

HydroPêche: experimental and numerical developments for fishing devices optimisation

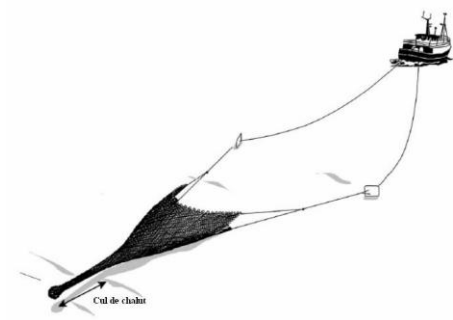
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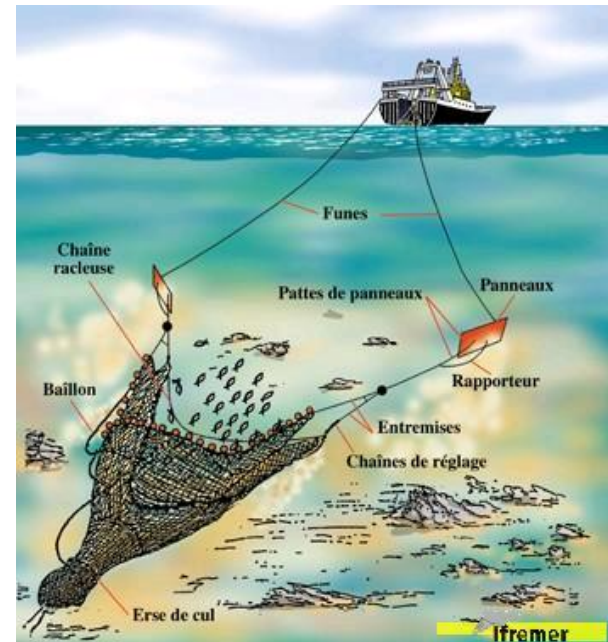
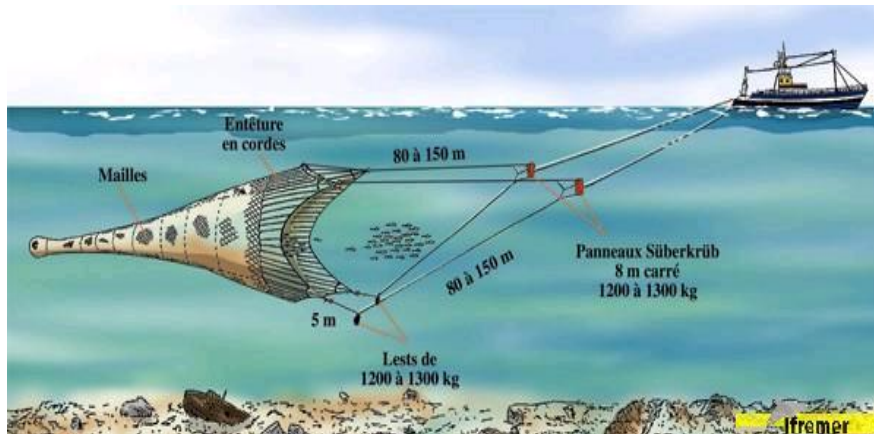


HydroPêche Project

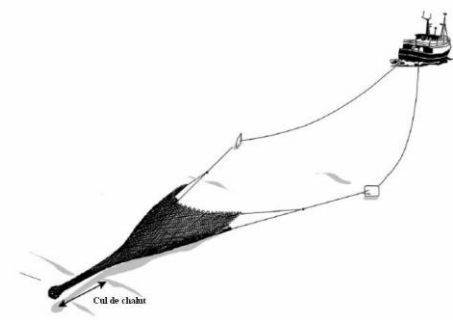


Goal of the project:

to develop tools for trawl optimisation in order to minimize the drag of the gear.



HydroPêche Project

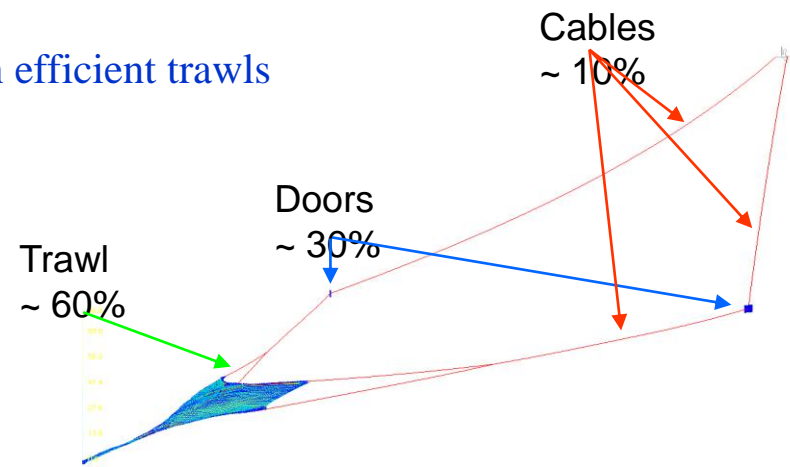


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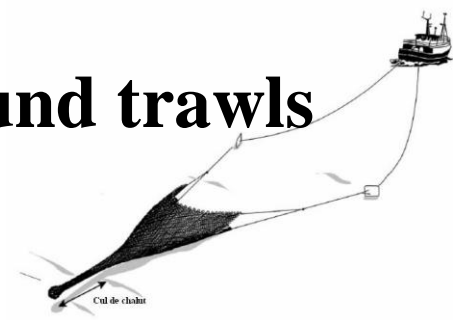
to develop tools for trawl optimisation in order to minimize the drag of the gear.

A work in three areas:

- to extend the basis of experimental data on flow characteristics governing the hydrodynamic behaviour of different porous structures
- to develop numerical tools to simulate more realistic flow around porous structures taking into account fluid / structure interactions
- to develop optimisation tools to design efficient trawls in terms of energy consumption.

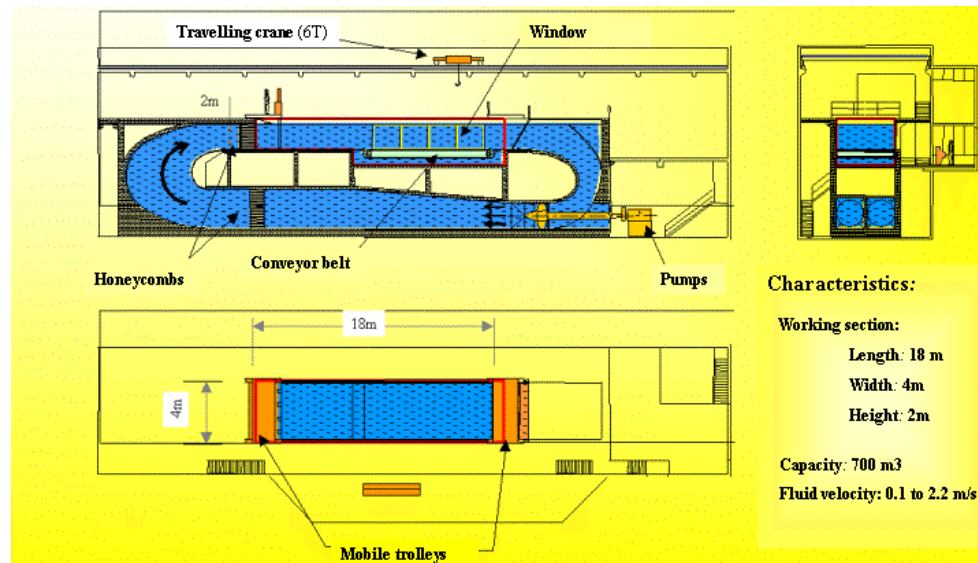


Experimental flow characterization around trawls



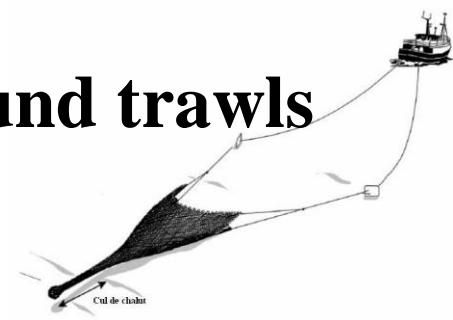
Goal of this task:

- to extend the basis of experimental data on flow characteristics governing the hydrodynamic behaviour of different porous structures (sheets of net, trawls)
- to identify the areas where the drag is generated



Wave – Current flume tank

Experimental flow characterization around trawls

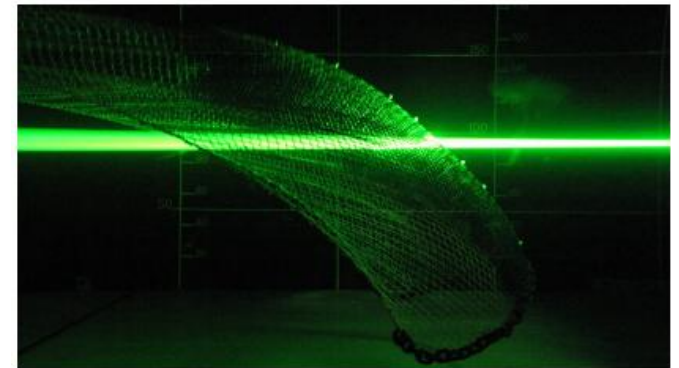
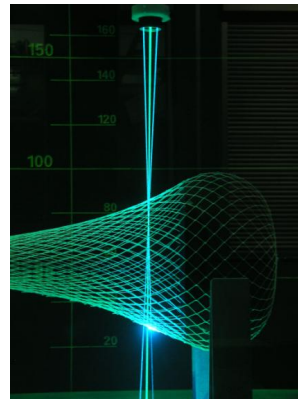
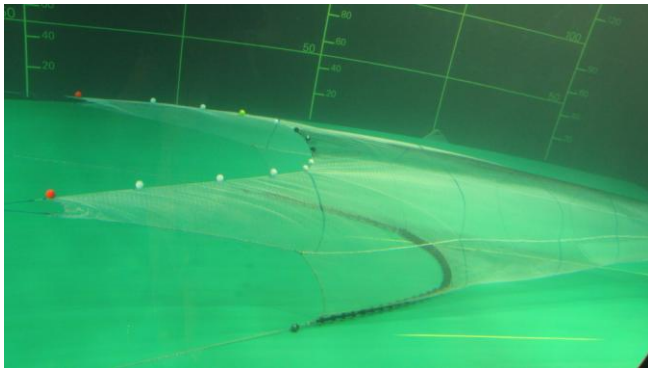


Goal of this task:

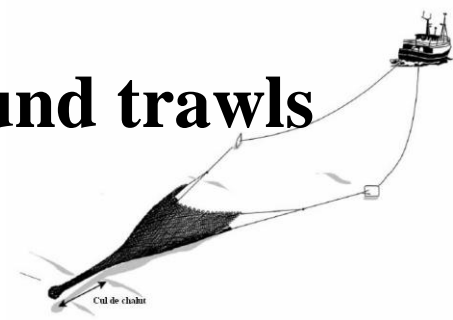
- to extend the basis of experimental data on flow characteristics governing the hydrodynamic behaviour of different porous structures (sheets of net, trawls)
- to identify the areas where the drag is generated

Three kinds of trials:

- Flow characterisation around a 1/10 bottom trawl
- Flow characterisation around a rigid cod-end
- Flow characterisation around a large rectangular piece of net



Experimental flow characterization around trawls



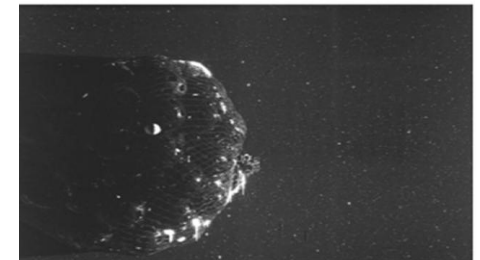
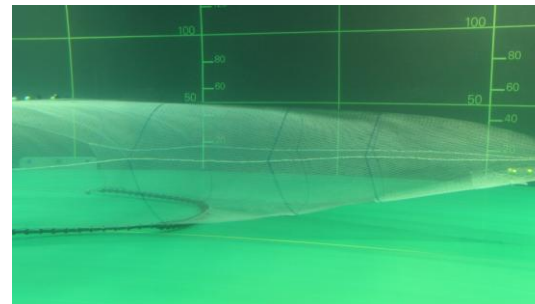
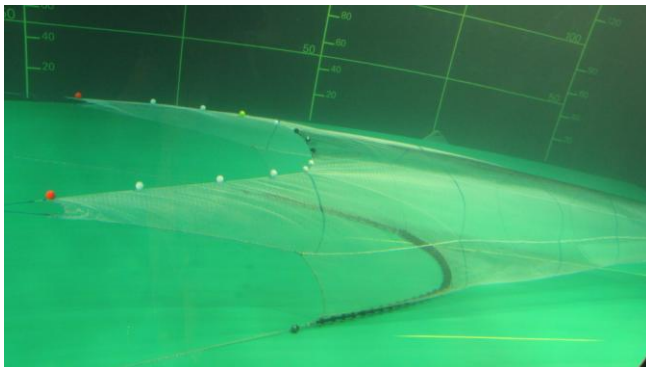
Flow characterisation around a 1/10 bottom trawl



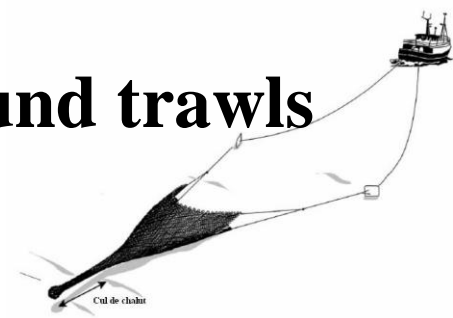
to perform velocity field measurements around a moving bottom trawl
to develop post-processing tools aiming at characterizing the

to provide measurement benchmark for numerical modeling

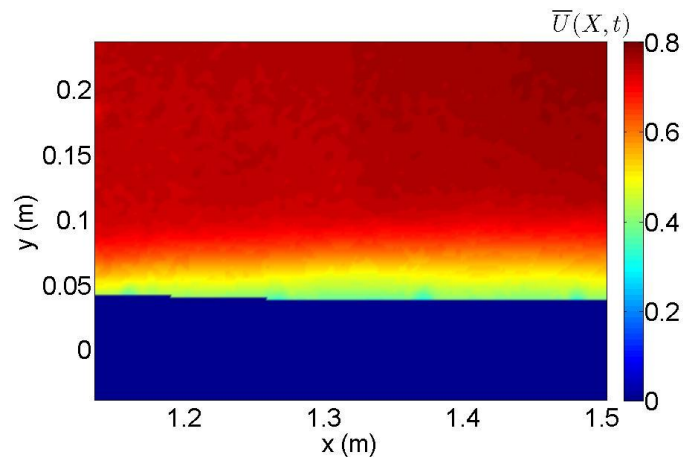
unsteady flow



Experimental flow characterization around trawls

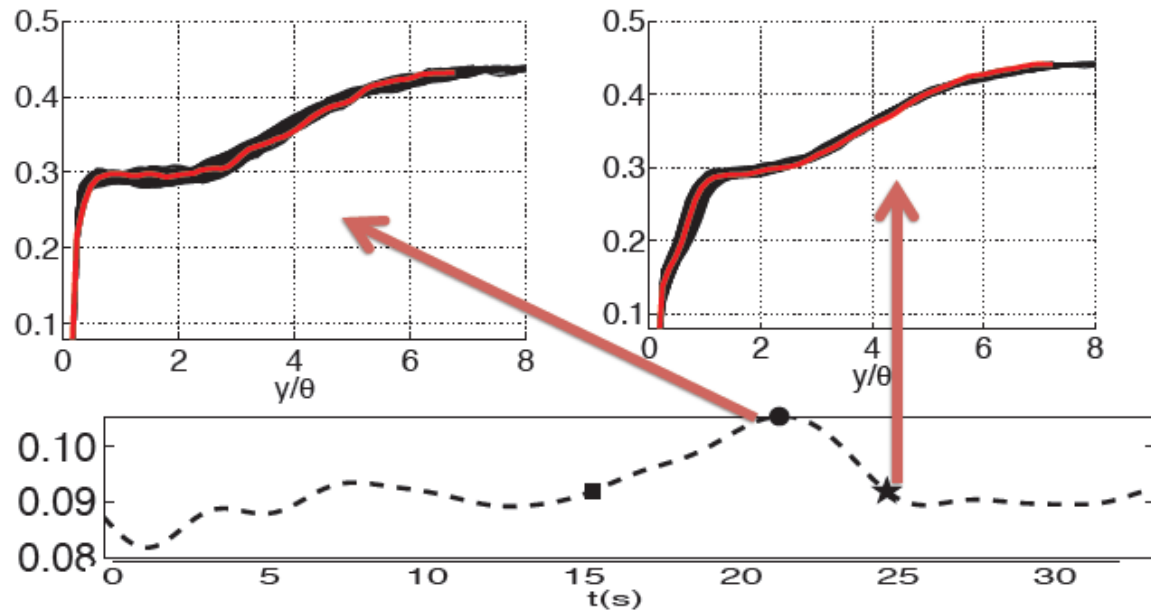


Flow characterisation around a 1/10 bottom trawl



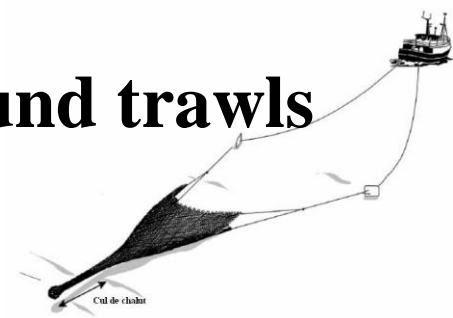
Boundary layer evolution

Representation of mean flow field along the transverse direction at a fixed streamwise location and for two different instants

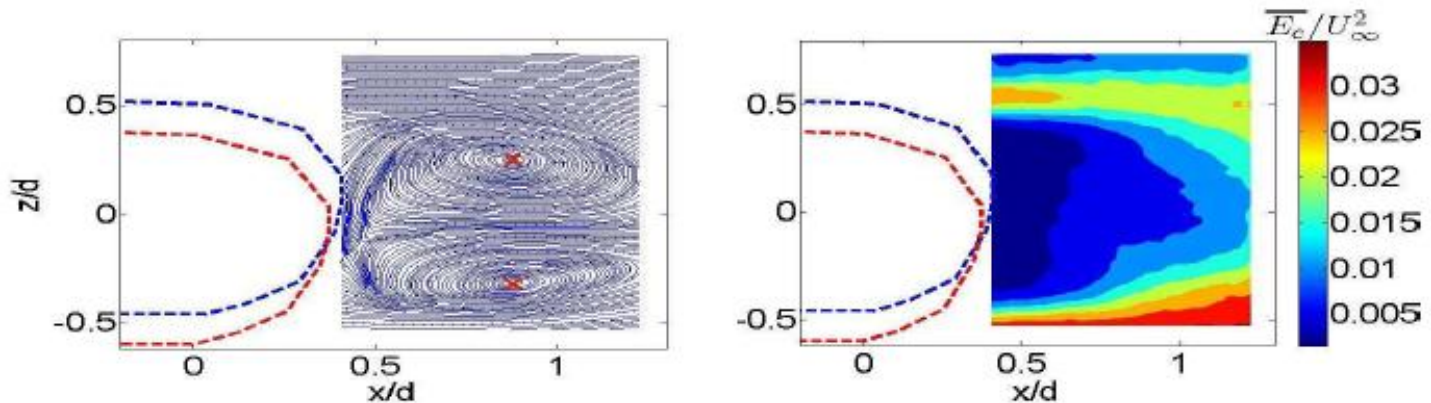


Time evolution of the bottom trawl during measurement

Experimental flow characterization around trawls

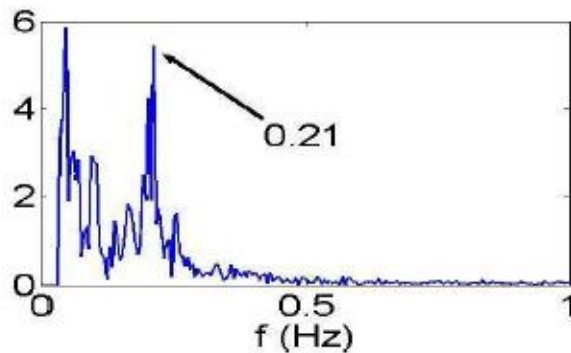


Flow characterisation around a 1/10 bottom trawl

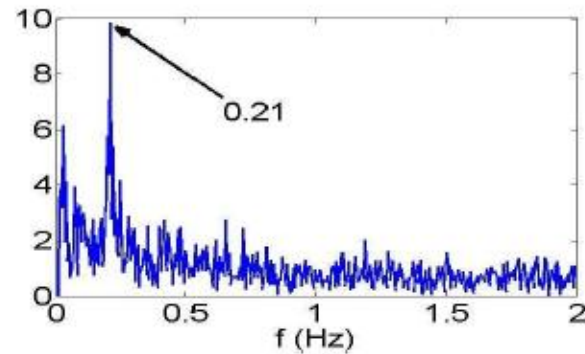


Mean flow streamline topology

Kinetic energy

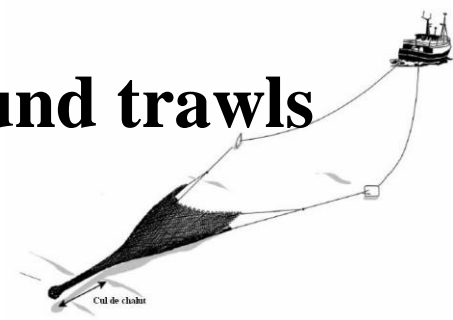


Power spectrum of the vertical motion



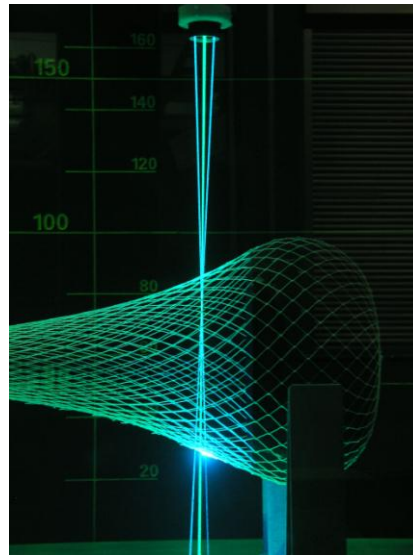
Power spectrum of Ux

Experimental flow characterization around trawls



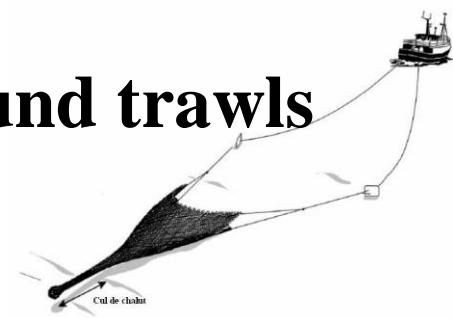
Three kinds of trials:

- Flow characterisation around a 1/10 bottom trawl
- Flow characterisation around a rigid cod-end
- Flow characterisation around a large rectangular piece of net




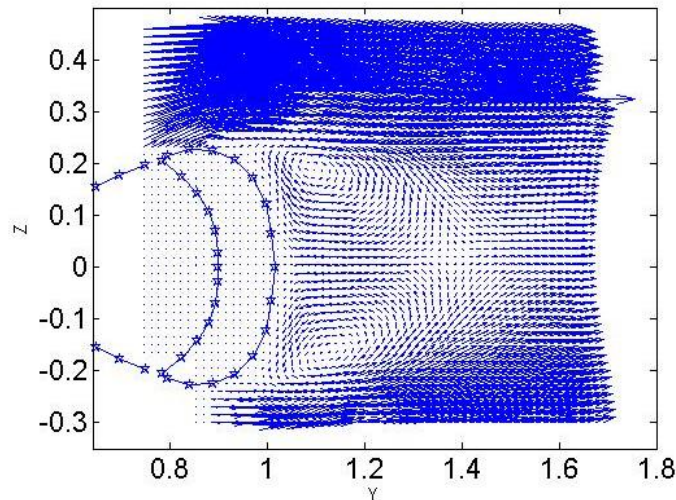
LDV measurements on a rigid cod-end

Experimental flow characterization around trawls

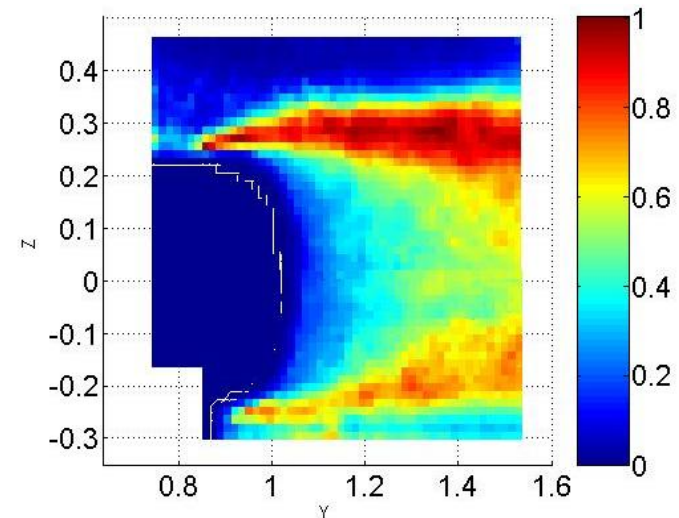


Flow characterisation around a rigid cod-end

- 
- mean flow field
 - mean kinetic energy
 - vortex shedding frequency

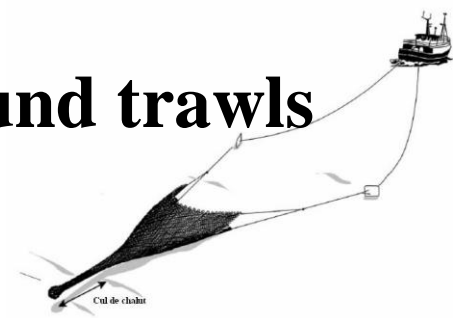


Mean velocity field



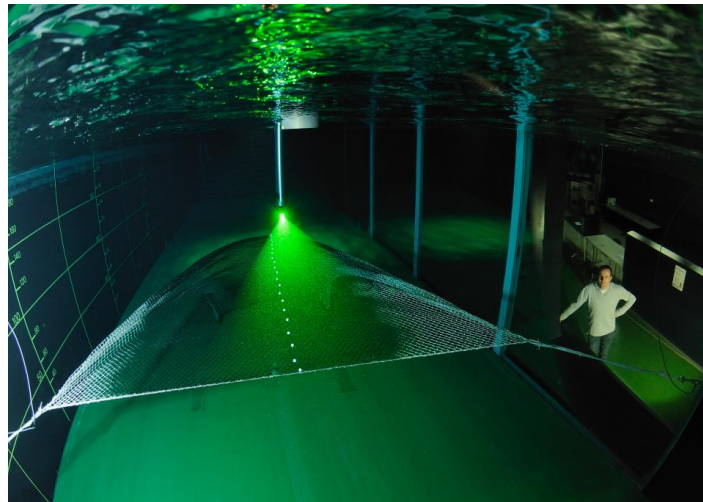
Turbulent kinetic energy

Experimental flow characterization around trawls



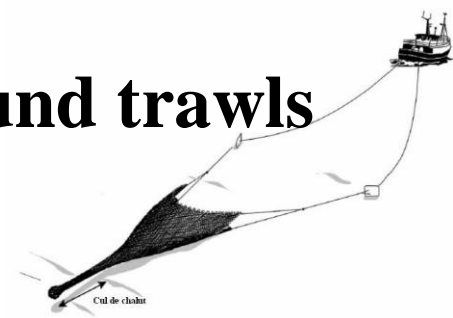
Three kinds of trials:

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PIV measurements on a piece of net

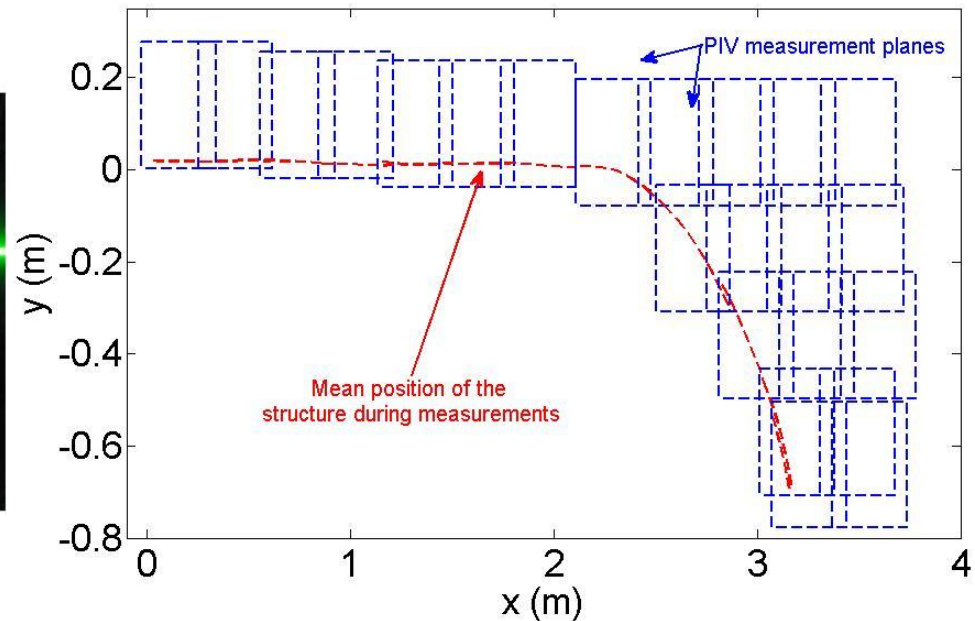
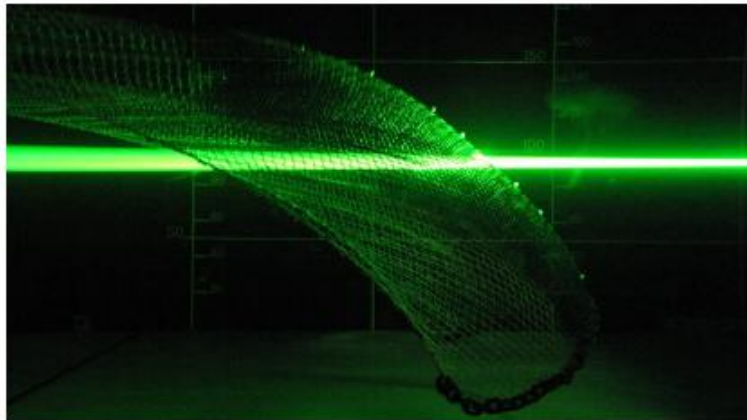
Experimental flow characterization around trawls



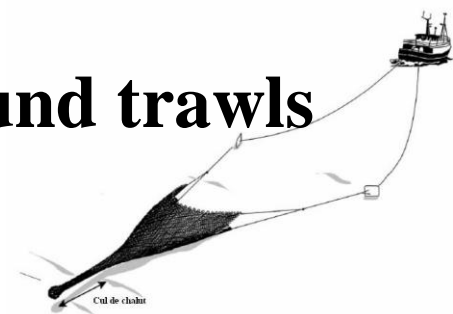
Flow characterisation around a large rectangular piece of net



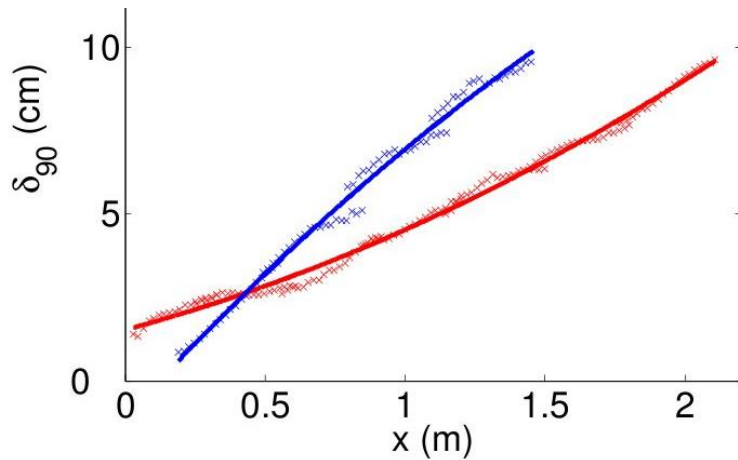
- mean flow field
- comparison with bottom trawl results
- flow behavior over the curved part



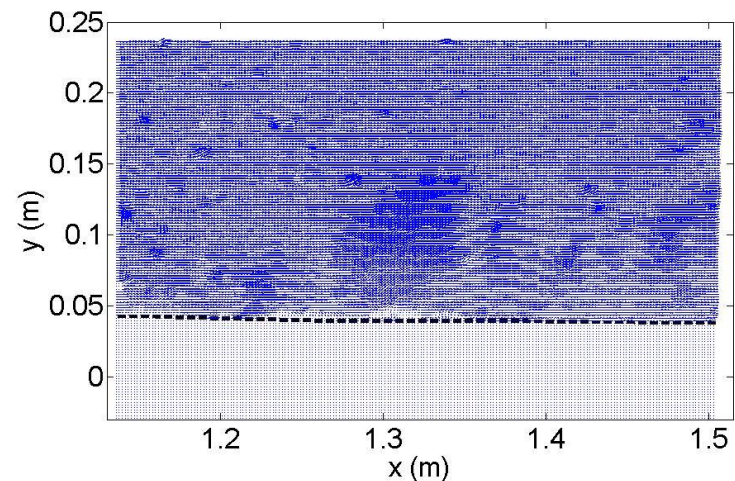
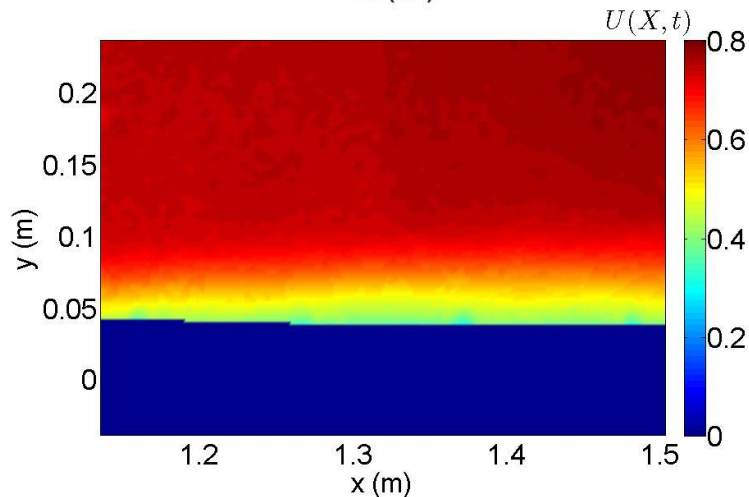
Experimental flow characterization around trawls



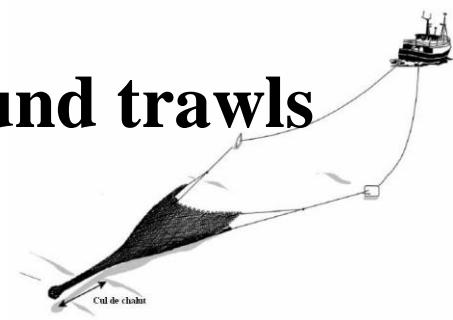
Flow characterisation around a large rectangular piece of net



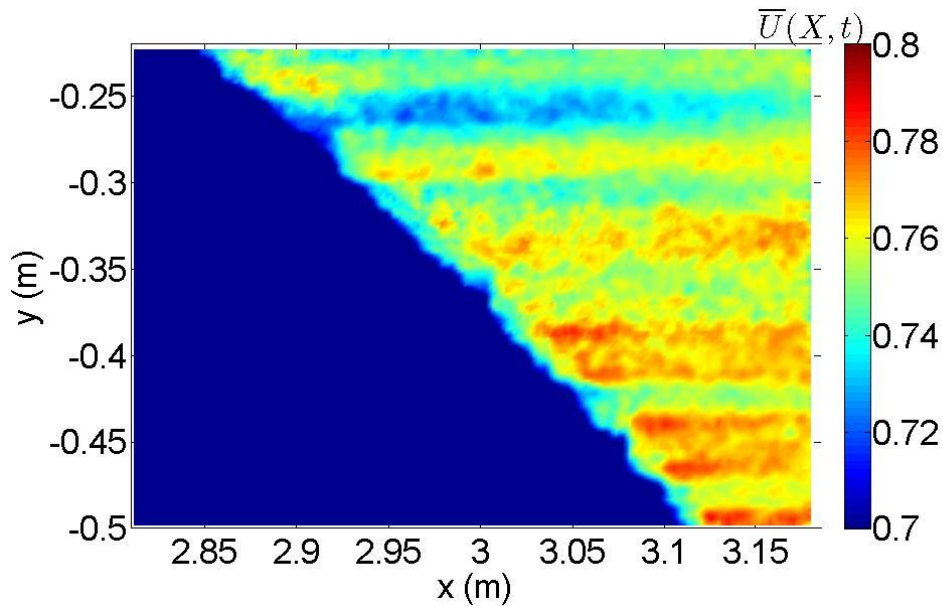
δ = function of : porosity,
Reynolds number,
and ??



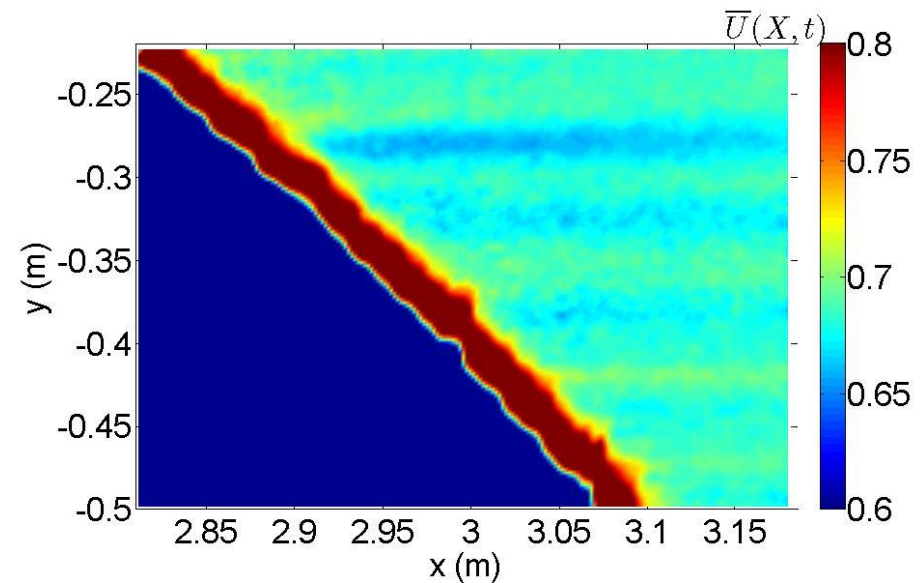
Experimental flow characterization around trawls



Flow characterisation around a large rectangular piece of net

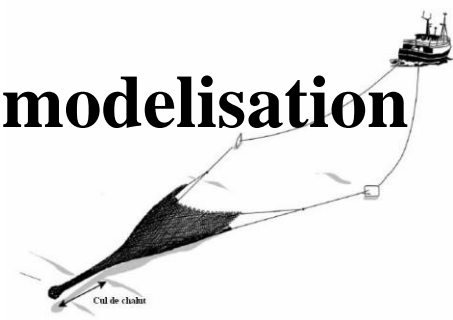


Mean velocity at a upper location



Mean velocity at a lower location

Numerical simulations for trawl behaviour modelisation



Goal of this task:

- to develop numerical tools to simulate more a realistic flow around porous structures taking into account fluid / structure interactions

State of the art:

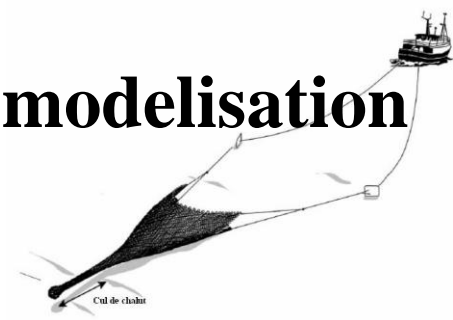
- use of Landweber / Richtmeyer law to calculate the fluid forces on the net:

$$F = \frac{1}{2} \rho C_d D L (V \sin \theta)^2$$

$$T = f \frac{1}{2} \rho C_d D L (V \cos \theta)^2$$

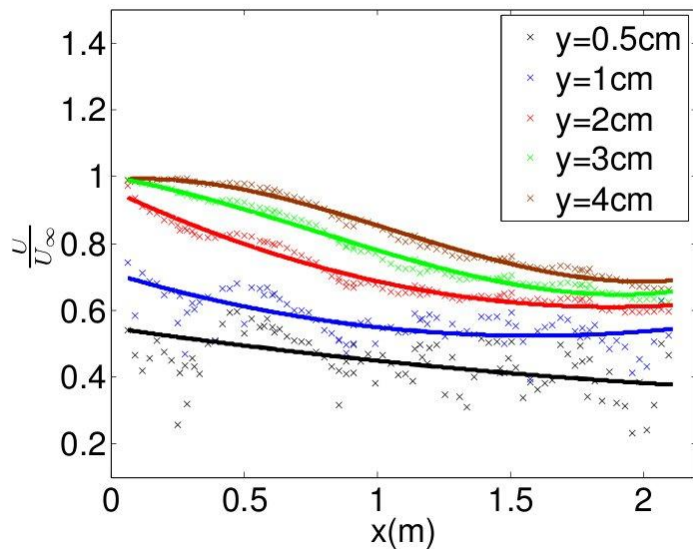
- no fluide / structure interaction

Numerical simulations for trawl behaviour modelisation

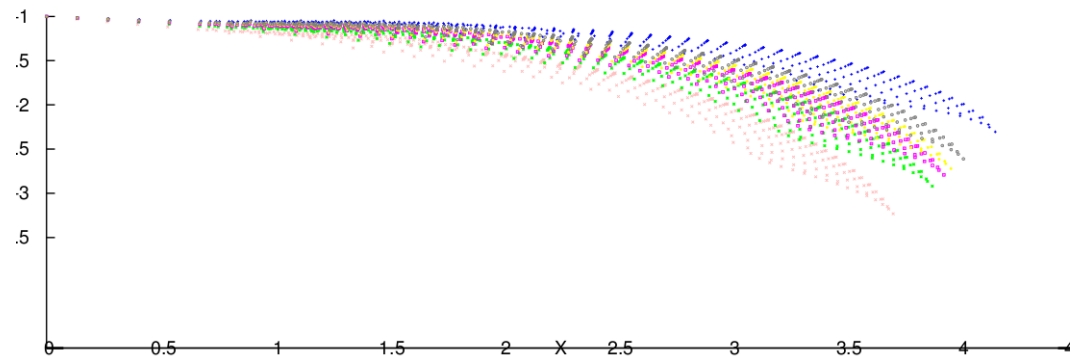


First step of development:

experimental velocity profil integration in FEM model:
- in the turbulent boundary layer zone



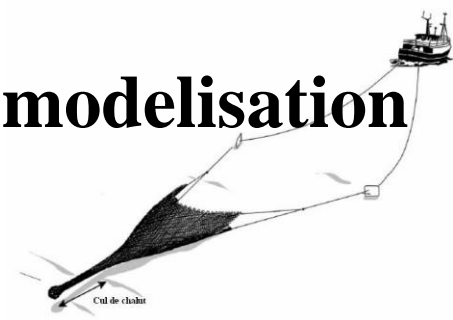
Flow velocity in the TBL



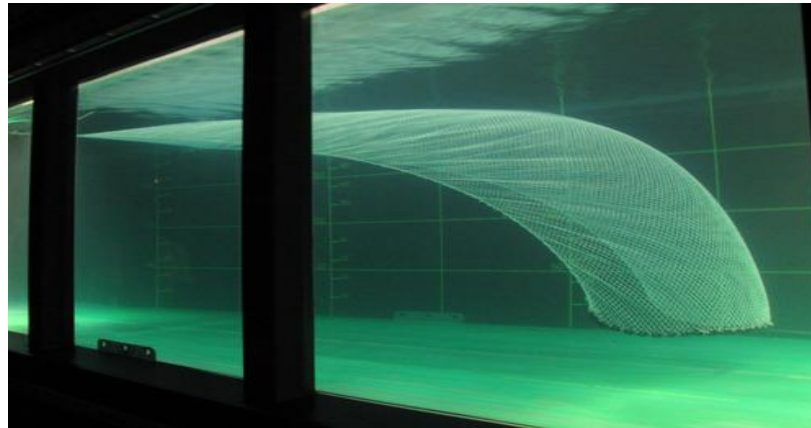
Sensibility of the FEM net model to TBL velocity

- around curved parts: in progress

Numerical simulations for trawl behaviour modelisation

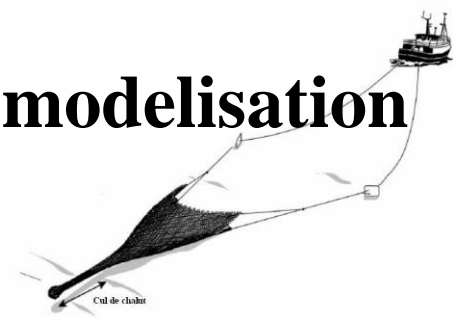


3D integration in progress:

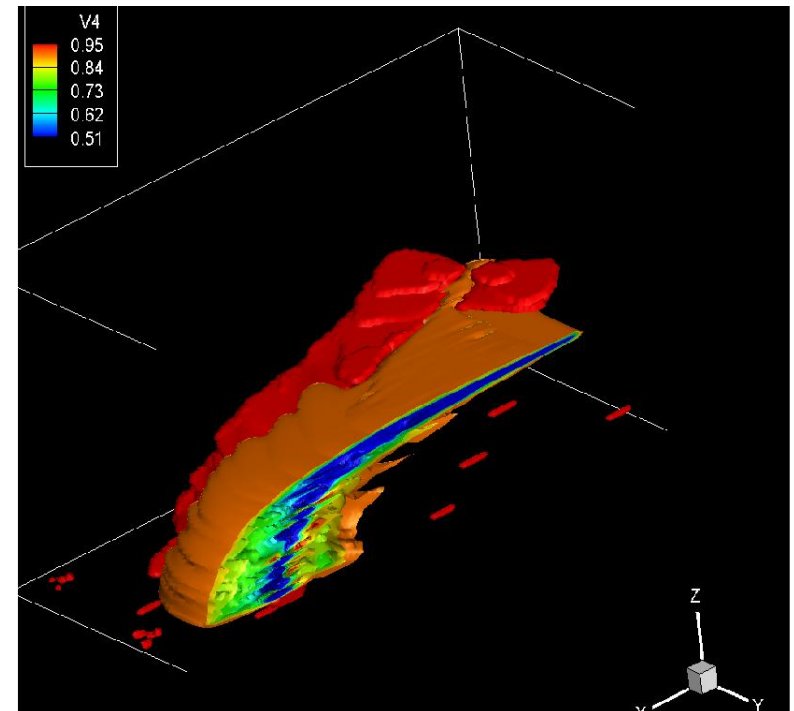
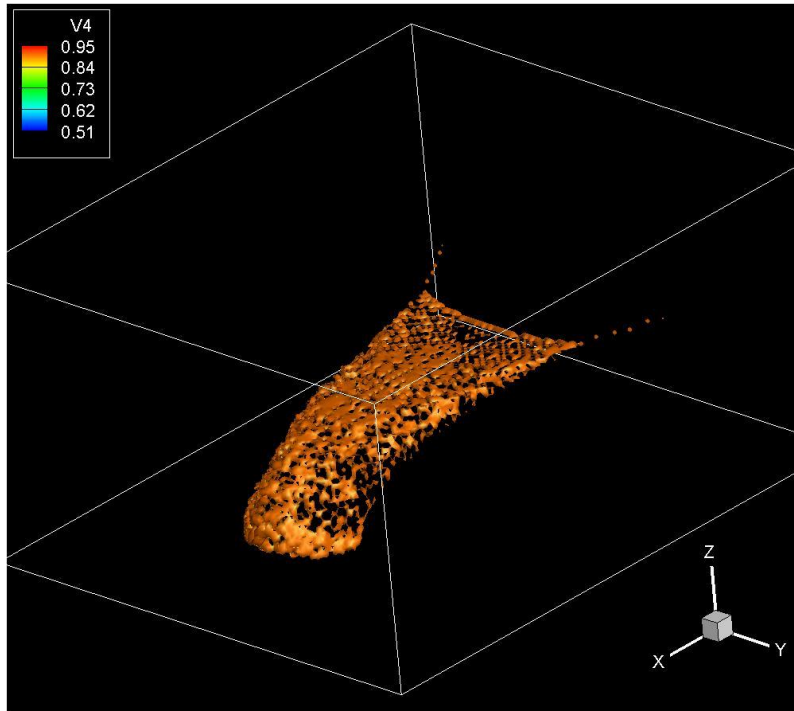


- Source terms from structure code to represent a rectangular piece of net
- Integration to Navier-Stokes code
- Coupling in progress

Numerical simulations for trawl behaviour modelisation

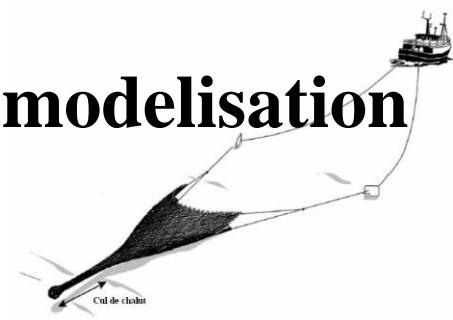


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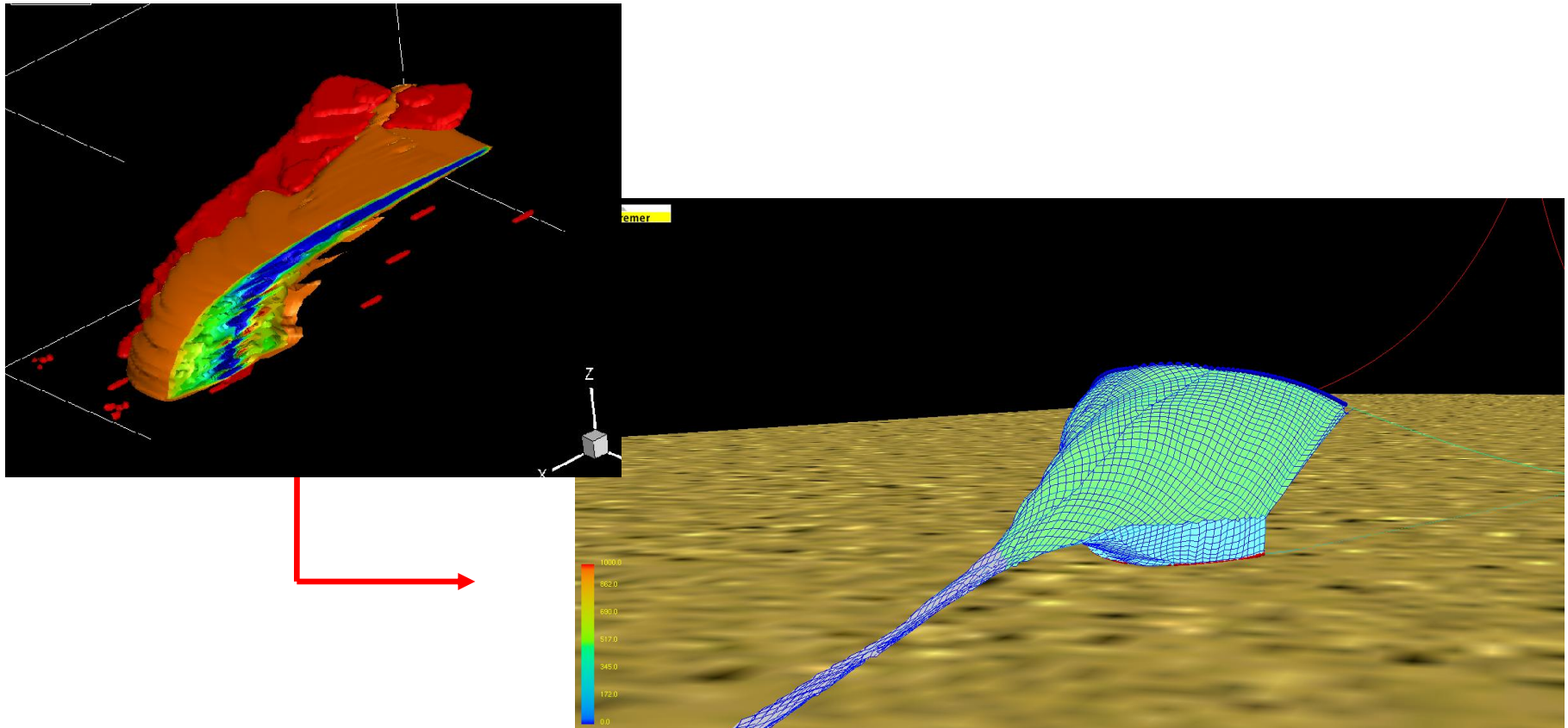
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Numerical simulations for trawl behaviour modelisation

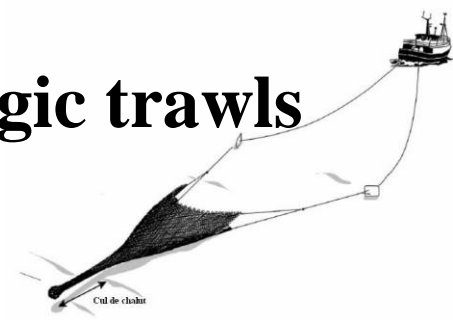


3D developments:

for a complete fluid/structure modelisation



Energy optimisation of bottom and pelagic trawls

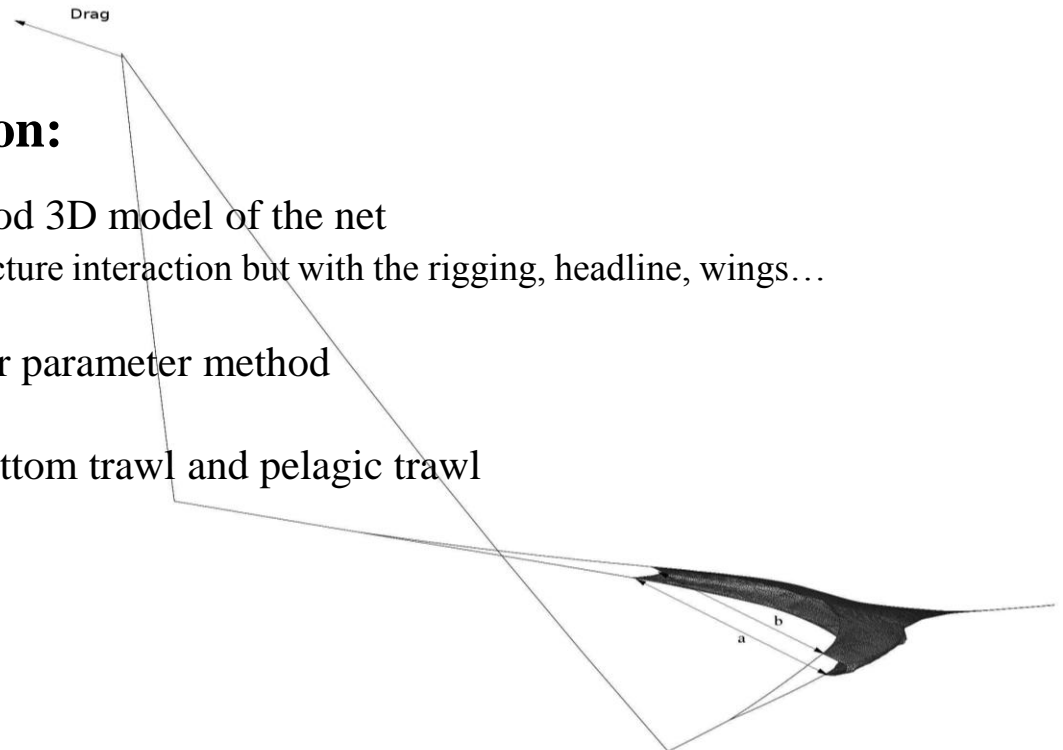


Goal of this task:

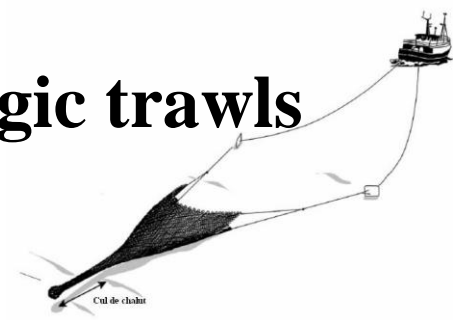
- to develop automatic optimisation tools to design efficient trawls in terms of energy consumption and to adapt the numerical code for the routine used by an optimiser

Optimisation tool based on:

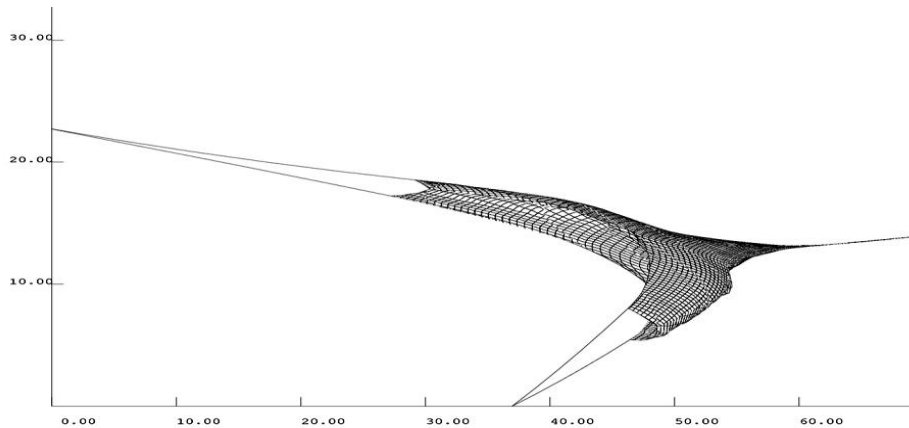
- Finite Element Method 3D model of the net
no fluid/structure interaction but with the rigging, headline, wings...
- Successive search per parameter method
- Specific target for bottom trawl and pelagic trawl



Energy optimisation of bottom and pelagic trawls



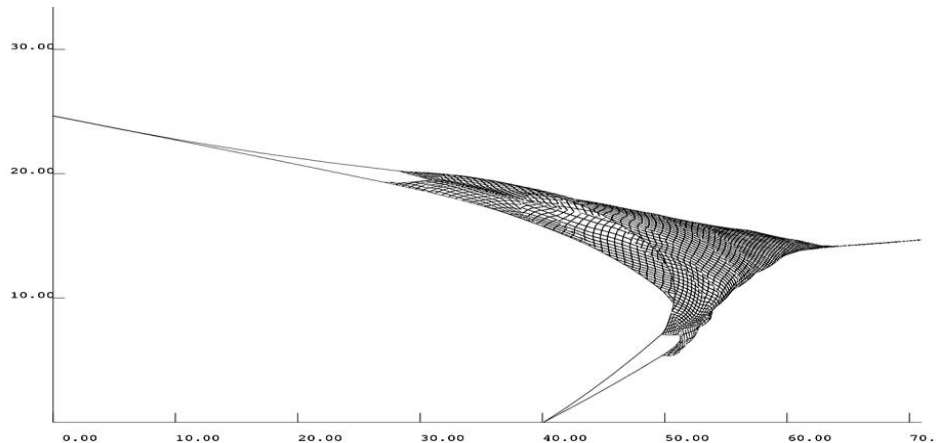
Optimisation of a bottom trawl:



Objective: optimised the drag over swept width ratio

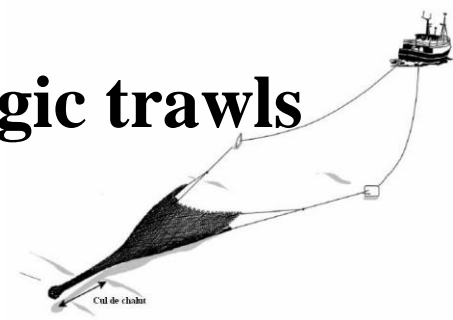
Results:

- improvement of 17% on fuel consumption
- optimised swept width 27m (22.3m for the reference one)



↙ potential increase of fishing catch

Energy optimisation of bottom and pelagic trawls

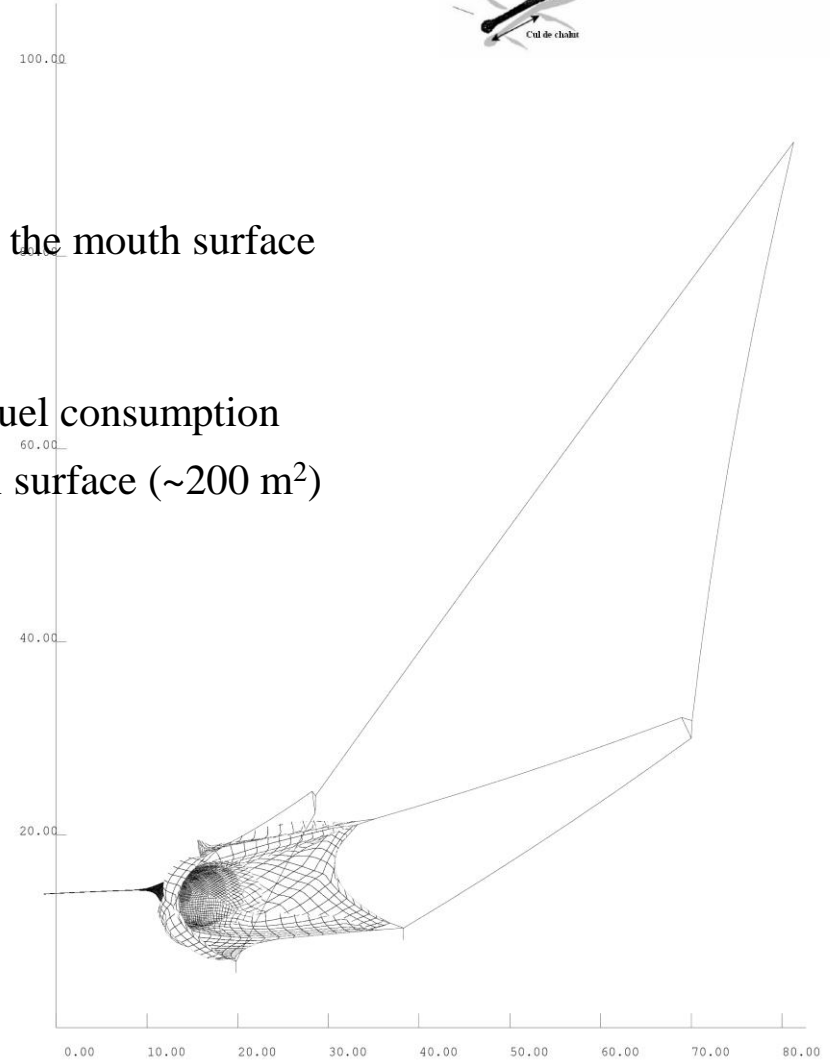
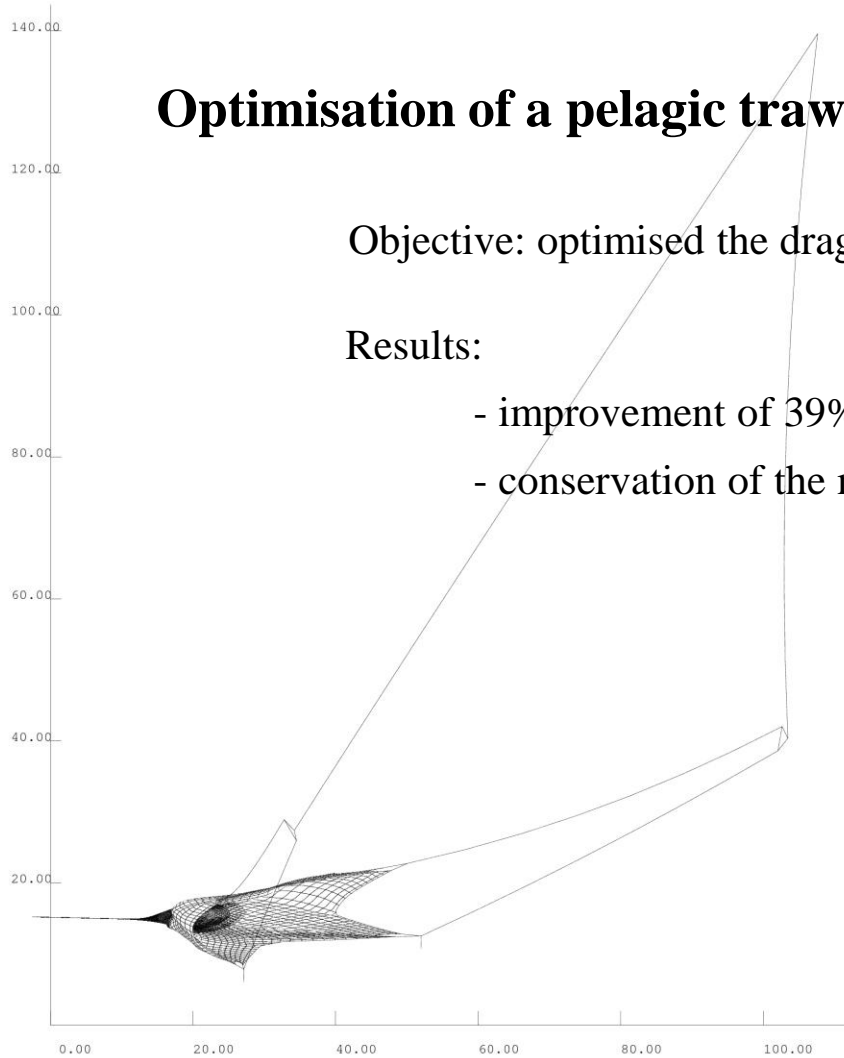


Optimisation of a pelagic trawl:

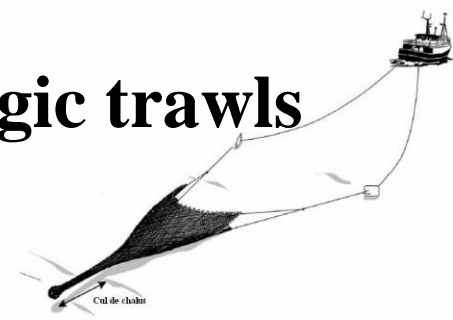
Objective: optimised the drag over the mouth surface

Results:

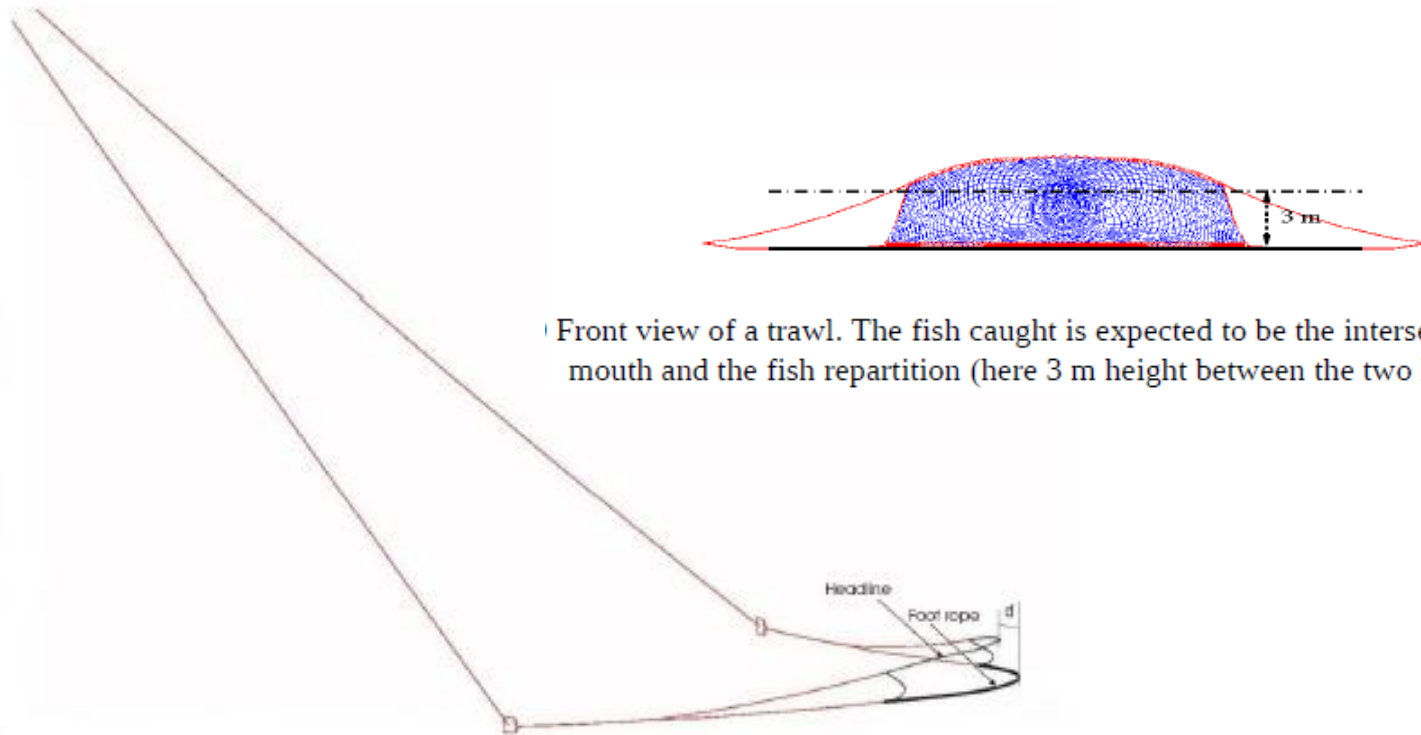
- improvement of 39% on fuel consumption
- conservation of the mouth surface ($\sim 200 \text{ m}^2$)



Energy optimisation of bottom and pelagic trawls



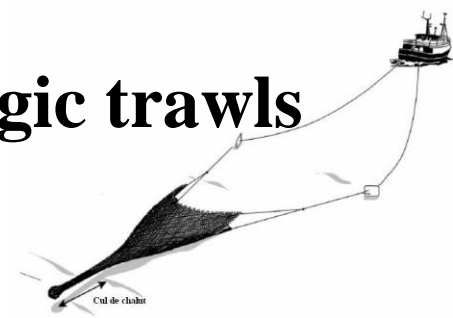
Optimisation of a bottom trawl:



Front view of a trawl. The fish caught is expected to be the intersection of the trawl mouth and the fish repartition (here 3 m height between the two lines).

Presentation of the different cables used on a bottom trawl (warps, doors, foot-rope).

Energy optimisation of bottom and pelagic trawls



Conclusion:

- specific data analysis carried out from PIV measurements around a bottom trawl, a rigid cod-end and a large rectangular piece of net



unsteady mean boundary layer flow field
unsteady wake flow vortex

- numerical tools to simulate the flow around trawls
- developments of optimisation tools

Perspective:

development of a complete fluid/structure model to simulate the behavior of bottom and pelagic trawls usable by the optimisation tools