HydroPêche: experimental and numerical developments for fishing devices optimisation

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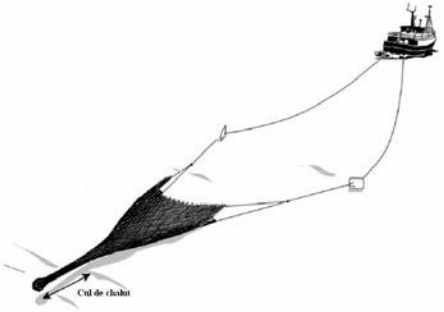
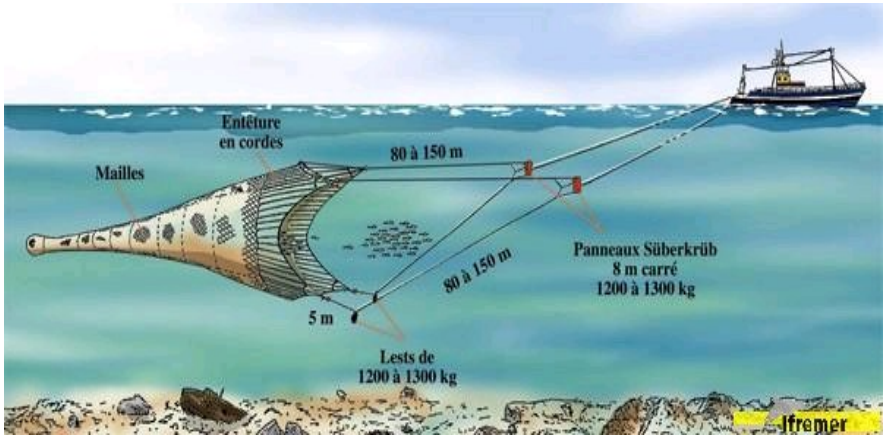
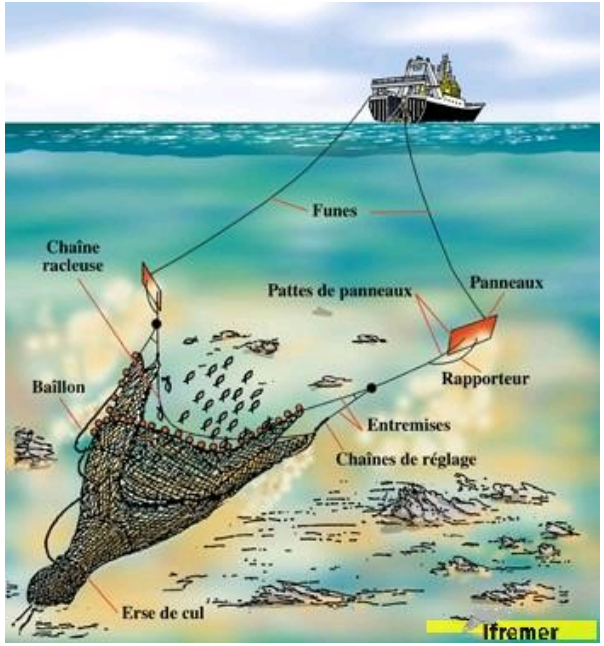
HydroPêche Project



Goal of the project:

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





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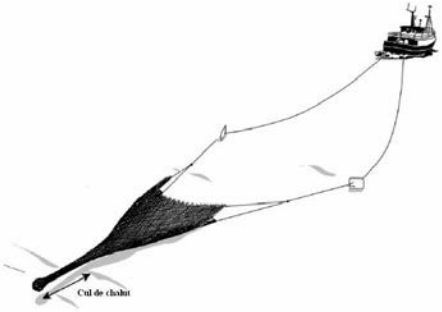


Goal of the project:

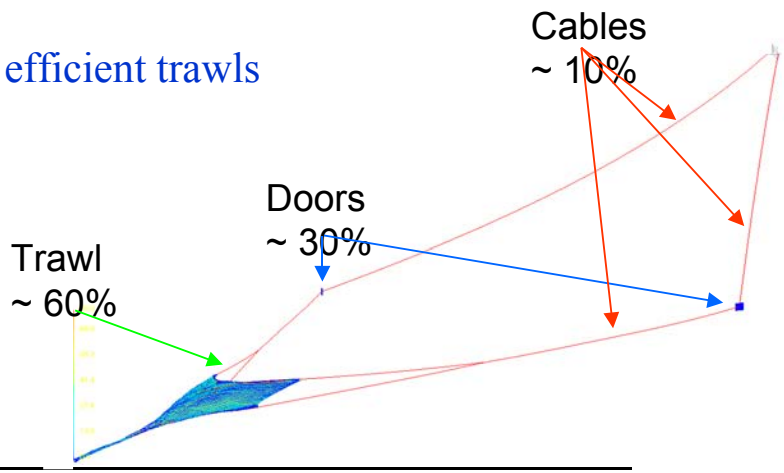
to develop tools for trawl optimisation in order to minimize the drag of the gear.

A work in three areas:

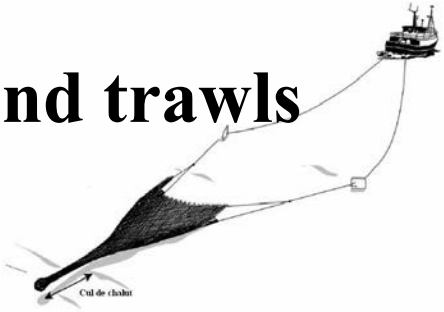
- to extend the basis of experimental data on flow characteristics governing the hydrodynamic behaviour of different porous structures

- 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.



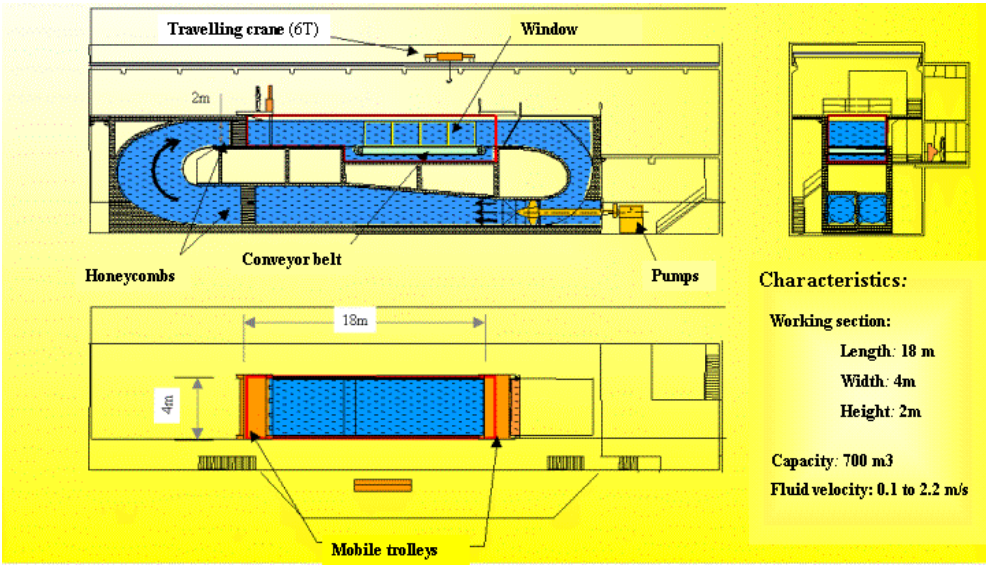
Experimental flow characterization around trawls



Goal of this task:

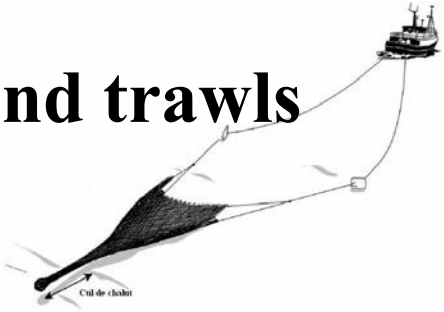
- to extend the basis of experimental data on flow characteristics governing the hydrodynamic behaviour of different porous structures (sheets of net, trawls)

- to identify the areas where the drag is generated



Wave – Current flume tank

Experimental flow characterization around trawls



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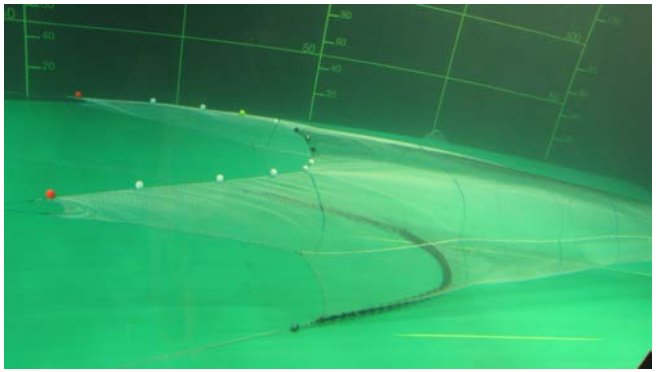
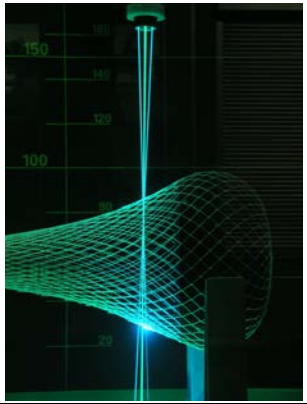
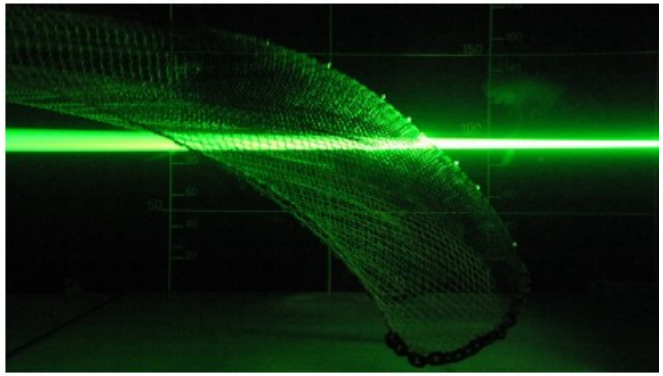
Three kinds of trials:

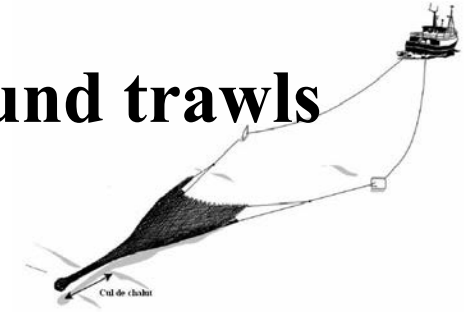
- Flow characterisation around a 1/10 bottom trawl
- Flow characterisation around a rigid cod-end
- Flow characterisation around a large rectangular piece of net







Experimental flow characterization around trawls



Flow characterisation around a 1/10 bottom trawl

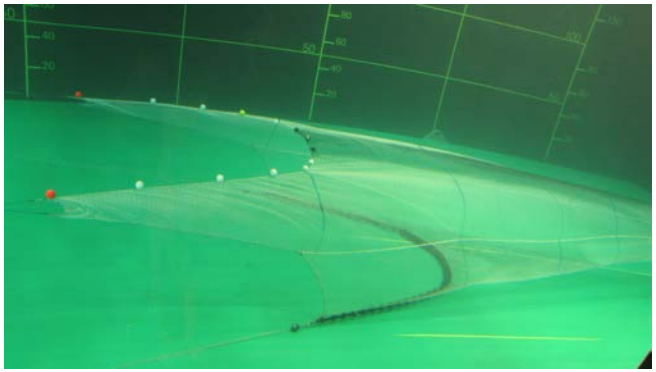
bottom trawl

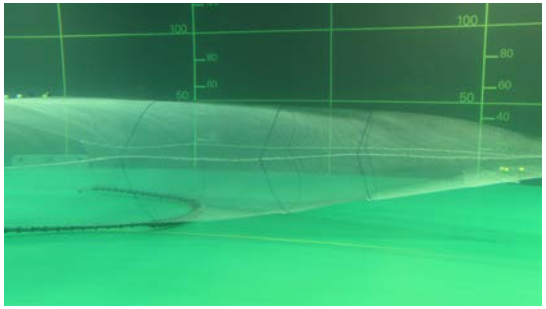
the unsteady flow

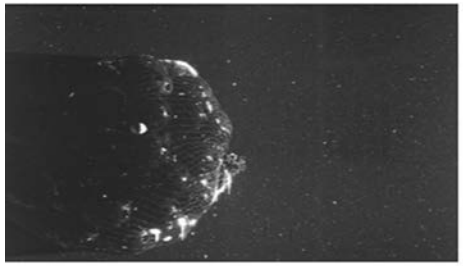
to perform velocity field measurements around a moving

to develop post-processing tools aiming at characterizing

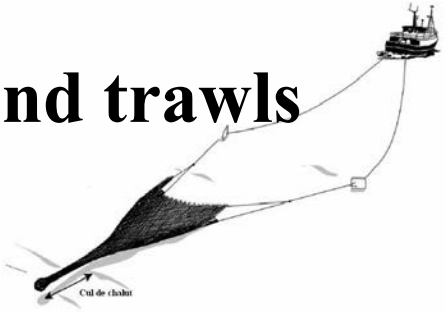
to provide measurement benchmark for numerical modeling



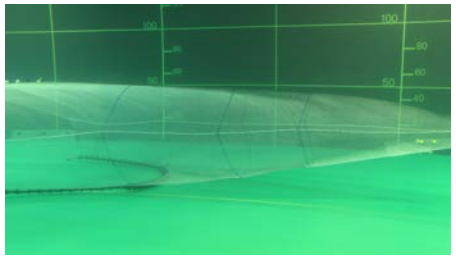


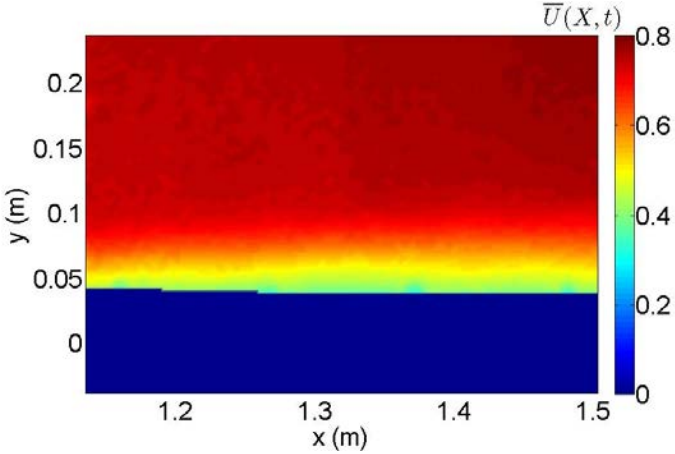


Experimental flow characterization around trawls



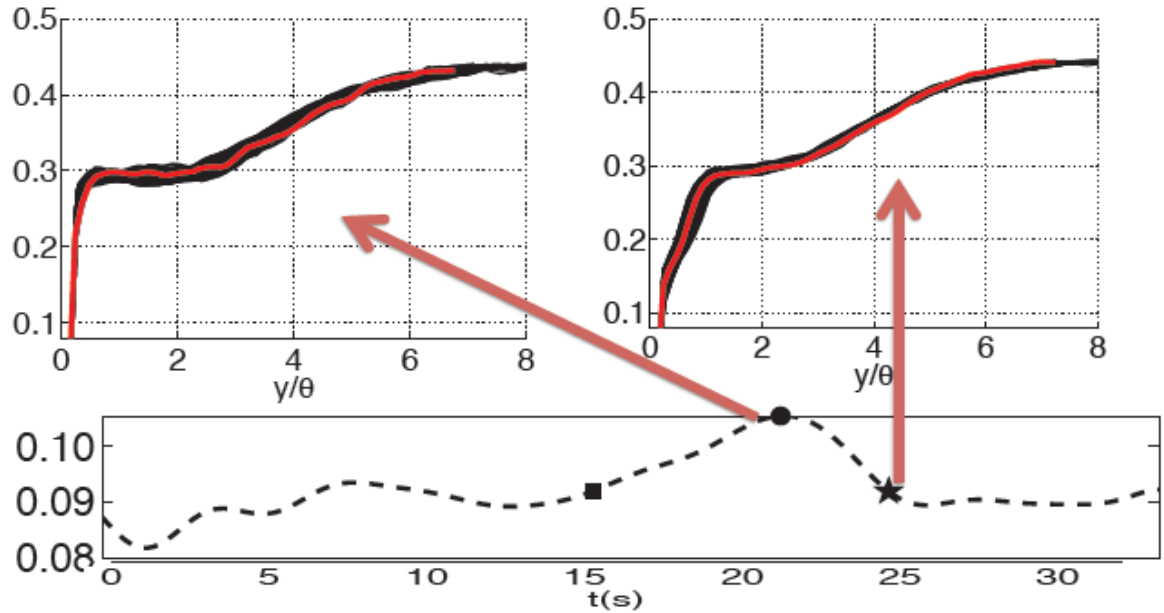
Flow characterisation around a 1/10 bottom trawl





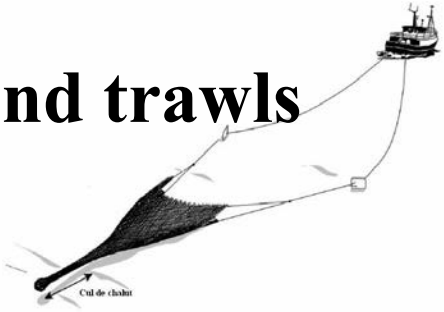
Boundary layer evolution

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

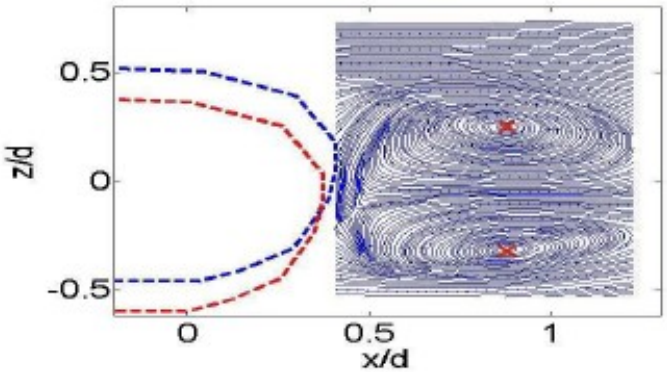


Time evolution of the bottom trawl during measurement

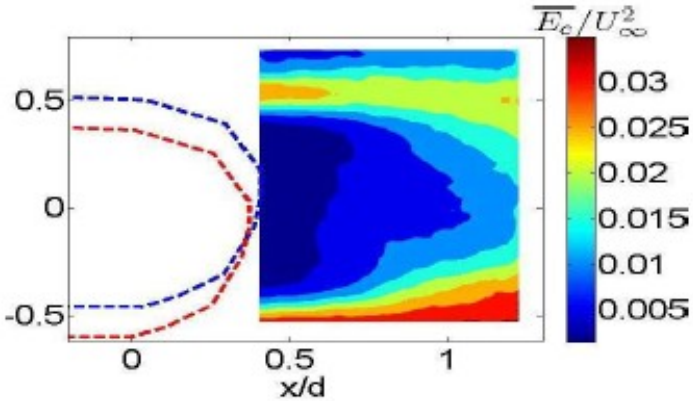
Experimental flow characterization around trawls



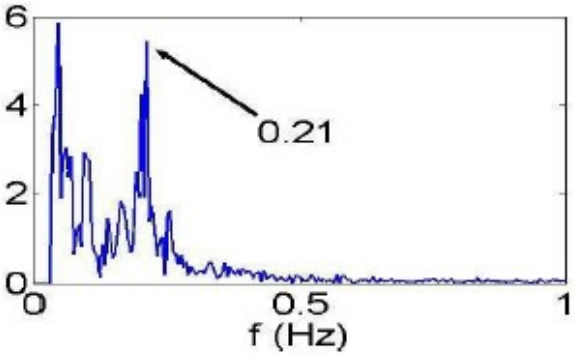
Flow characterisation around a 1/10 bottom trawl



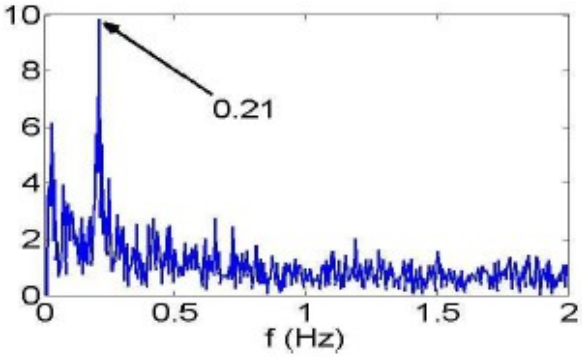
Mean flow stremline topology



Kinetic energy

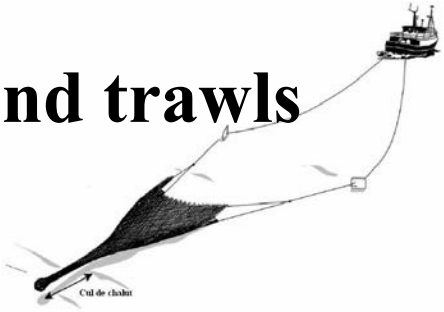


Power spectrum of the vertical motion



Power spectrum of Ux

Experimental flow characterization around trawls



Three kinds of trials:

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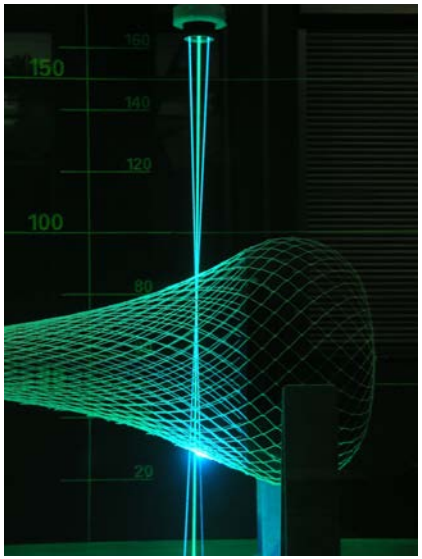
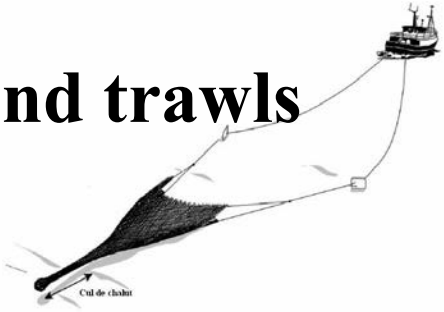


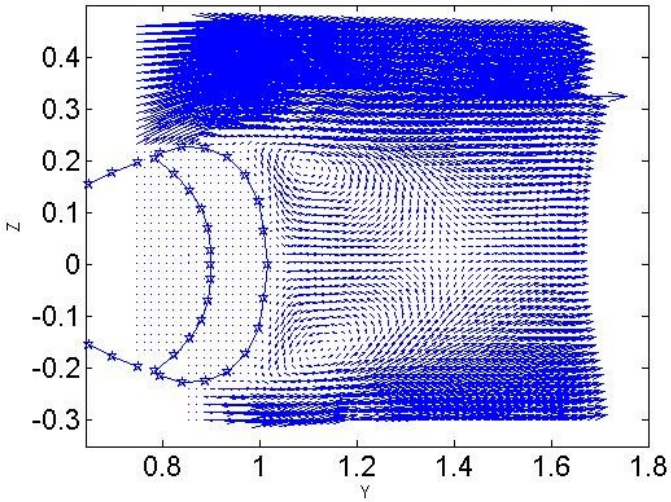
LDV measurements on a rigid cod-end

Experimental flow characterization around trawls

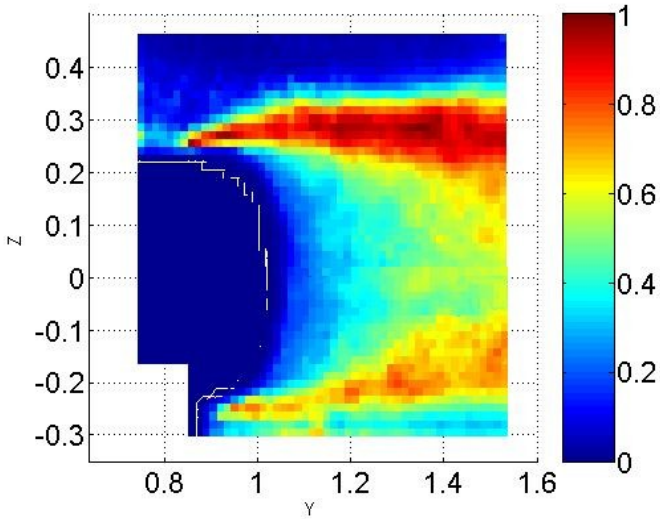


Flow characterisation around a rigid cod-end

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

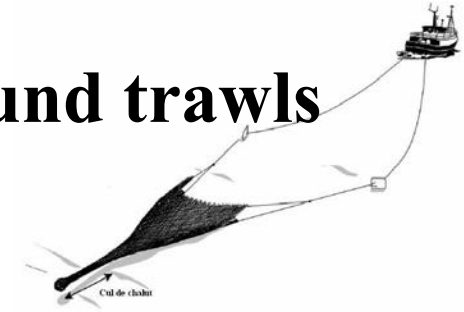


Mean velocity field



Turbulent kinetic energy

Experimental flow characterization around trawls



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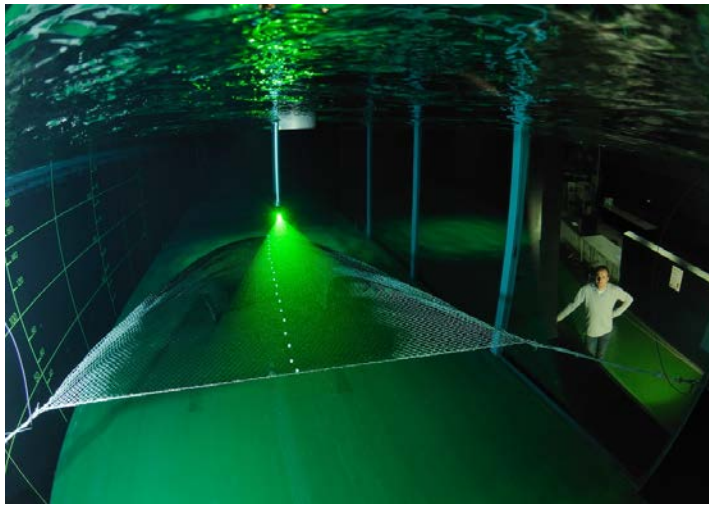
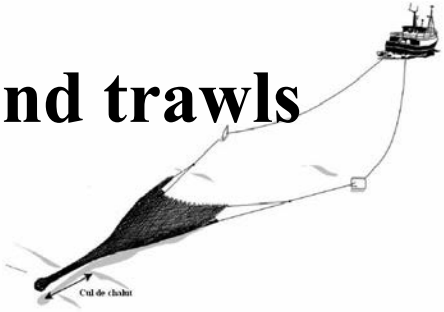


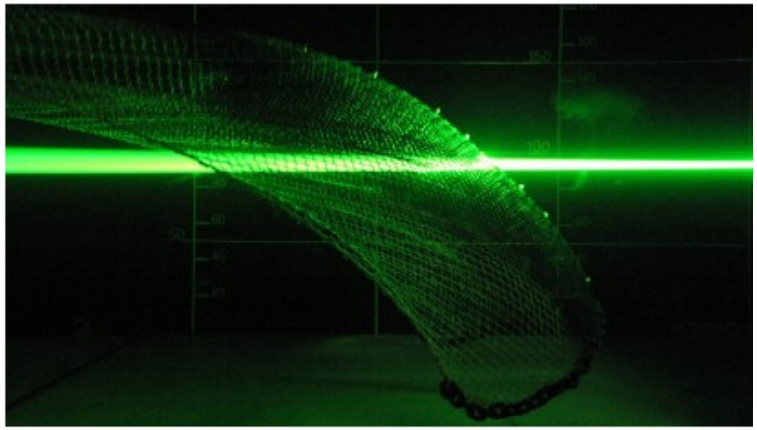
PIV measurements on a piece of net

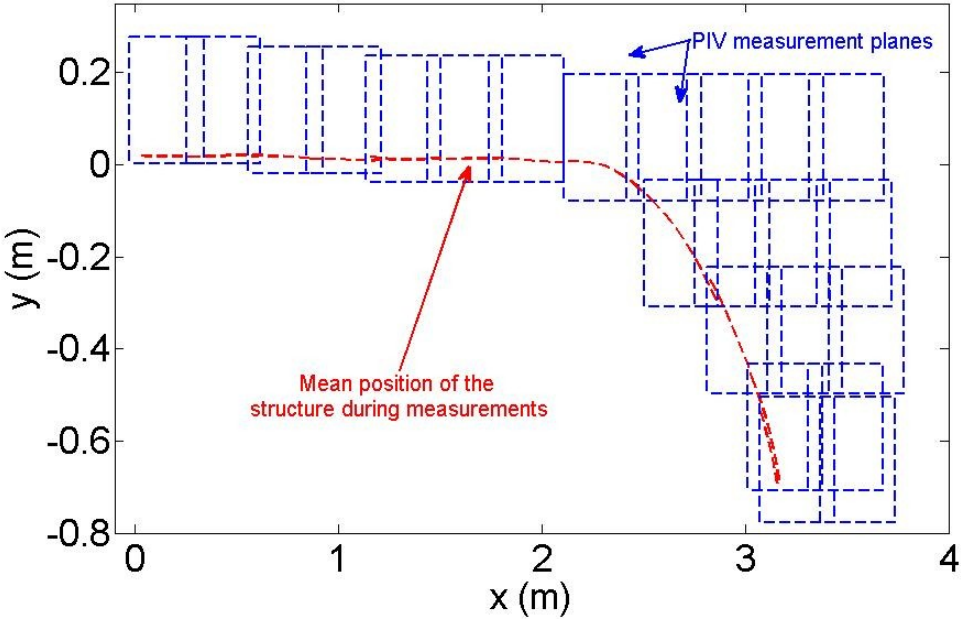
Experimental flow characterization around trawls



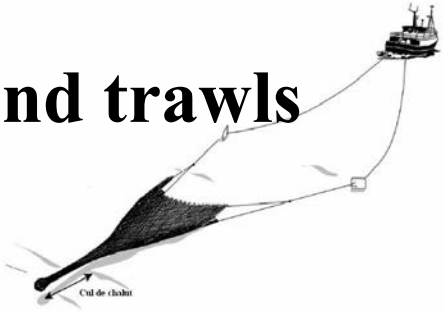
Flow characterisation around a large rectangular piece of net

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





Experimental flow characterization around trawls



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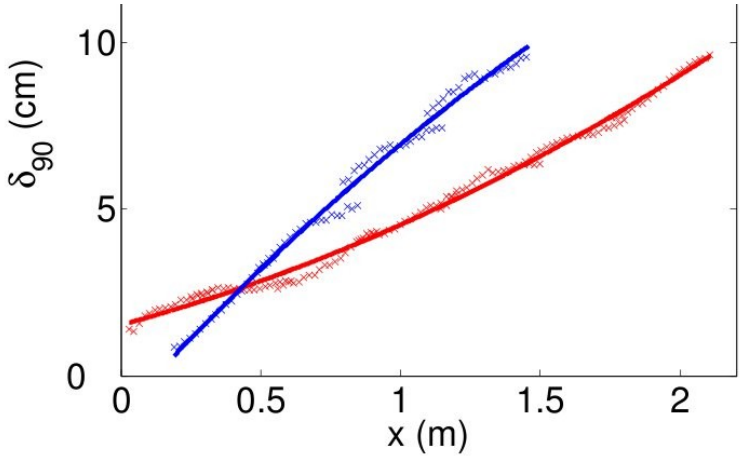
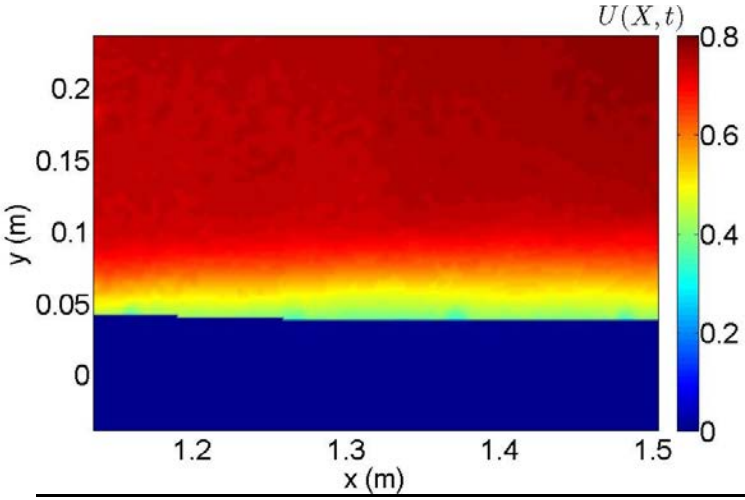
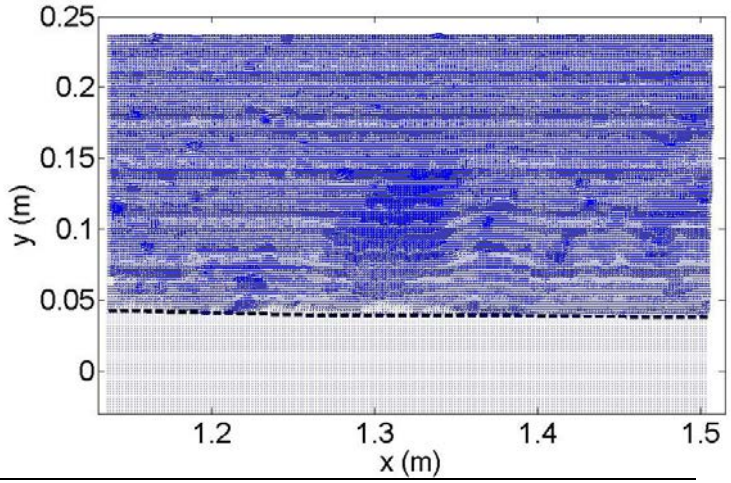


δ = function of : porosity,
Reynolds number,
and ??





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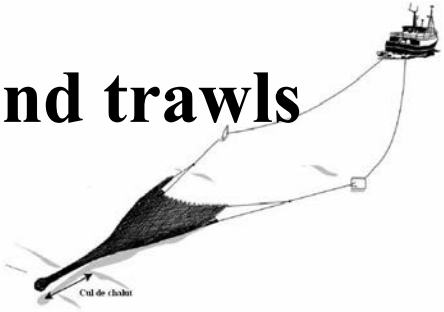
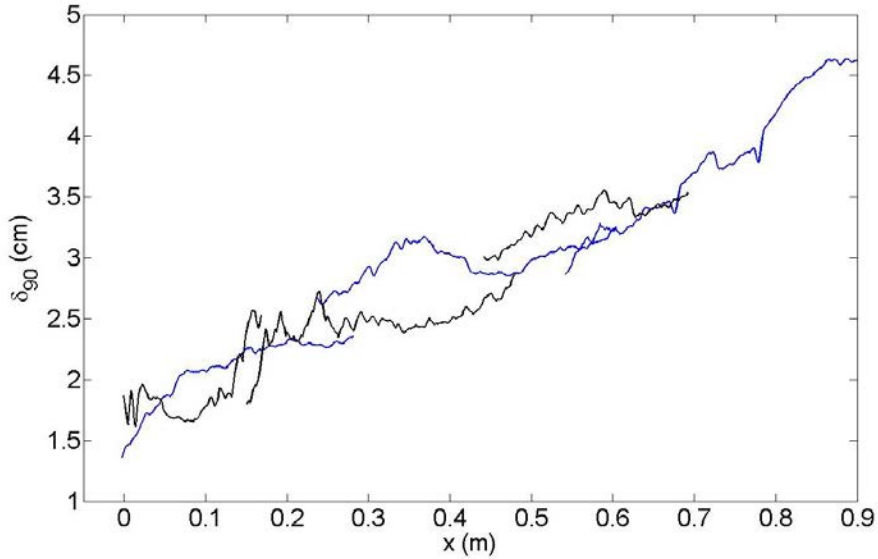
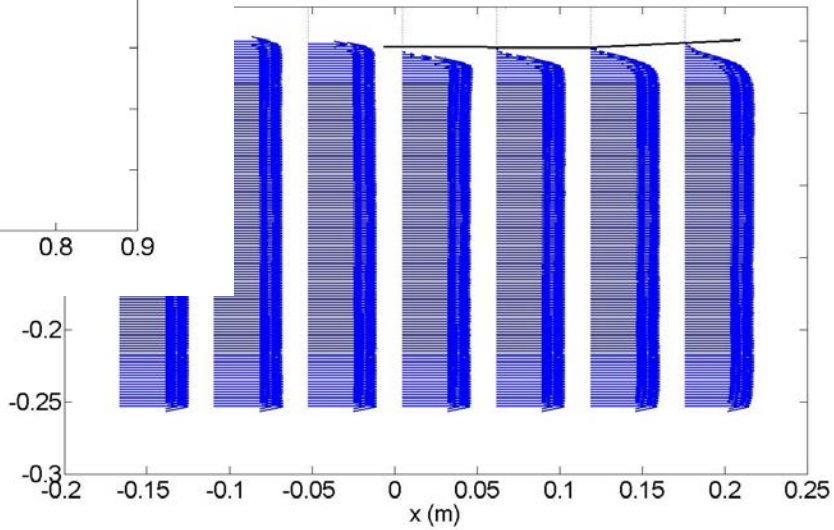
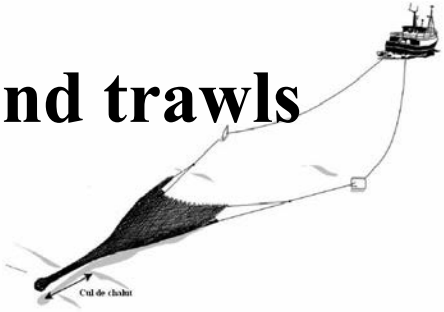


Boundary layer evolution on both sides of the rectangular piece of net

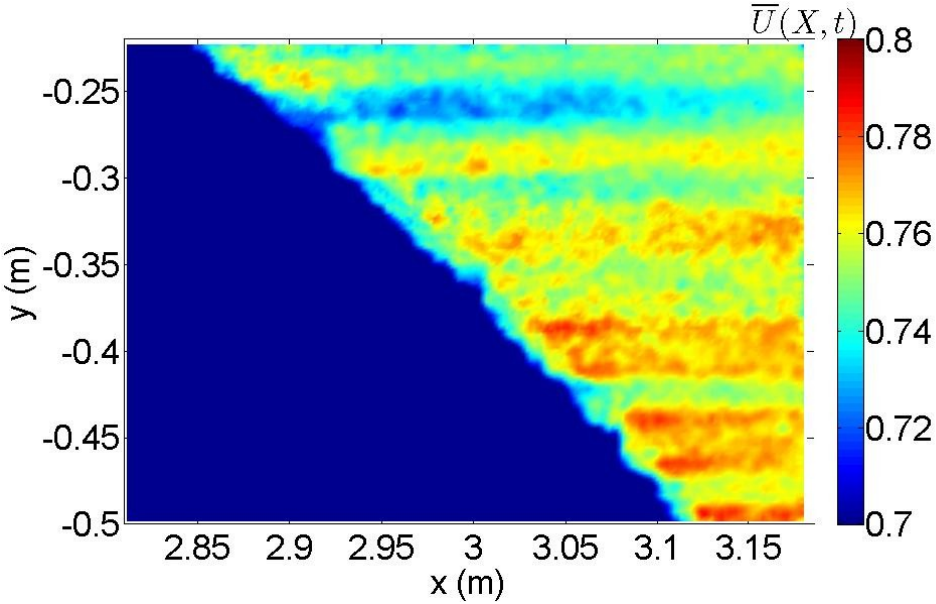




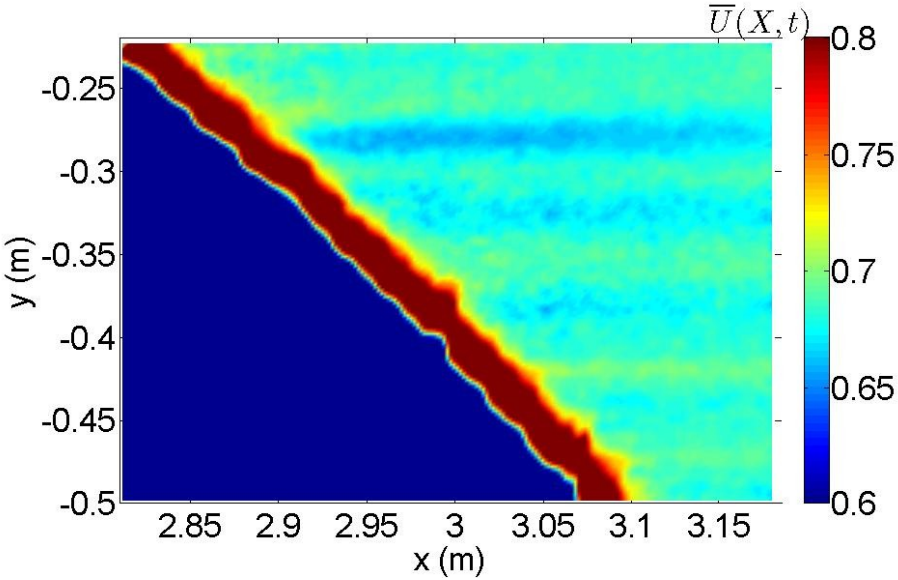
Experimental flow characterization around trawls



Flow characterisation around a large rectangular piece of net

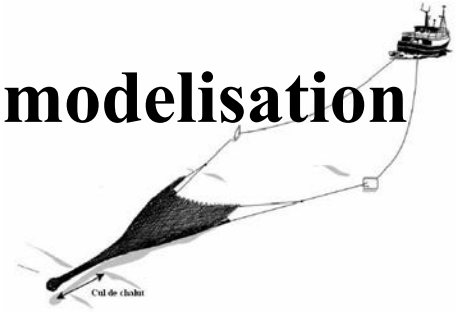


Mean velocity at a upper location



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:

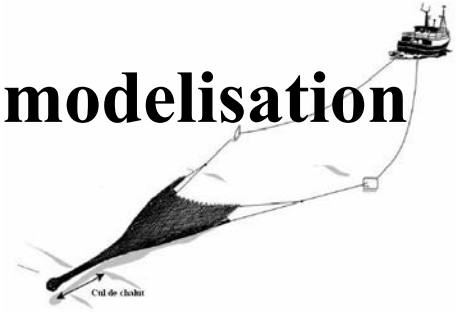
- use of Landweber / Richtmeyer law to calculate the fluid forces on the net:

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

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

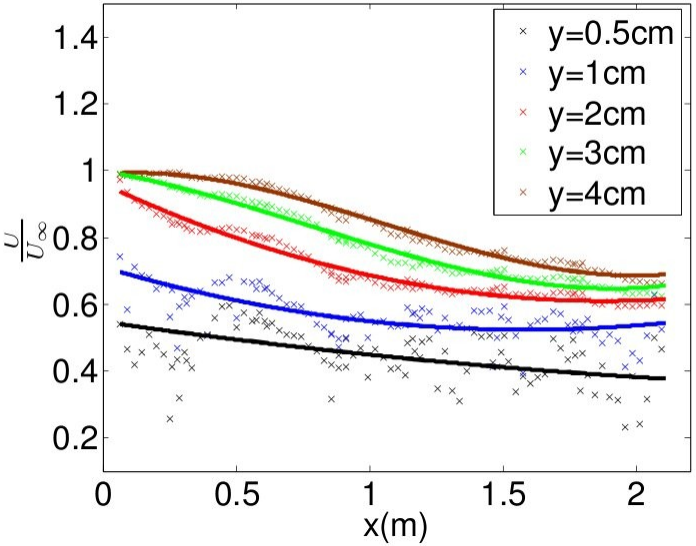
- no fluide / structure interaction

Numerical simulations for trawl behaviour modelisation

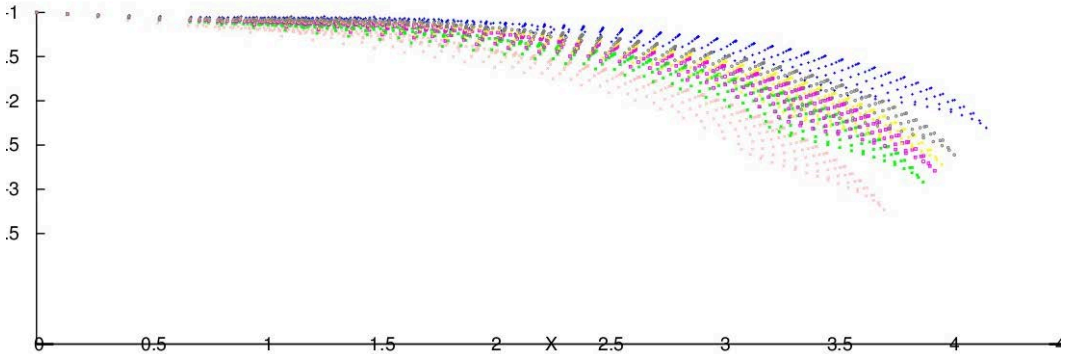


First step of development:

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



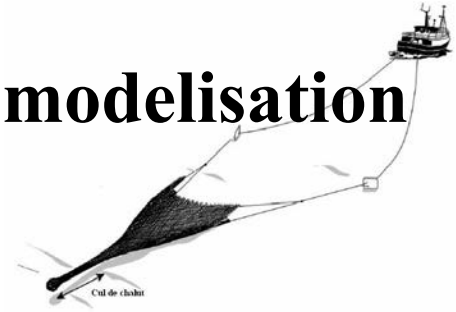
Flow velocity in the TBL



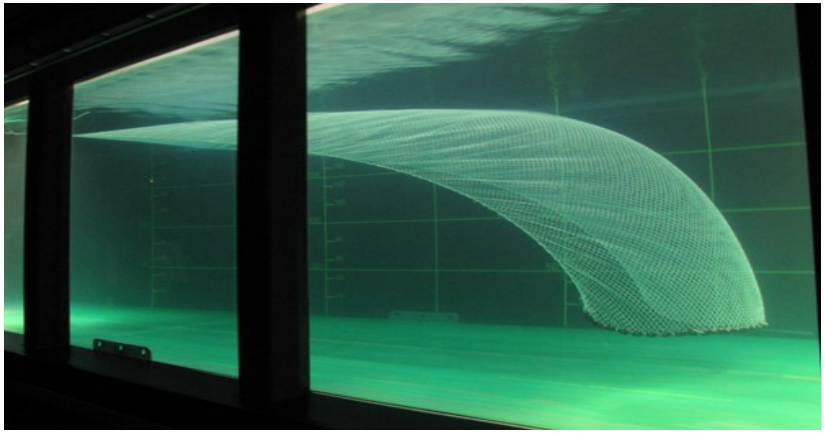
Sensibility of the FEM net model to TBL velocity

- around curved parts: in progress

Numerical simulations for trawl behaviour modelisation

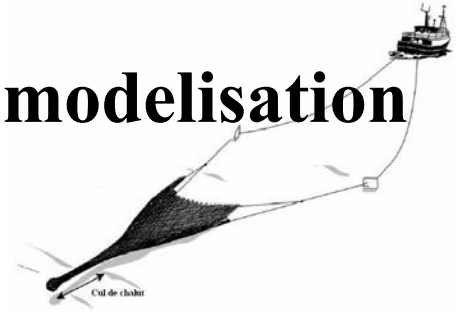


3D integration in progress:



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

Numerical simulations for trawl behaviour modelisation



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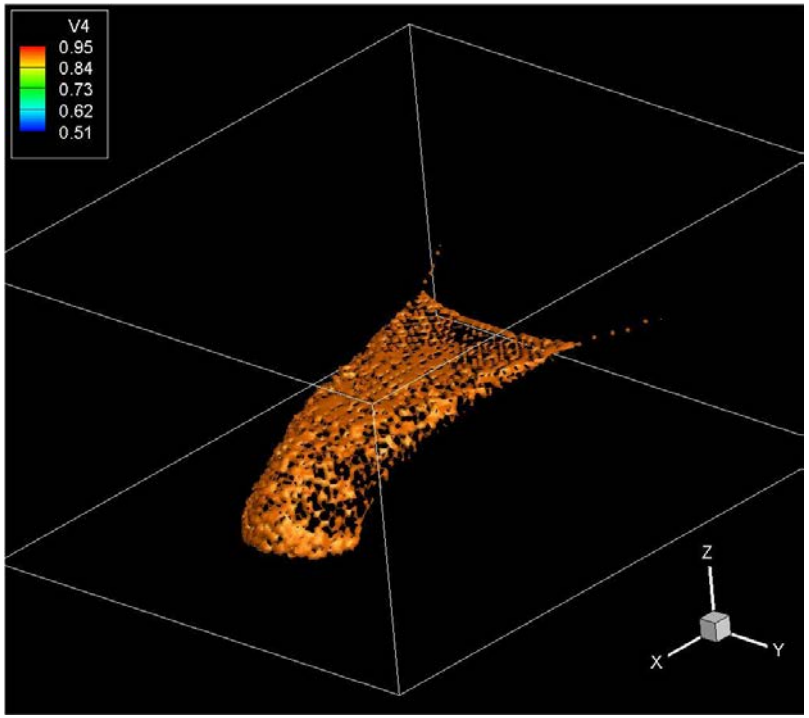

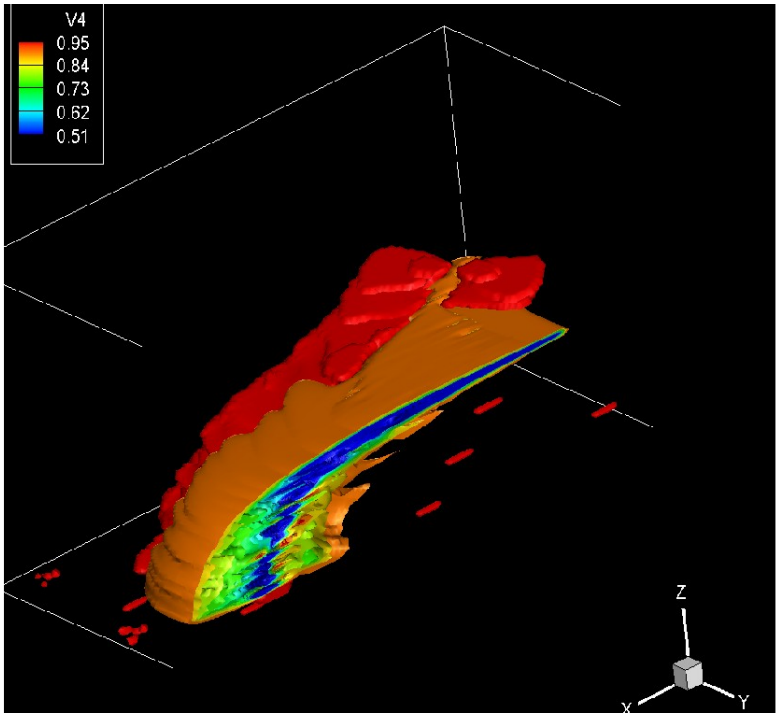

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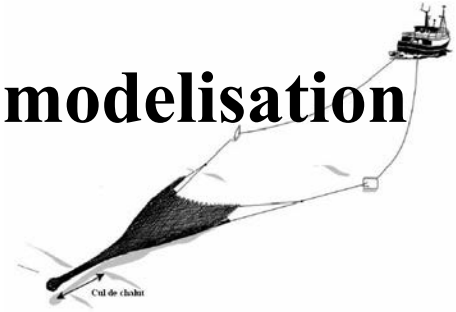
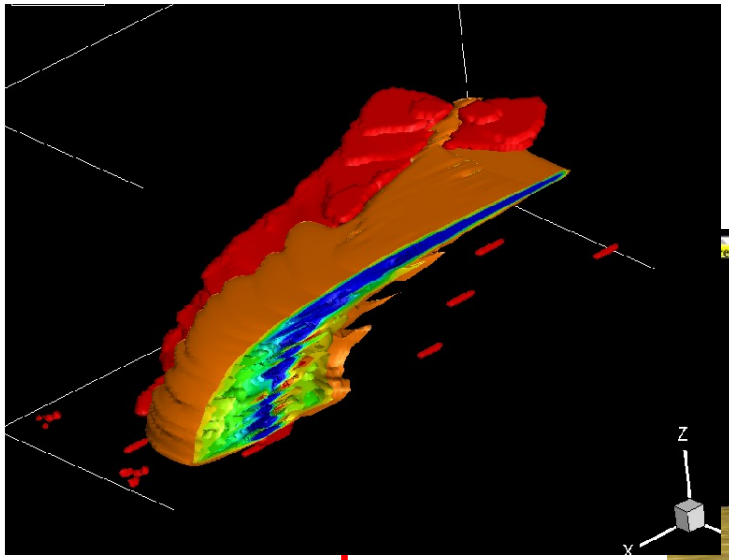
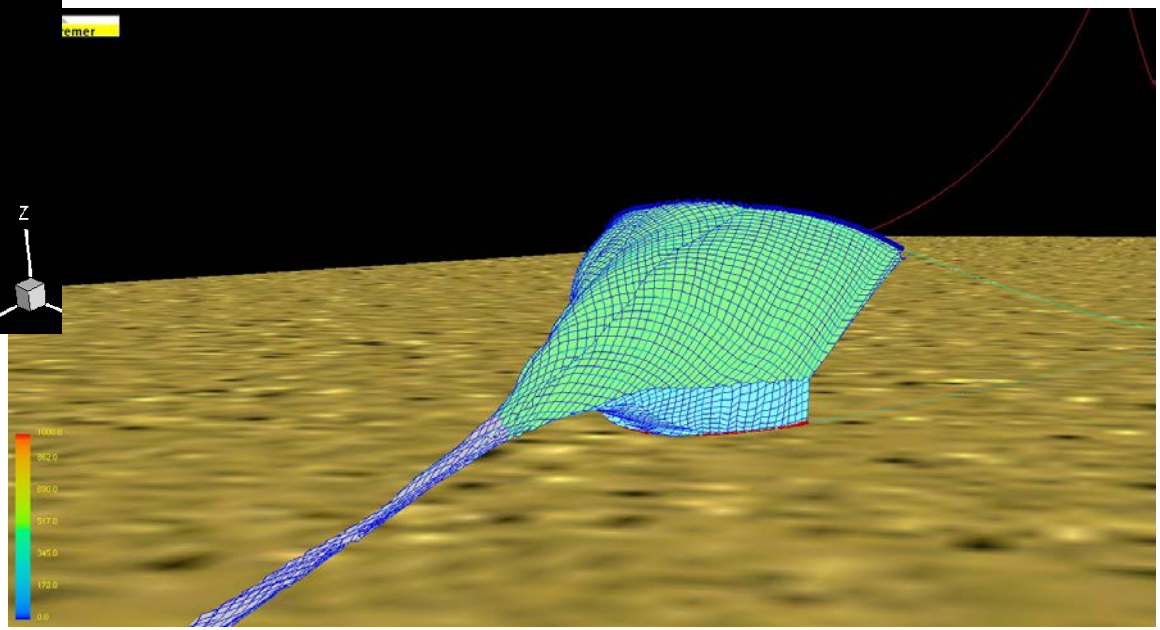


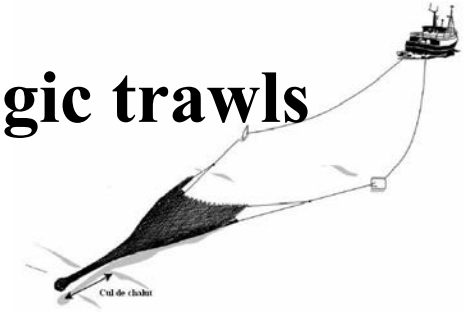
3D developments:

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

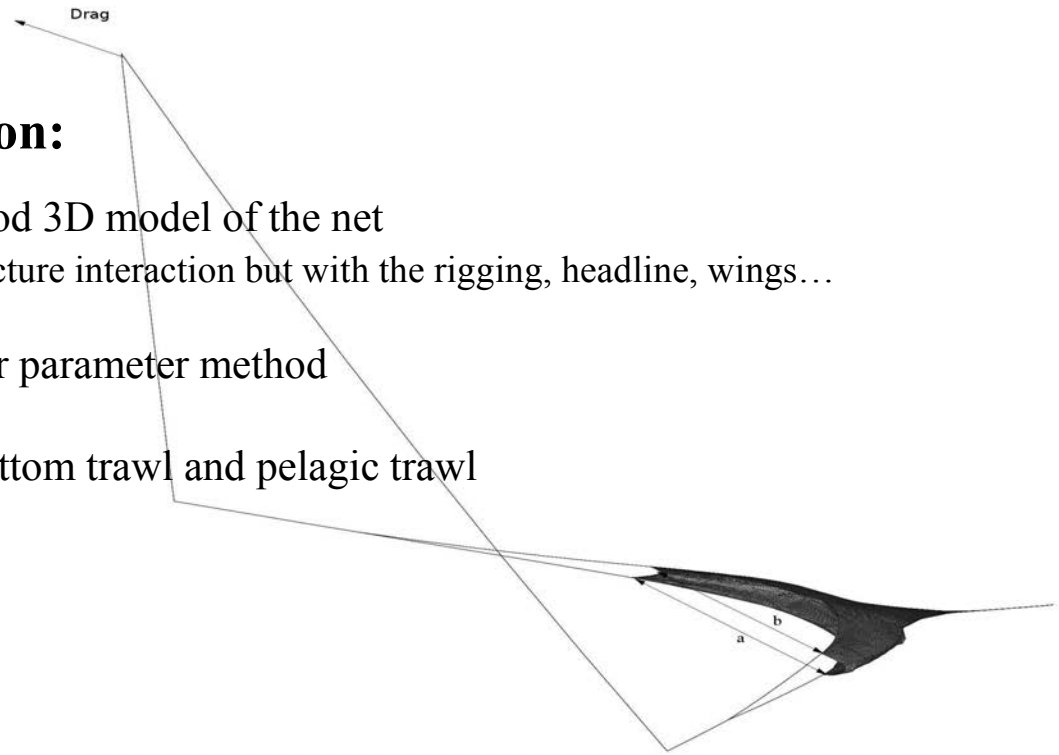
Optimisation tool based on:

- Finite Element Method 3D model of the net

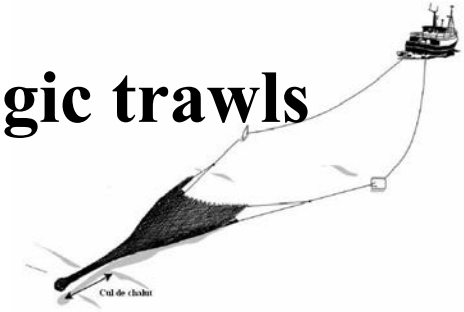
  no fluid/structure interaction but with the rigging, headline, wings…

- Successive search per parameter method

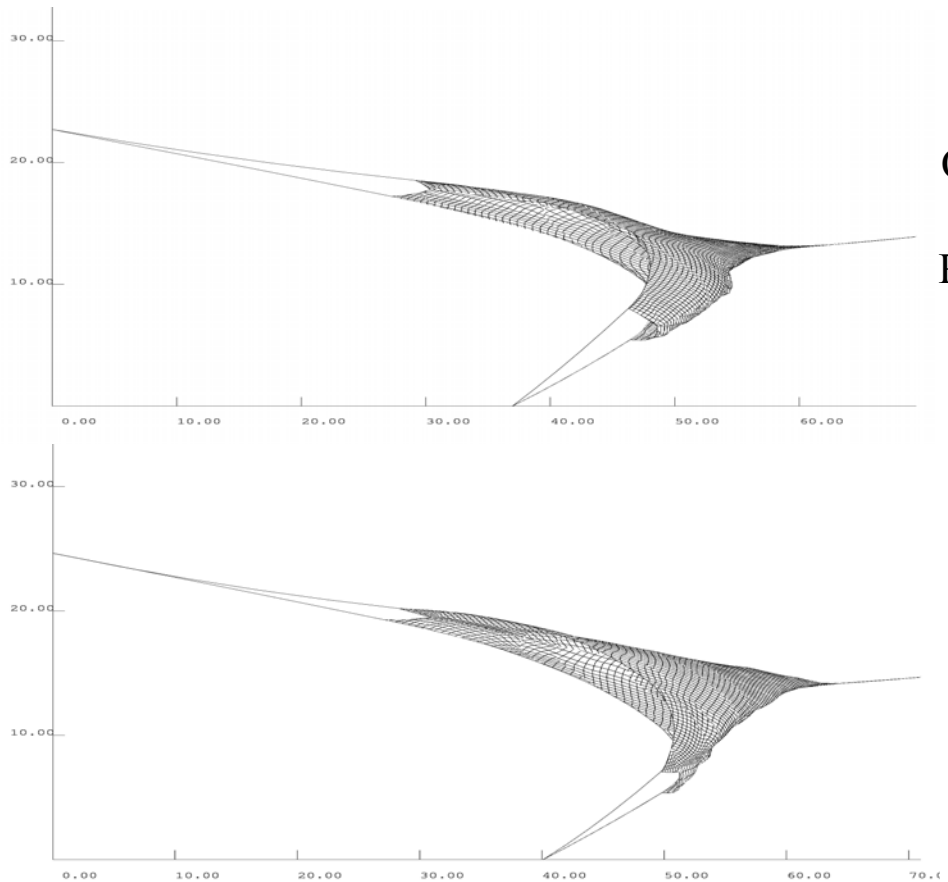
- Specific target for bottom trawl and pelagic trawl



Energy optimisation of bottom and pelagic trawls



Optimisation of a bottom trawl:



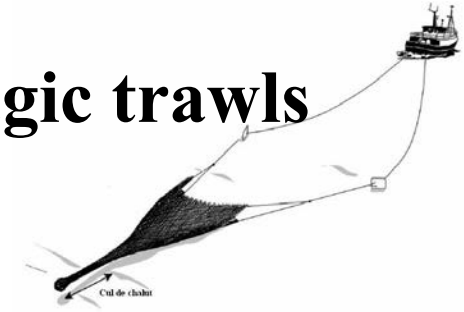
Objective: optimised the drag over swept width ratio

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

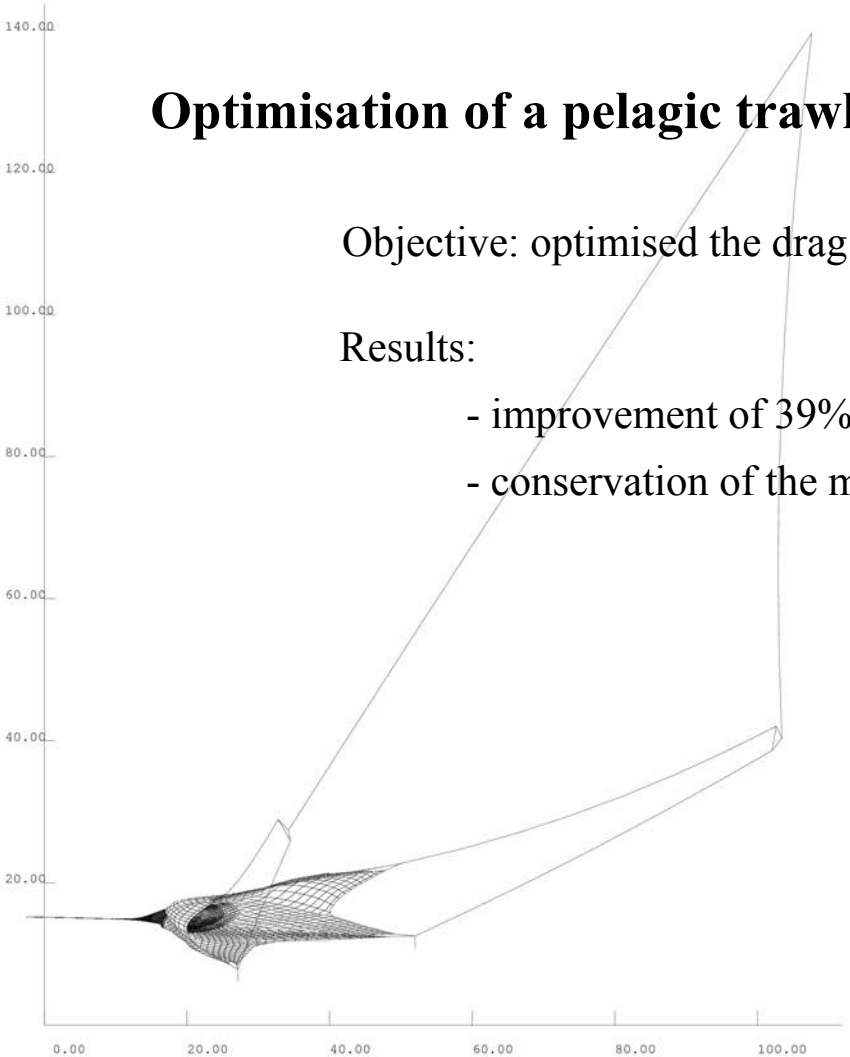


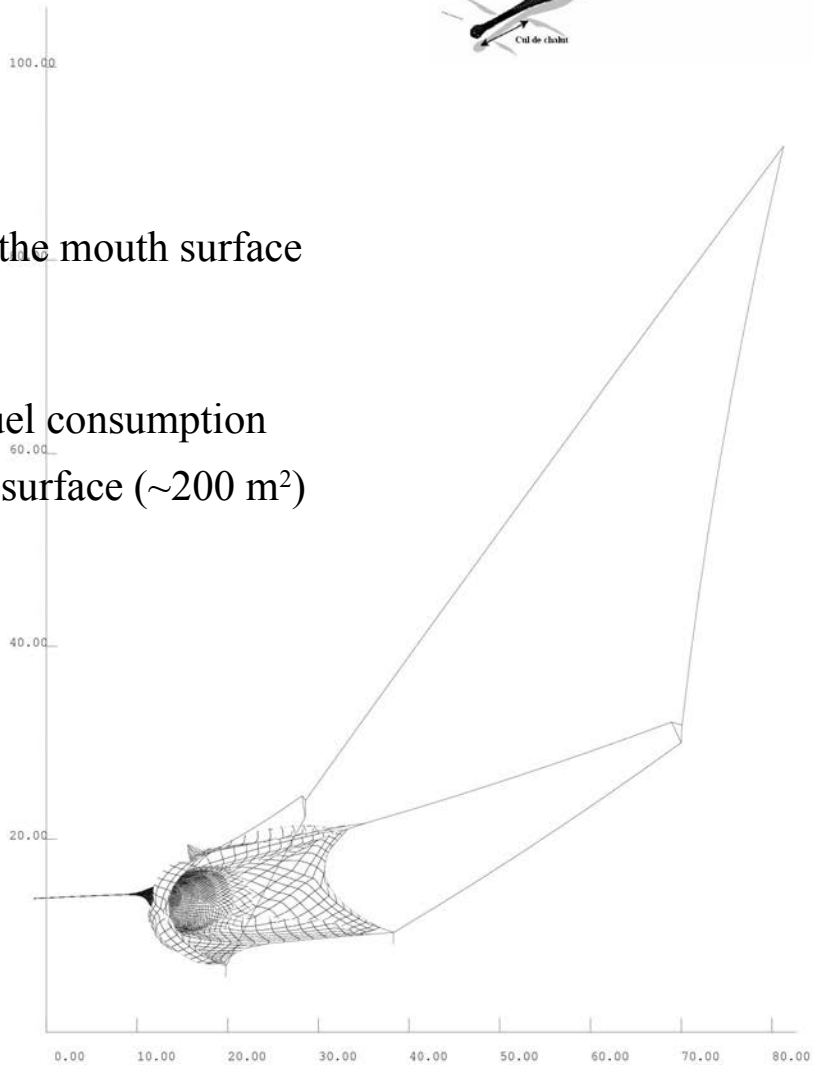
Optimisation of a pelagic trawl:

Objective: optimised the drag over the mouth surface

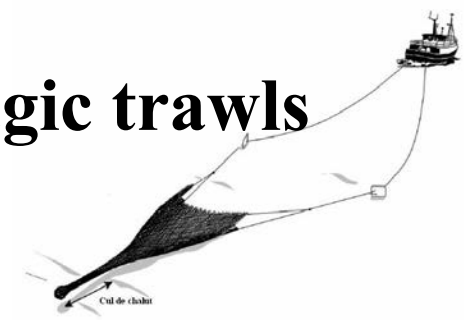
Results:

- improvement of 39% on fuel consumption
- conservation of the mouth surface (~200 m²)

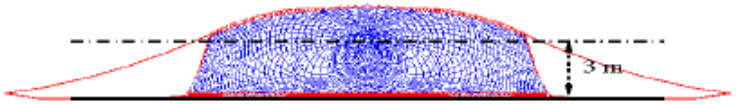




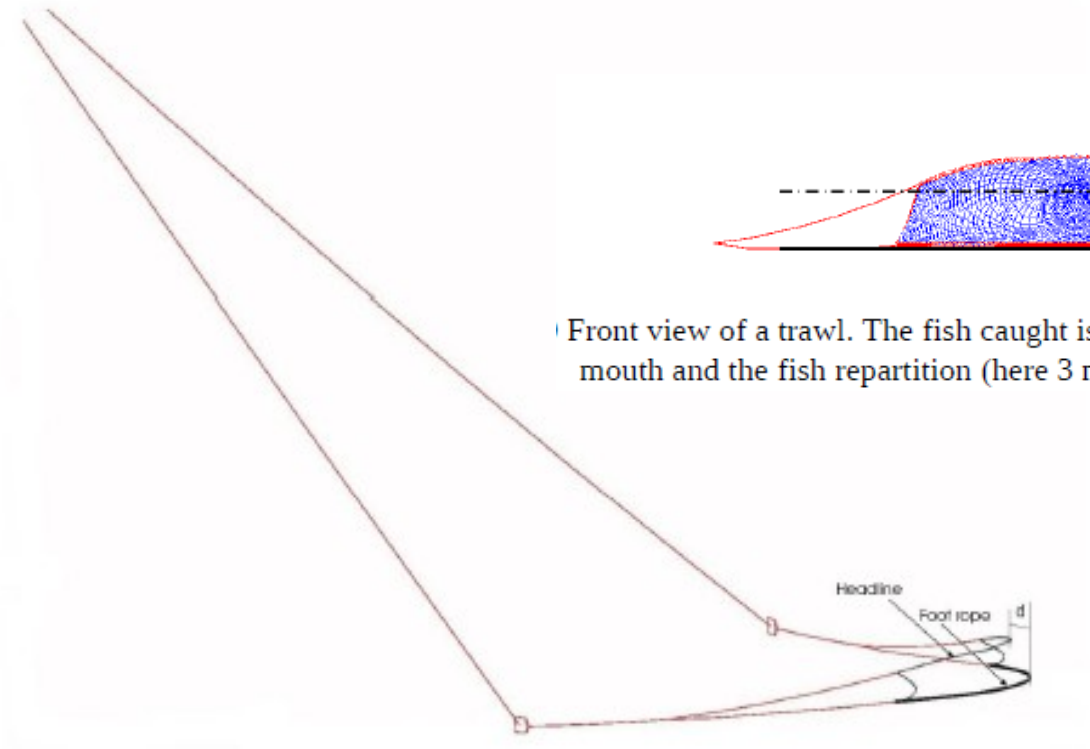
Energy optimisation of bottom and pelagic trawls



Optimisation of a bottom trawl:

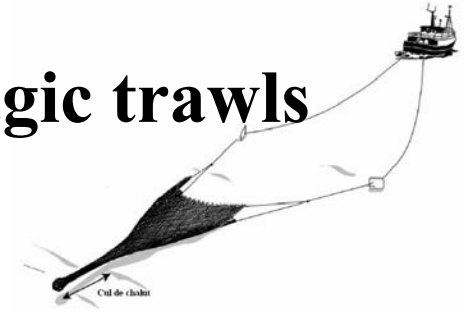


Front view of a trawl. The fish caught is expected to be the intersection of the trawl mouth and the fish repartition (here 3 m height between the two lines).



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

Energy optimization 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 filed
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 optimization tools