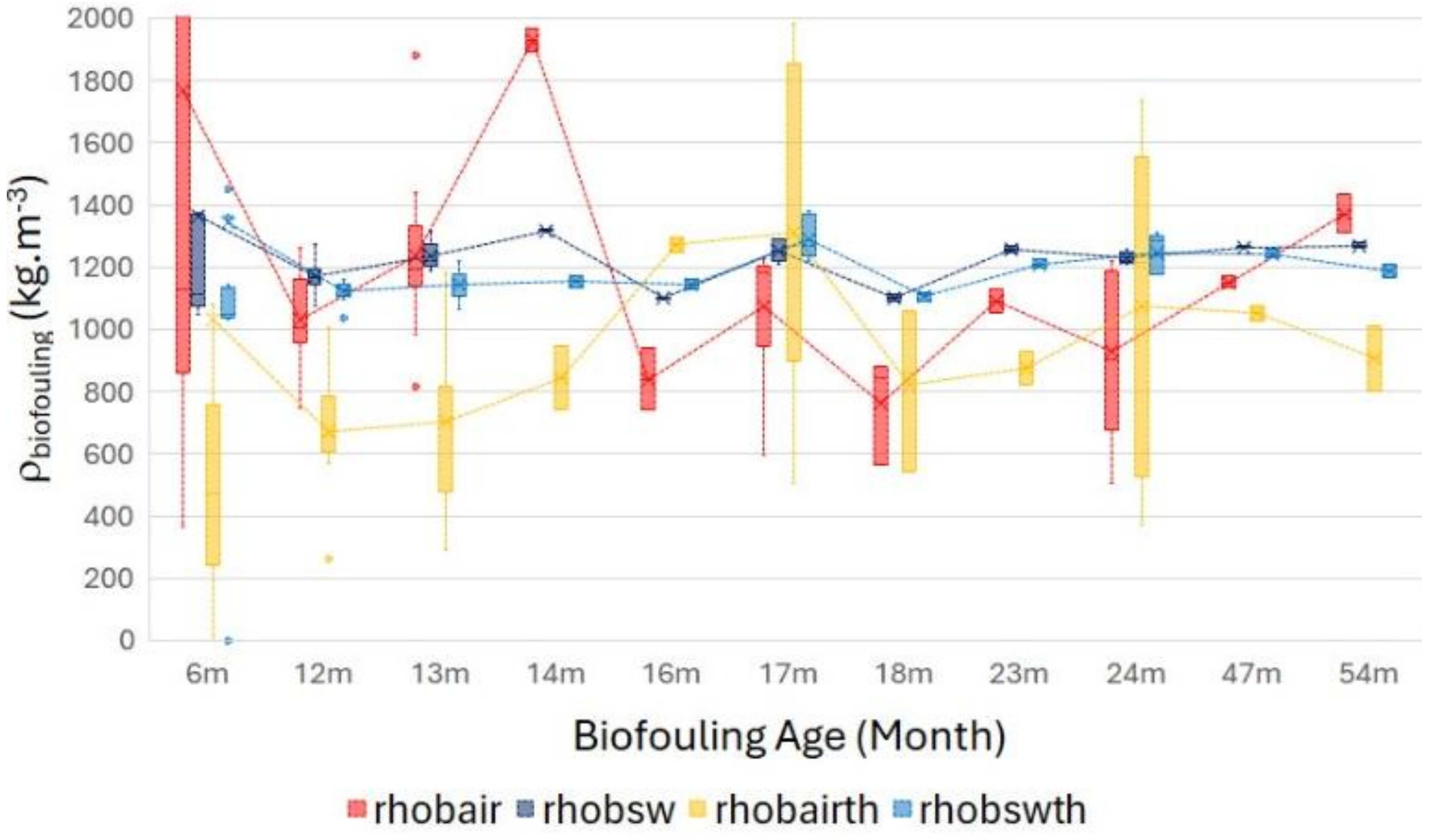
Key learnings

- Strong discrepancies observed on density when using m_{air}
- The use of volume deduced from mean Th induces a non-conservative low-density value
- Strong variability when younger than 2 years

→Calculate the density on biofouling of minimum 2 years old using mass in water and not mass in air



$$\rho_{bair} = \frac{M_b}{V_b}$$

ρ_{bairth}: using volume deduced from Th (Vth) instead of Vb

$$\rho_{bsw} = \frac{M_{bsw}}{V_b} + \rho_{seawater}$$

ρ_{bswth}: using volume deduced from Th (Vth) instead of Vb

Recommendations for biofouling measurement protocol:
Refine biofouling characteristics of offshore sites: Key learnings

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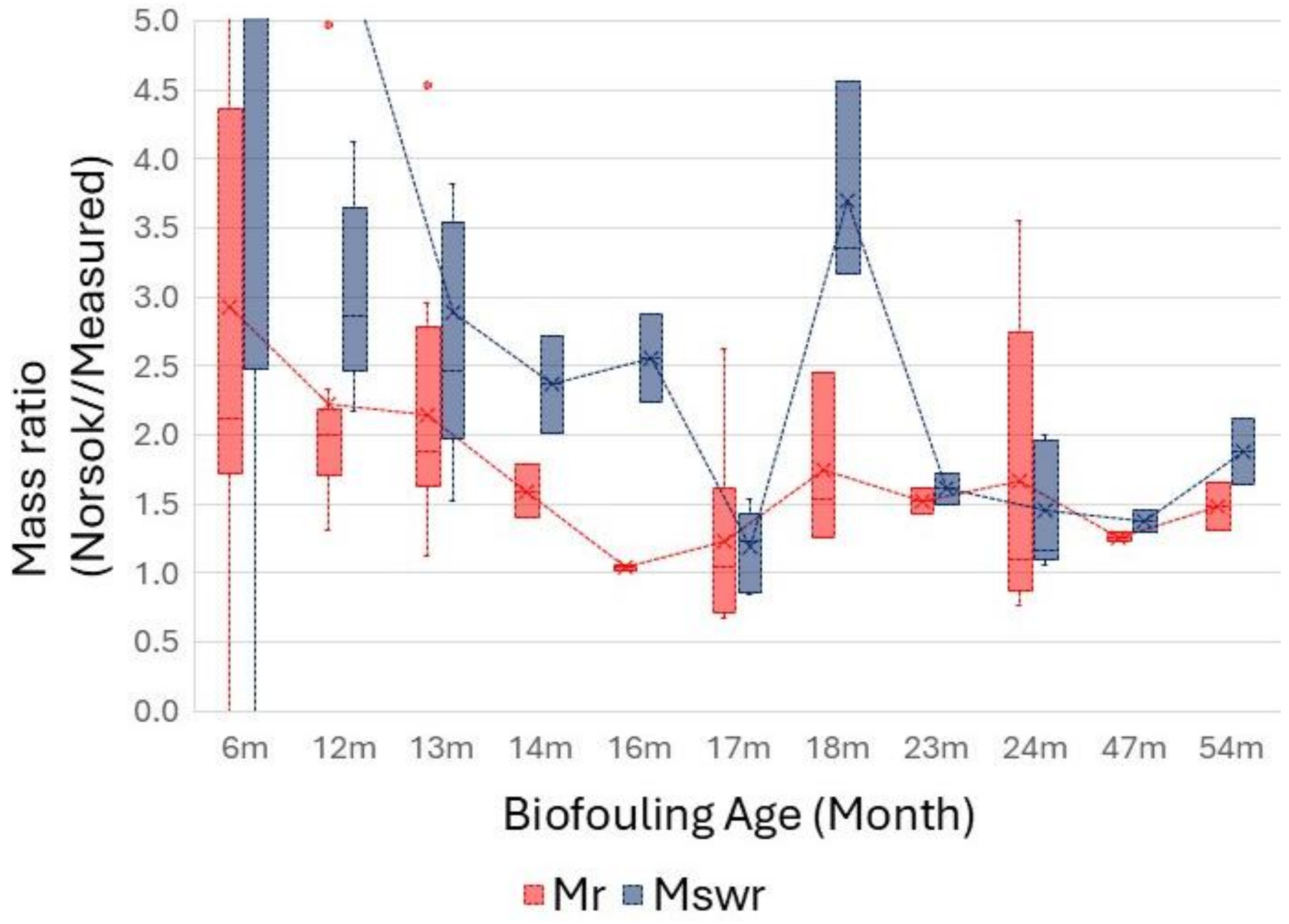
Key learnings

- Recommended in-situ protocol: Th deduced from perimeter measurements
- Even in using refined local thicknesses measurements, the Norsok calculation method overestimates both mass in air and in water
- Overestimation for mass in water is higher since volume overestimation of Norsok approach is partially compensated by water released in air on field data
- Again, value seems more stable after 2 years



Norsok Method : V_{th} & constant density ρ_{bio} = 1 325 kg.m^{-3}

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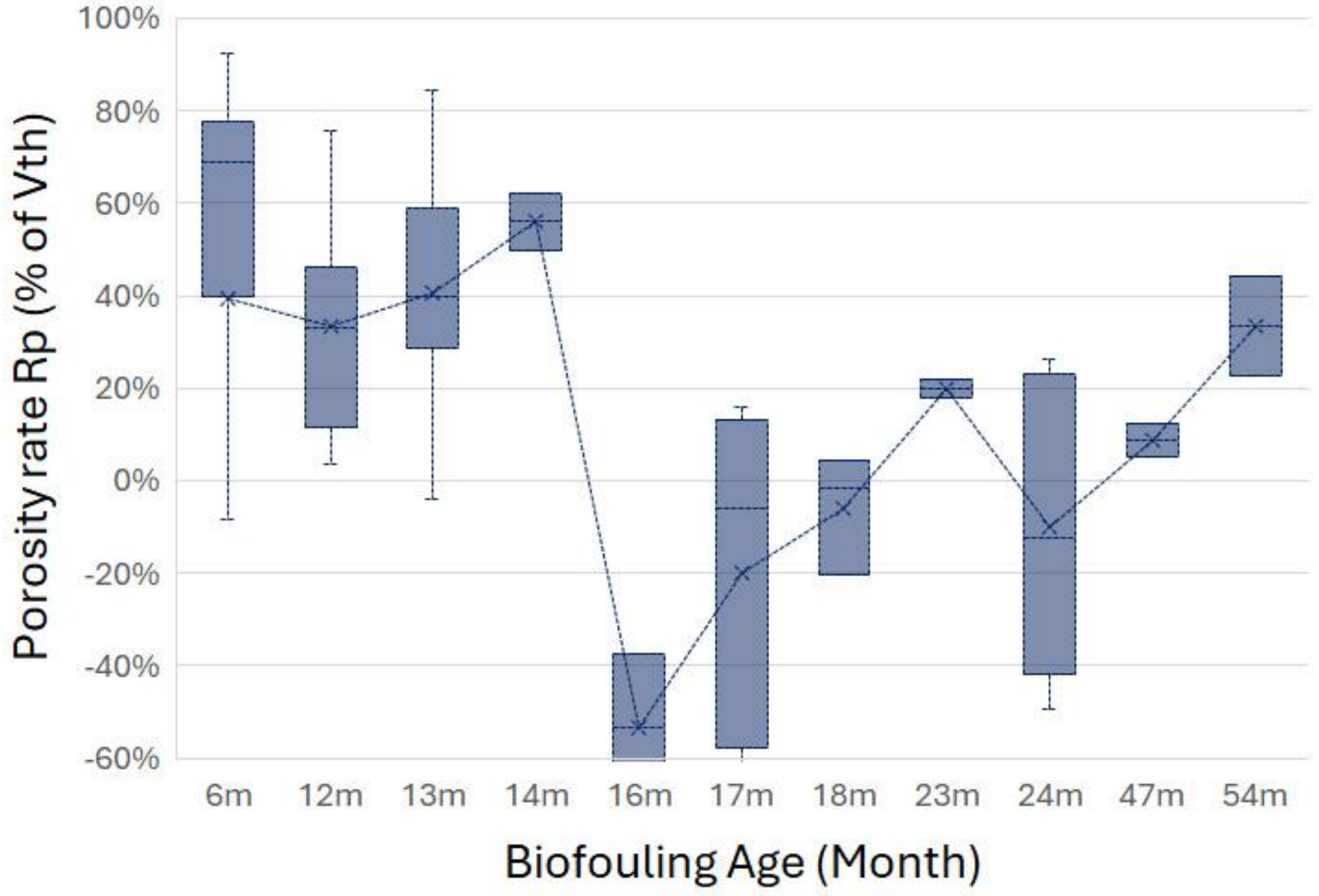
Key learnings

- Porosity rate shows high deviations because of numerous influences: age, communities but also the measurement protocol
- Start with high values (heterogeneity) ≈70%, final values around 30%
- The method to calculate roughness (hydrodynamic effect) should be still refined

- The determination of porosity and roughness properties required refined thickness measurements protocol



$$R_p = 1 - \frac{V_b}{V_{th}}$$

Recommendations for biofouling measurement protocol: Main conclusions

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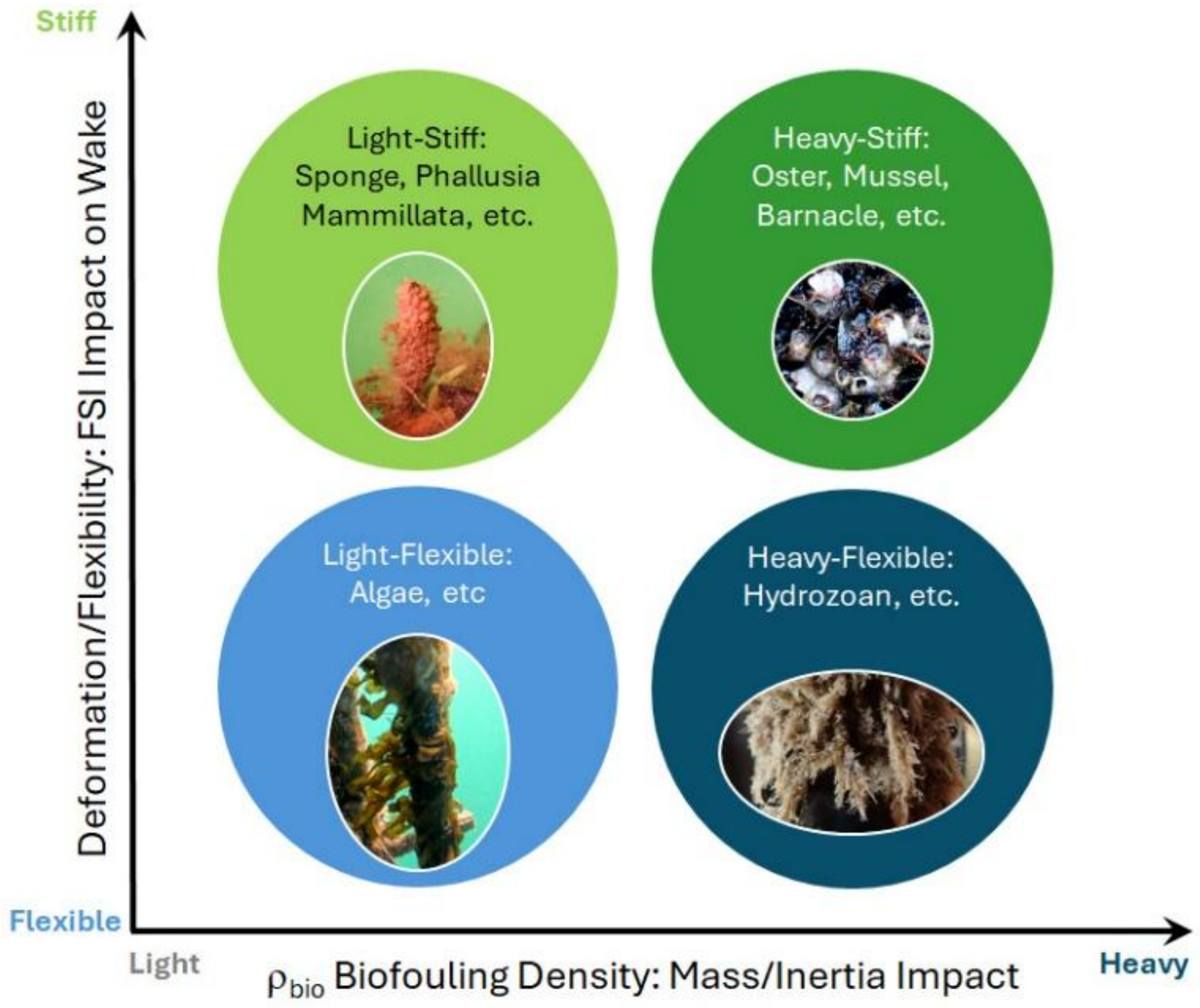
Final recommendations

Representativity

- Fibre rope AND HDPE tube should be deployed to characterize biofouling on a FWT site
- Density should be deduced from mass in water and NOT mass in air.
- Do not use data younger than 2 years
- Multi-disciplinary approach necessary for fine characterization and long-term anticipation

- Account for biological traits to better characterize hydro-mechanical properties



Thank you for your attention!