

Impact of biofouling on the design of a floating wind turbine

Illustration with FLOATGEN project



IDEOL

A PATENTED FLOATING FOUNDATION: DAMPING POOL®
for offshore wind turbines and offshore substations

A PROVEN TECHNOLOGY

2 full-scale demonstrators in operation in 2 strategic markets

A GLOBAL TEAM

HQ in France, Subsidiary in Japan, Offices in Northern Europe

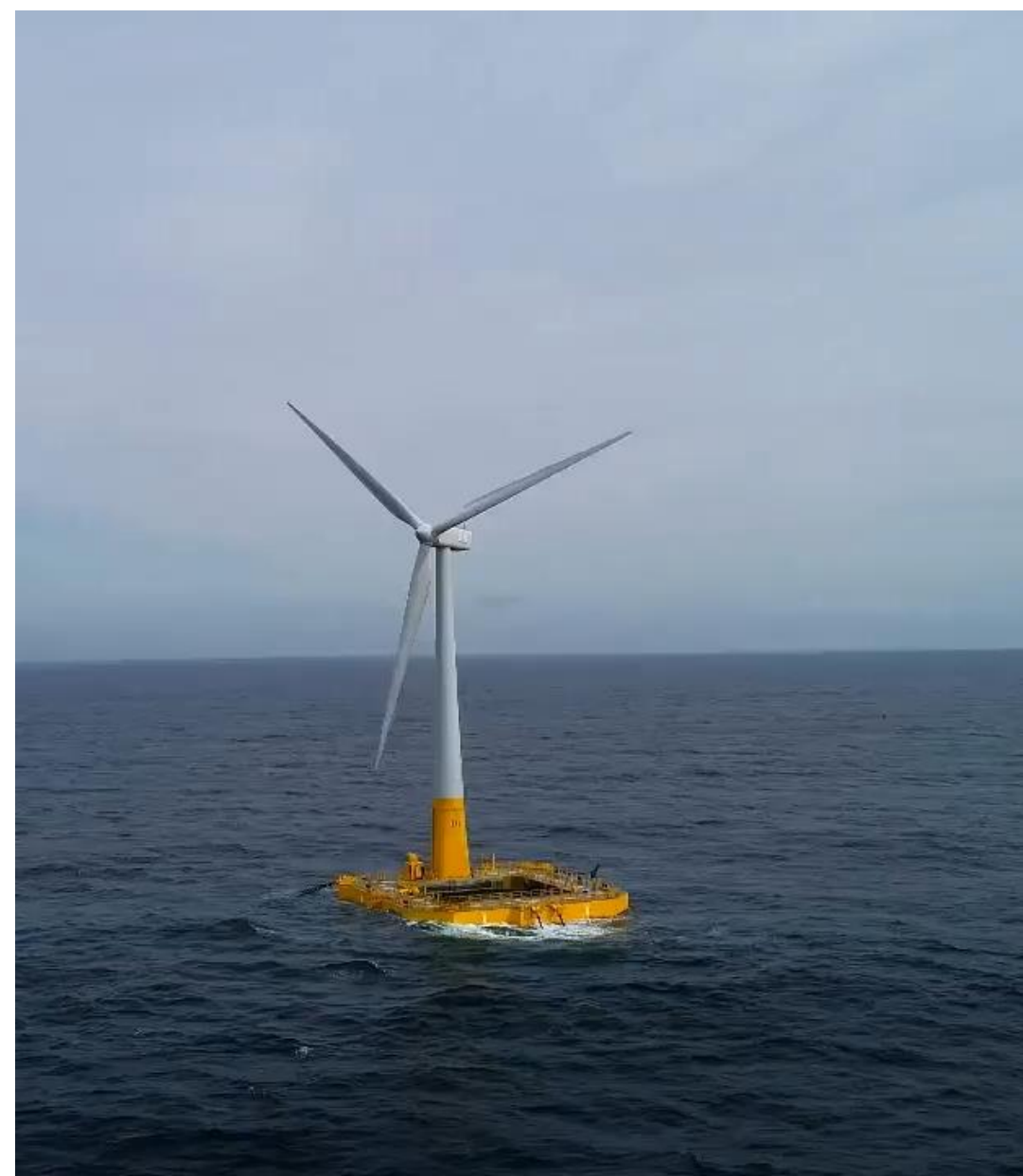


- 1 | PIONEER IN CONCRETE HULLS AND SYNTHETIC MOORING
- 2 | BUILDABLE IN STEEL OR CONCRETE
- 3 | PROVEN POWER PRODUCTION AND SEAKEEPING PERFORMANCE
- 4 | MOST COMPACT SOLUTION, HIGHEST LEVEL OF LOCAL CONTENT
- 5 | DOZENS OF R&D PROJECTS TO ACCELERATE THE COST REDUCTION TRAJECTORY OF FLOATING WIND



FLOATGEN DEMONSTRATOR

- | European project, France's first offshore wind turbine
- | Installed on SEM-REV site since April 2018
 - Water depth of 35m
 - 50-year significant wave height (H_s) of almost 9m
- | A concrete caisson
 - 36 meters square
 - 7.5 meters water draught
 - Built at quayside
- | 6 synthetic fibre mooring lines



OVERVIEW OF BIOFOULING MODELLING

Due to lack of site-specific information, biofouling is considered based on Standards

- Example of DNV-RP-C205 Environmental Conditions and Environmental Loads, 2010

6.7.4.2 In lack of site specific information the thickness of marine growth can be taken as (NORSOK N-003):

	56-59 ° N	59-72 ° N
Water depth (m)	Thickness (mm)	Thickness (mm)
+2 to -40	100	60
below -40	50	30

The thickness may be assumed to increase linearly to the given value over a period of 2 years after the member has been placed in the sea.

The density of marine growth may be set to 1325 kg/m³.

It increases the weight and drag loads on a floating structure (particularly in shallow water)

It has a limited impact on the floater, but consequent on mooring lines and dynamic cable

Increase due to biofouling	Weight in water	Drag area/diameter
Floater	+1.5%	+2%
Mooring lines	+1000%	+100%
Dynamic cable	+150%	+200%



DESIGN IMPLICATIONS



| On Floatgen, mooring lines are mainly composed of nylon fibre:

Pros	Cons
Maximum tensions reduced due to low stiffness	More important offsets
Cheaper material per length than chain	Cannot be in contact with seabed
Catenary effect is limited in shallow water	Cannot rest at the sea surface (collision, UV)

| Disadvantages are importantly linked to biofouling:

- Through the whole life of the floater, the synthetic part must remain in mid-water
- The dynamic cable must present a consequent extra length to absorb offsets, also remaining in mid-water

➤ Technical solutions must be found to accommodate for the biofouling apparition

TECHNICAL SOLUTIONS

At this stage, several options besides a regular inspection:

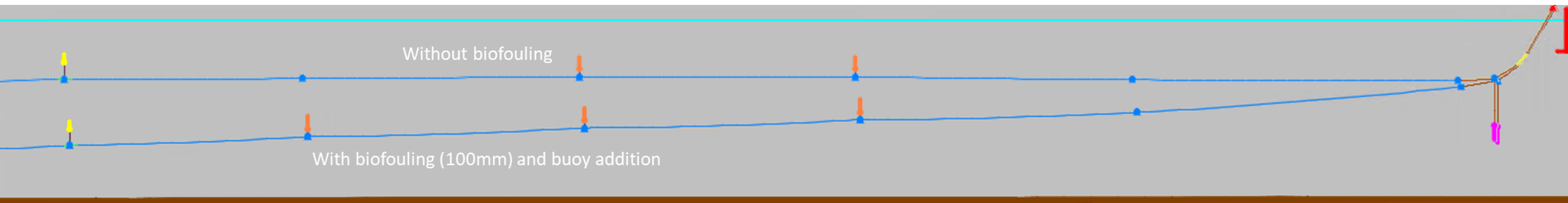
- | Finding the correct buoyancy for both extreme configurations
 - Easiest solution, but not always achievable in shallow water

- | Cleaning periodically
 - Requires important periodic offshore operations

- | Adding buoyancy at a determined level of biofouling
 - Requires a complex offshore operation and spare buoyancy

FLOATGEN MOORING SYSTEM

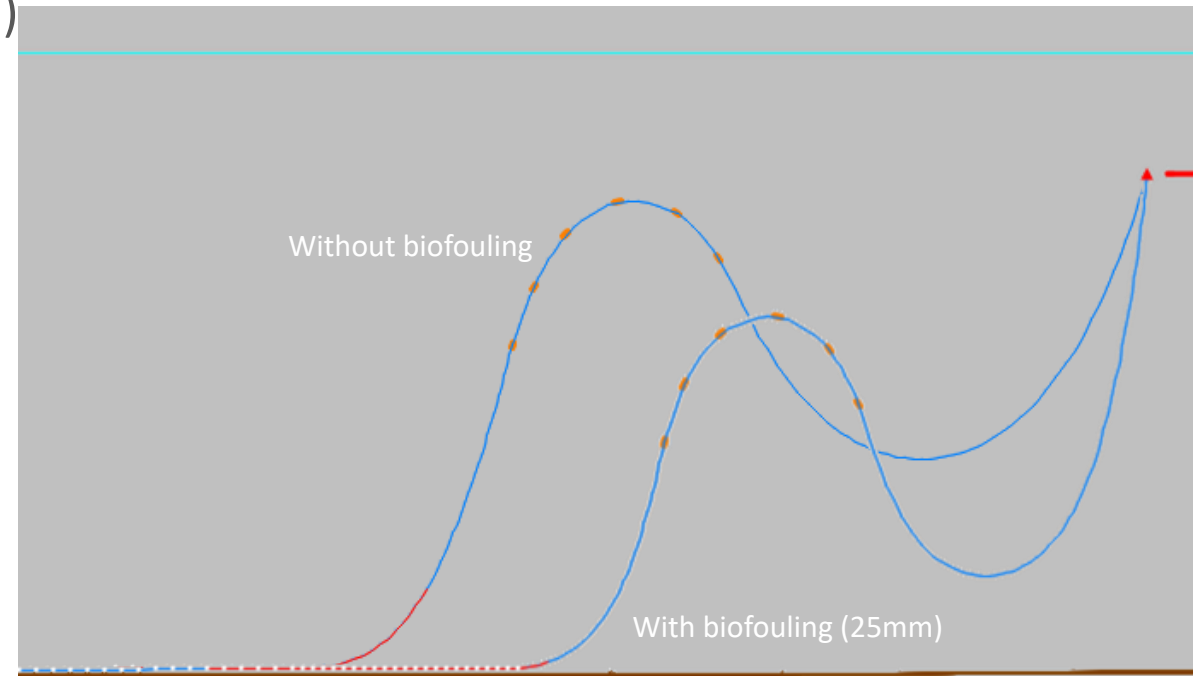
- | Floatgen has a taut mooring system composed of nylon fibre; some additional buoyancy is required to avoid contact with the seabed
- | A buoyancy configuration for both 0% and 100% of biofouling cannot be found
- | **Solution:** monitoring the mooring lines clearance with seabed/sea surface, and planning for buoys addition if required



FLOATGEN DYNAMIC CABLE

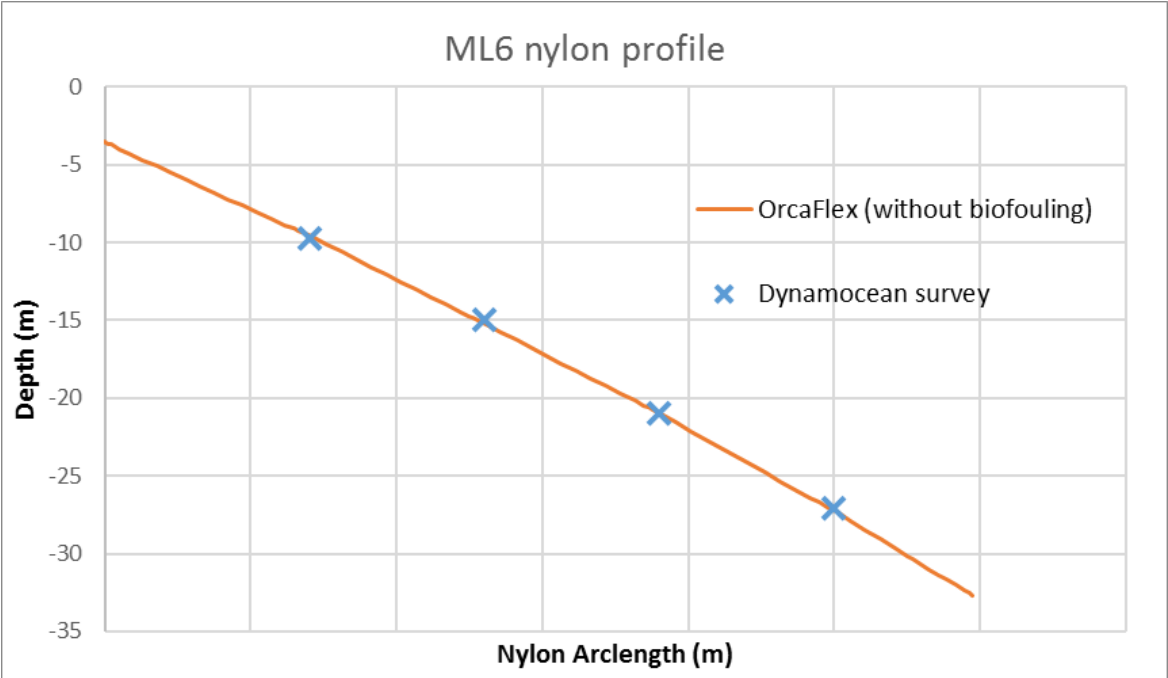
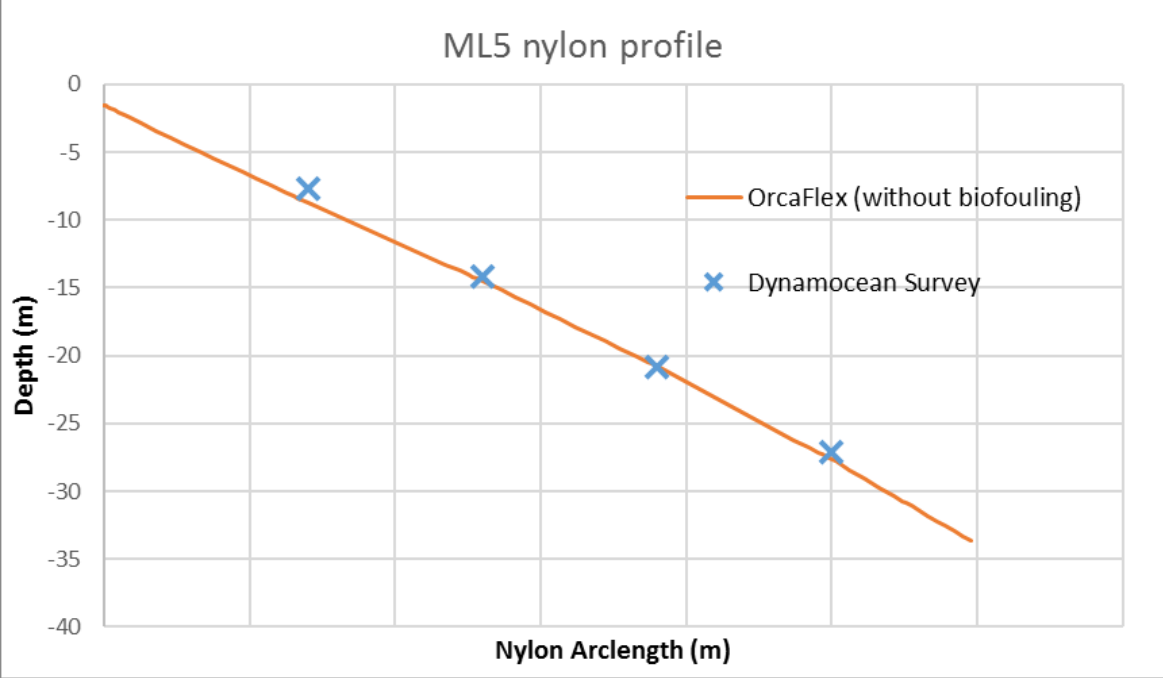
- | The Floatgen dynamic cable requires a consequent extra length (important offsets)
- | A buoyancy configuration for both 0% and 100% of biofouling cannot be found
- | **Solution:** monitoring the lazy wave clearance with seabed/sea surface, and planning for cleaning if required (>25mm all over the cable)

Load increase due to biofouling (25mm)	Effective tension	Maximum curvature
Dynamic cable	+39%	+31%



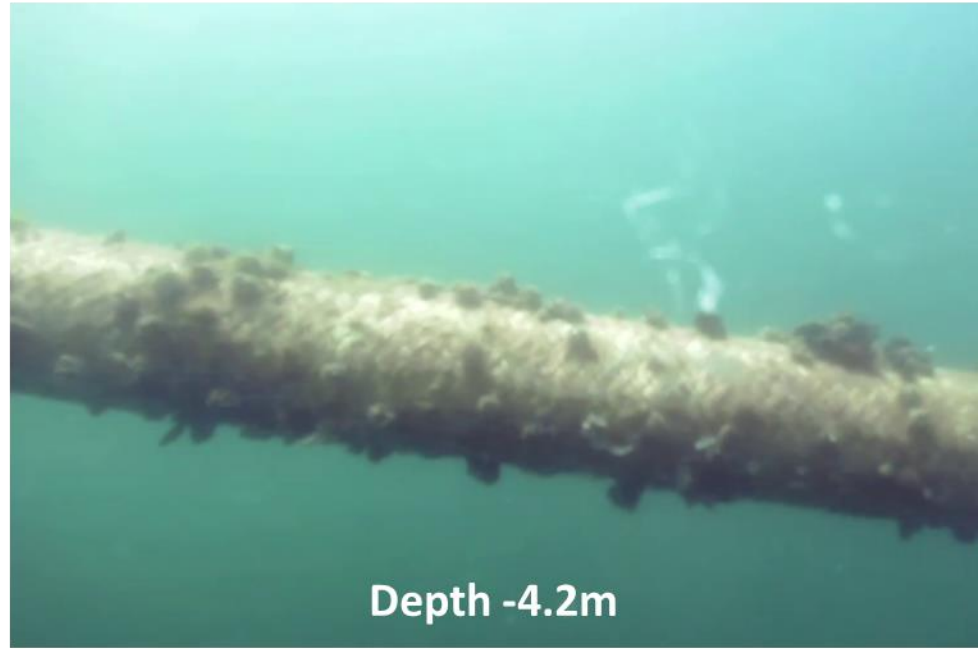
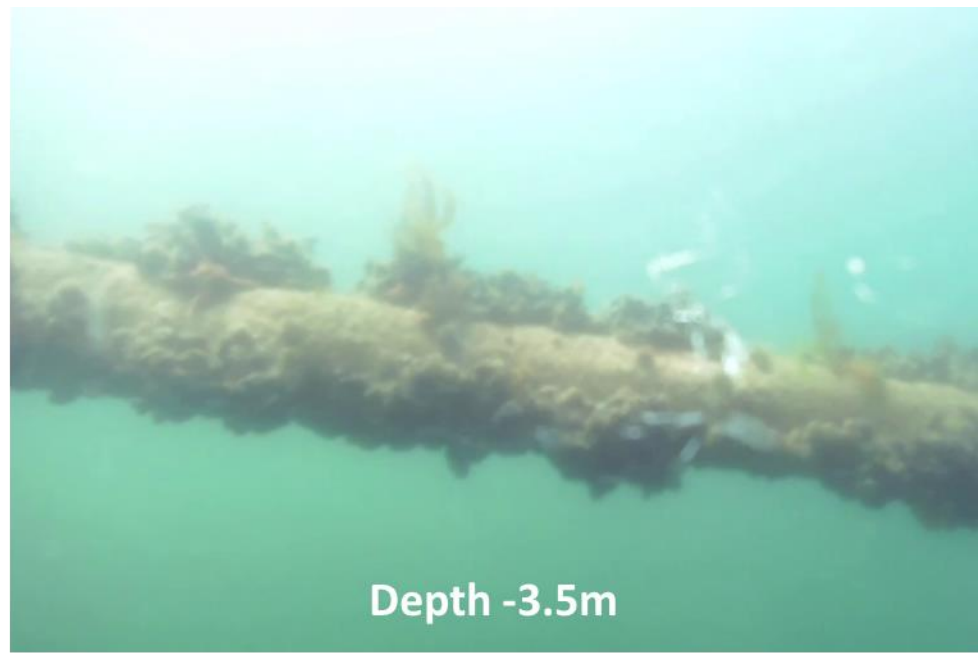
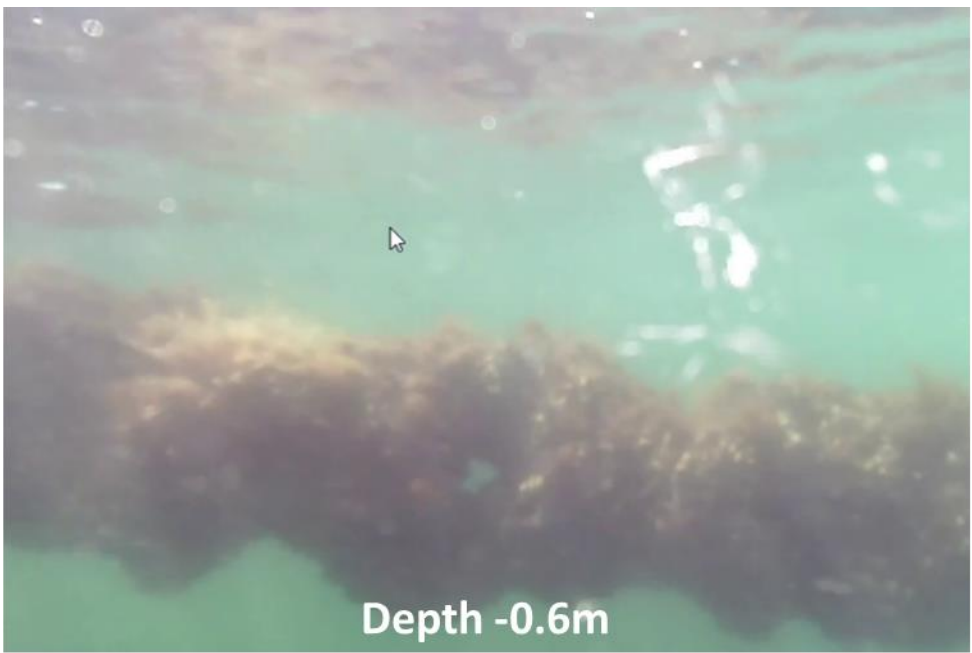
OBSERVATIONS MAY 2019 (+13 MONTHS)

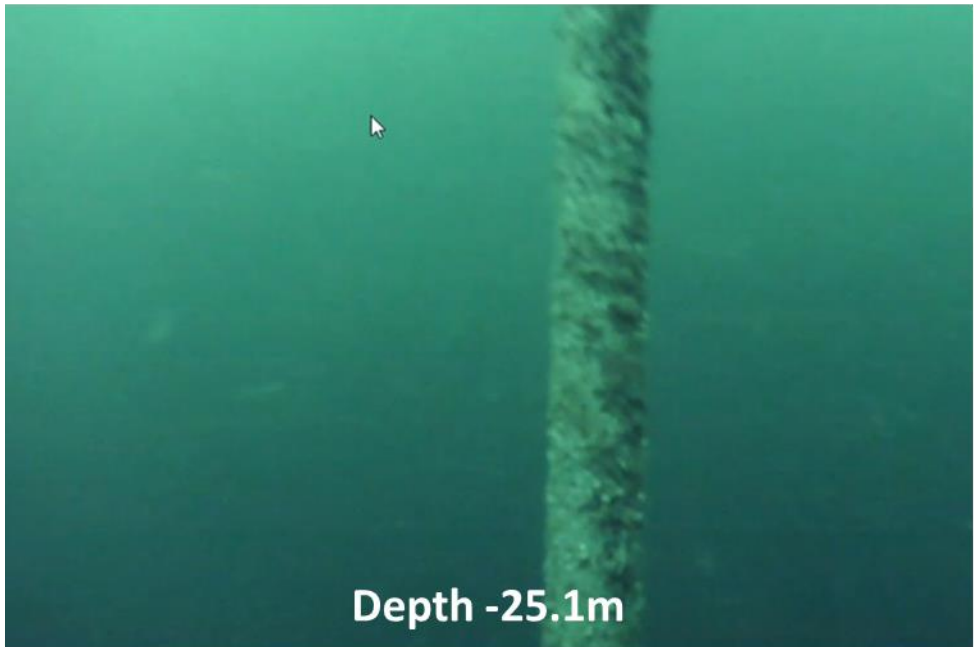
- Survey with an ROV of mooring lines and dynamic cable



➤ Comparison with numerical model suggests that very limited quantity of biofouling has colonized the lines







CONCLUSIONS

- | Marine Growth increases the weight and drag loads on a floating structure, mooring lines and dynamic cable

- | It has a limited impact on the floater, but important on mooring lines and dynamic cable

- | In shallow water, technical solutions must be found to accommodate for the biofouling apparition, besides regular inspections:
 - Finding the correct buoyancy for both extreme configurations
 - Cleaning periodically (dynamic cable solution)
 - Adding buoyancy at a determined level of biofouling (mooring lines solution)

- | Floatgen inspections show that a better characterisation could help the design of midwater components, and O&M prevision



THANK YOU FOR YOUR ATTENTION




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