Vortex Induced Vibrations on soft corals

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STUDIED SYSTEM

Soft coral - Bipinnate sea plume

Coral's polyps

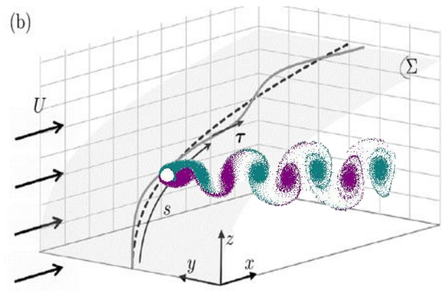
OBSERVATIONS

High frequency vibrations of the branches perpendicular to the flow

Caribbean Spiny Lobster and a Bipinnate Sea Plume coral on YouTube

HYPOTHESIS

Vortex shedding in the wake of the branches creates high frequency vibrations transverse to the flow allowing the coral to capture more nutrients.



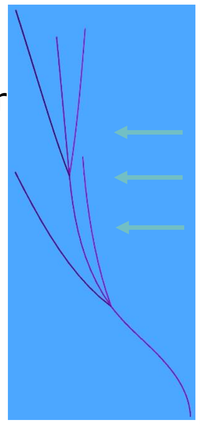
Tristan Leclercq, Emmanuel de Langre, *"Vortex-induced vibrations of cylinders bent by the flow"* *Journal of Fluids and Structures*, vol. 19, no. 2, pp. 123–140, March. 2018.

OBJECTIVES

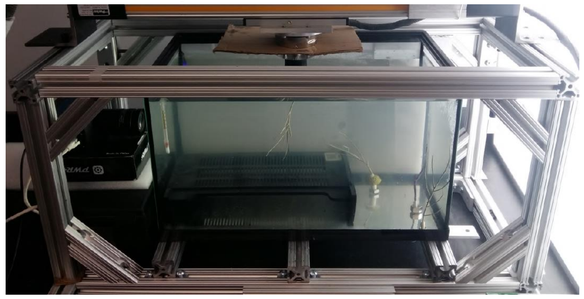
1. To model a 3D vibrating branched structure in crossflow with finite éléments methods.
2. Study the dynamics of a 3D printed coral in an oscillating crossfolw.

METHODOLOGY

1. A) Implement the wake oscillator model in ONSAS (Open Non linear Structural Analysis Solver)
   B) Study the influence of parameters like $\mathrm{K_C}, \mathrm{C_Y}, \Gamma, \theta$ on the coral dynamics



2. A) Use SLA printing to validate experimentally the numerical results
   B) Record coral vibrations to do a modal analyis of the vibrations



Setup made by Camille Soenen in 2019

WAKE-OSCILLATOR MODEL

To avoid DNS the wake is modelled by an oscillating lift force

$$\mathrm{C_L} = \frac{\mathrm{C_L^0}}{2} q$$

with *q* solution of the Vander Pol oscillator equation:

$$\ddot{q} + \varepsilon \left(2\pi \frac{S_t U}{D} \cos\theta_0\right)(q^2 - 1)\,\dot{q} + \left(2\pi \frac{S_t U}{D} \cos\theta_0\right)^2 q = A\frac{\ddot{Y}}{D}.$$

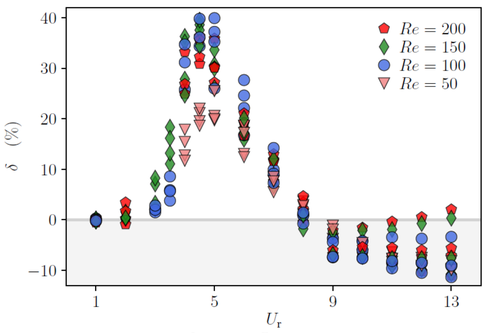
FIRST RESULTS (Boudina 2020 thesis)

Capture efficiency of a fixed cylinder:

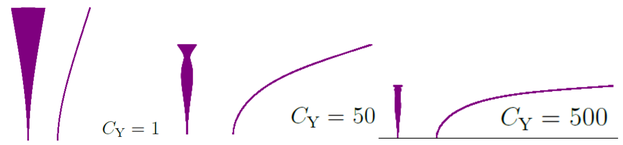
$$\langle\eta\rangle_{\mathrm{fixed}} = 0.38 R^{2.09} Re^{0.52}$$

Capture efficiency of a vibrating cylinder:

$$\delta = \frac{\langle\eta\rangle - \langle\eta\rangle_{\mathrm{fixed}}}{\langle\eta\rangle_{\mathrm{fixed}}}$$



There should be an optimal $\mathrm{C_Y}$ for capture



CONCLUSION (Boudina 2020 thesis)

- VIV are at the origin of the observed high frequency vibrations
- VIV allow up to 40% increase in capture efficiency

NOMENCLATURE

A :	coupling constant in the wake-oscillator model	Γ:	branch aspect ratio
$\mathrm{C_L^0}$:	constant lift coefficient	K_c:	Keulegan Carpenter number
C_L:	lift coefficient	q:	oscillating parameter(bidisperse case)
D	branch diameter	R:	particles radius
ϵ :	coupling constant in the wake-oscillator model	Re:	Reynolds number
$\langle\eta\rangle fixed$:	capture efficiency of a fixed cylinder	S_t:	Strouhal number
$\langle\eta\rangle$:	capture efficiency of a cylinder with VIV	θ_0:	flow incidence angle
		U:	constant flow velocity
		$\ddot{Y}$:	branch acceleration transverse to the flow

ACKNOWLEDGMENTS

CRSNG NSERC
FONCER
GPS Génie par la simulation
SBES Simulation - Based Engineering Science