Future Fishing Vessel Technologies

Challenges for a sustainable European fishing fleet

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1. Scope of the thematic

Improve <u>Safety</u> and <u>Energy Efficiency</u>

The general scope is to improve:

1. The safety at sea

Fishing at sea is probably the most dangerous occupation in the world.

Over 24,000 fishermen die every year.

- *More than 50% of the world's population lives within 60km of the coastline. Billions of people are depending on the scarce marine resources, they are depending on the fishermen and the fish that they bring home.*
- *A lost vessel and a lost fisherman have a vital impact on the coastal community.*

(from "Safety for Fishermen" website, hosted by FAO)

1. Scope of the thematic

Improve Safety and Energy Efficiency

The general scope is to improve:

1. The safety at sea
2. The Energy efficiency of the fishing vessels

Rules to reduce emissions of greenhouse gases (GHGs) from international shipping were adopted by the Marine Environment Protection Committee (MEPC) of the **International Maritime Organization** (11 to 15 July 2011), representing the **first ever mandatory global greenhouse gas reduction regime for an international industry sector.**

Regulations on energy efficiency for ships :

- **Energy Efficiency Design Index** (**EEDI**), for new ships, and
- **Ship Energy Efficiency Management Plan** (**SEEMP**) for all ships.

The regulations apply to all ships of **400 gross tonnage and above** and are expected to enter into force on 1 January 2013

It is reasonable to foresee that an Energy Efficiency Index will be introduced sooner or later for fishing vessels too.

1. Scope of the thematic

Improve Safety and Energy Efficiency

The general scope is to **develop new design tools** for **safer** and **greener** fishing vessels

Current tools adopted for the design are inadequate, based on **:**
- calm water simulation and tests for powering and
- linear seakeeping models.

Non linear events are never taken into account. **Dynamic stability** and other **non-linear motions in heavy seas** are NOT considered (e.g. **damaged stability** , **effects of water on deck**, etc ...)

There is a need for more knowledge on the behavior of these ships in a representative marine environment.

Develop mathematical and simulation models to study fishing vessels **in real wind and sea state condition and in operation**, in order to improve performance and reliability of structures and safety for personnel in fisheries and aquaculture

Main Challenges on Violent Water-Vessel...

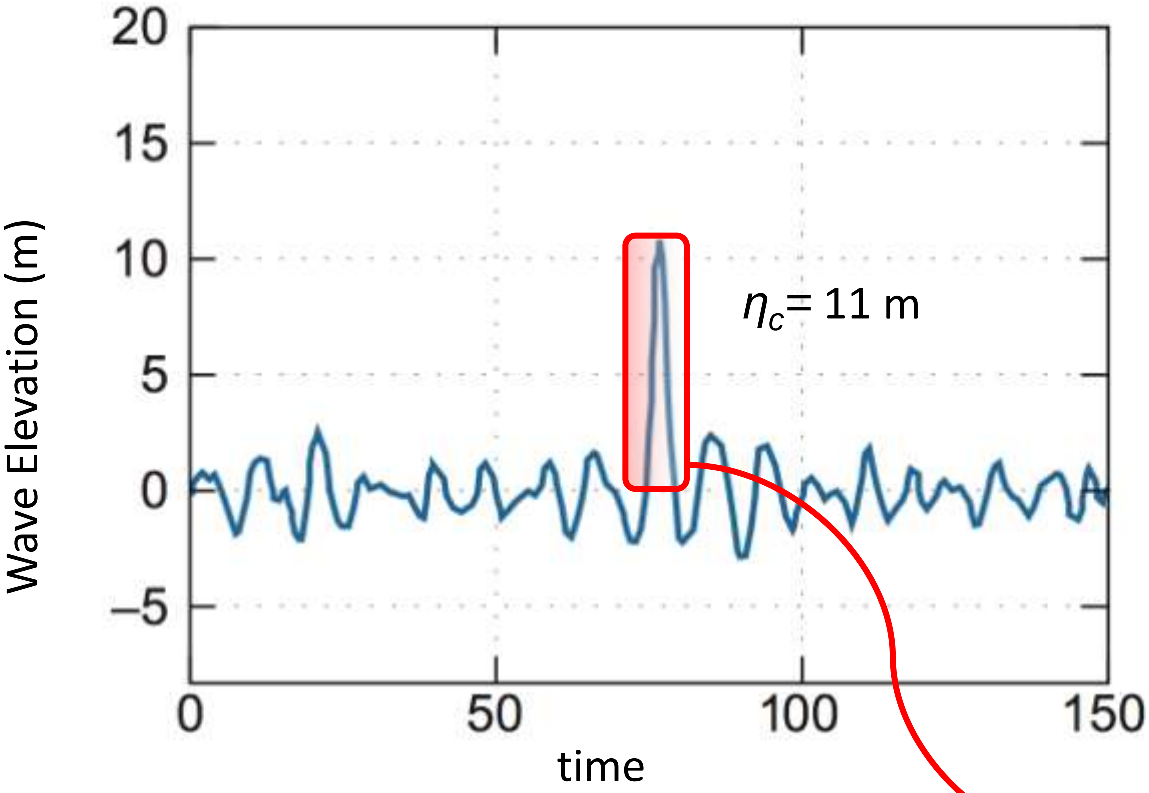
- Water on Deck Phenomena
  - Damage to superstructures & equipments
- Slamming
- Dynamic stability in waves
  - Parametric roll
  - Broaching
  - Capsizing
- Sloshing

Investigation Tools

- Numerical Methods
  - BEM Method
  - CFD Methods (URANS level)
  - Domain Decomposition (DD)
- Model Tests
  - Global quantities (i.e. ship motions, incident wave system)
  - Local quantities (i.e. pressure, local loads,
  - accelerations, relative wave height)
- Full Scale Trials
  - Global quantities (i.e. ship motions, sea state)
  - Local quantities (???)

2. Big challenges and relation with the proposed topics

Violent fluid – structure interactions: extreme waves, WOD, slamming, sloshing, parametric roll, broaching and capsizing



GORM

North Sea, Nov. 1984

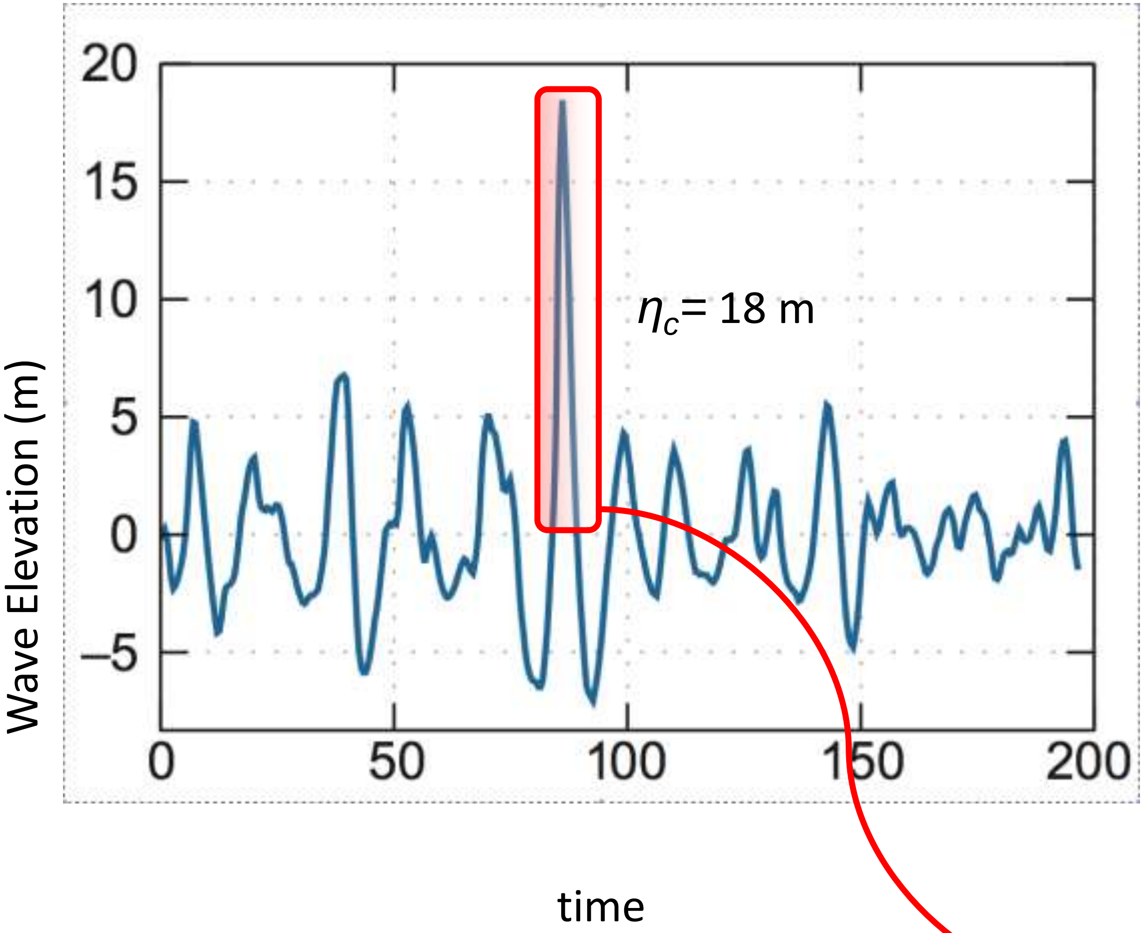
H_s=5 m

$$\frac{H}{H_S} > 2$$

or

$$\frac{h_C}{H_S} > 1.25$$

2. Big challenges and relation with the proposed topics



Extreme Waves from real life…

New Year (Draupner)

North Sea, Jan. 1995

H_s=11 m

$$\frac{H}{H_S} > 2$$

or

$$\frac{h_C}{H_S} > 1.25$$

2. Big challenges and ...

Extreme waves from the real environment ...

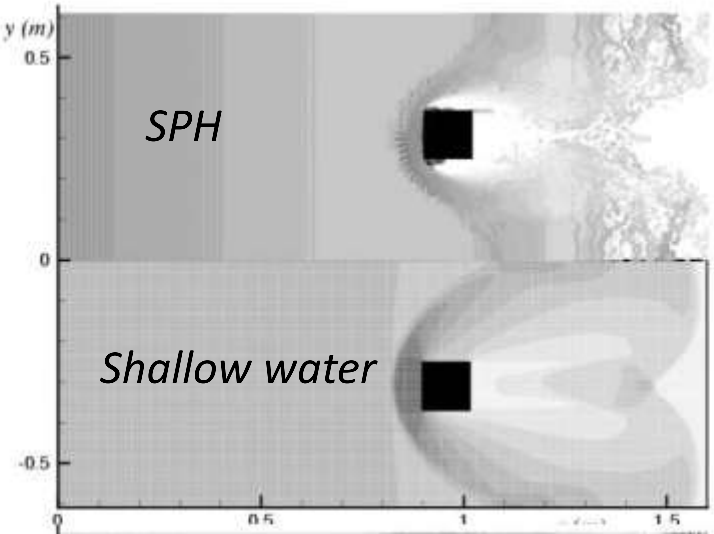
Olivieri et al. 2006

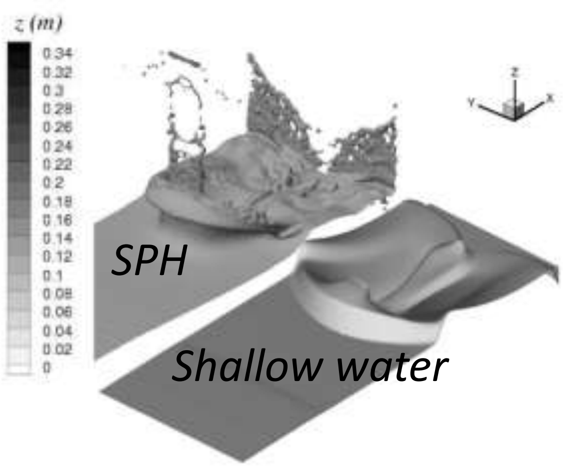
Extreme waves at Laboratory scale ...

...relation with the proposed topics

Deck and superstructures

Violent fluid – structure interactions: *extreme waves, WOD, slamming, sloshing, parametric roll, broaching and capsizing*





Lugni and Greco, submitted to Journal of Fluids and Structures

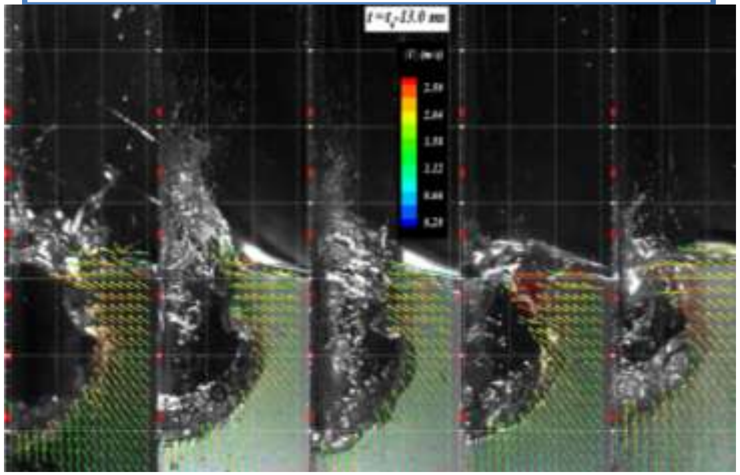
2. Big challenges and relation with the proposed topics

Water on deck, slamming, sloshing in tanks

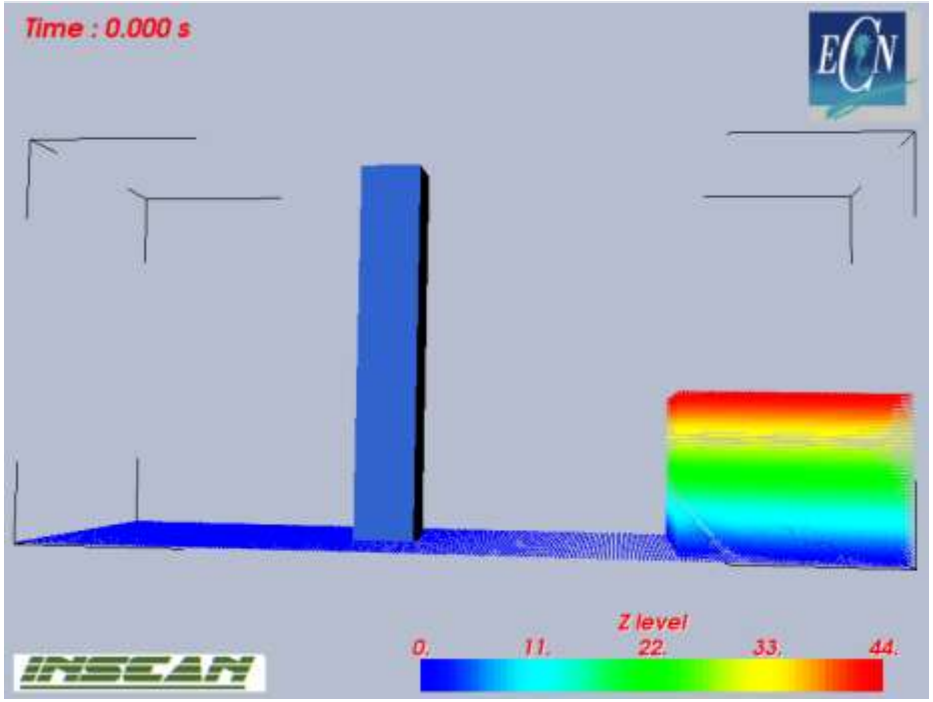
Wave impacts (water on deck, slamming) may damage infrastructures and load on board. Sloshing motion in tanks can produce air compression with damage/risk of the infrastructure.

Dynamic coupling between the sloshing and the external motions can greatly alter the system dynamics.

SPH simulation of WOD and impact on superstructures



Lugni et al. 2010



Colagrossi et al. 2009

2. Big challenges and relation with the proposed topics

Parametric roll, broaching and capsizing

Bulian et al. 2009

Olivieri et al. 2009

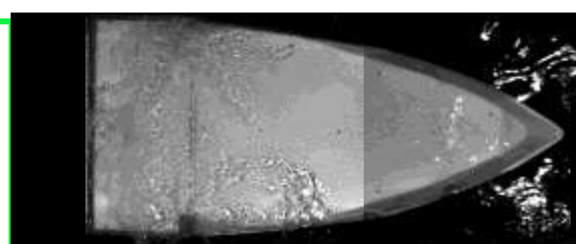
Umeda et al. 2008

3. Current status – experimental and numerical approaches

Model tests to evaluate bottom and side pressure, added resistance, motions and loads, ...

Heave and pitch motions

Deck Pressures

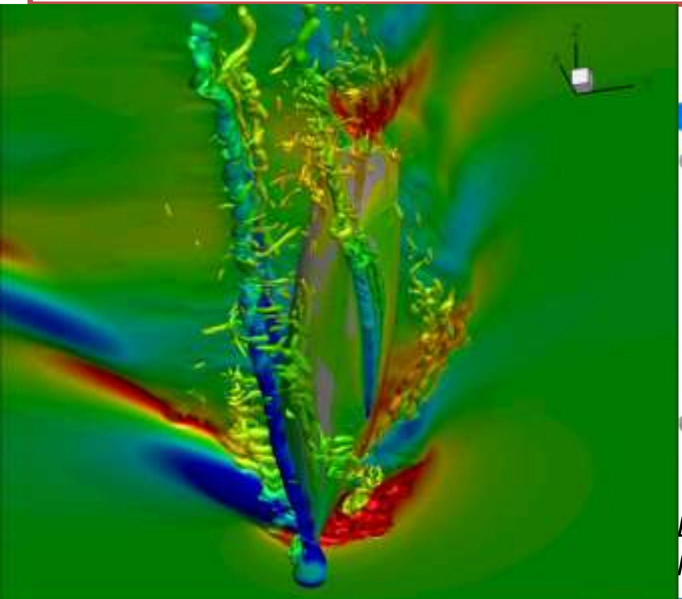


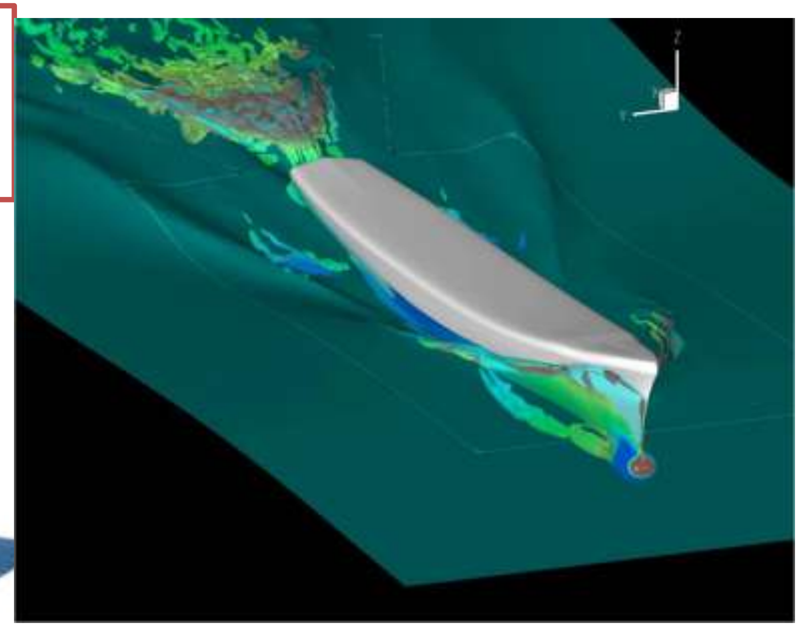
3D & Top videos

Greco, Lugni to appear on J. Fluids and Structures

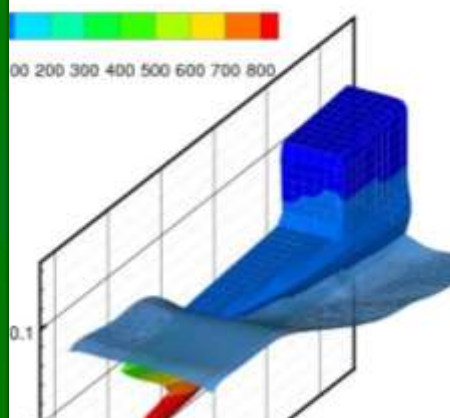
3. Current status – experimental and numerical approaches

Prediction the ship's behavior in calm water and in waves, dynamic loading and impacts, propulsion and cavitation

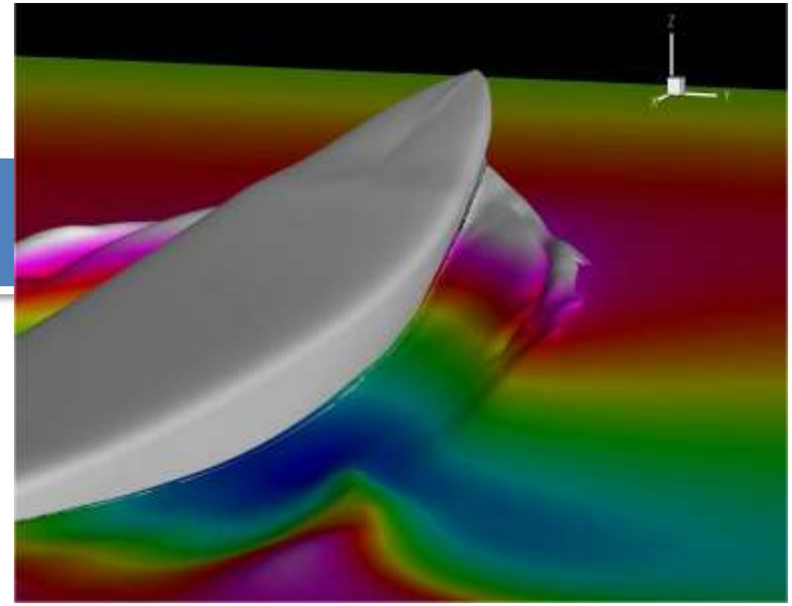


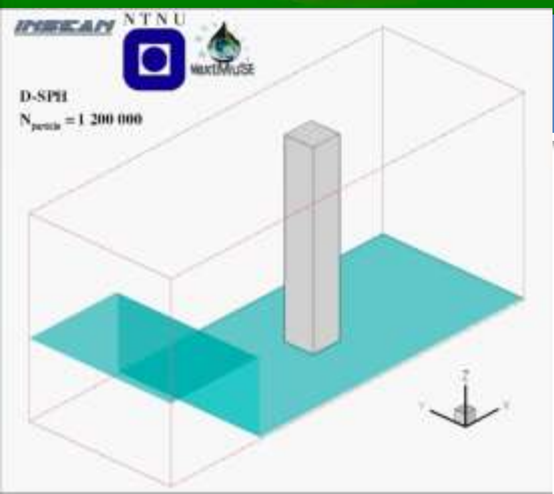


Stern et al. 2011



Lugni, Greco submitted to J. Fluids and Structures

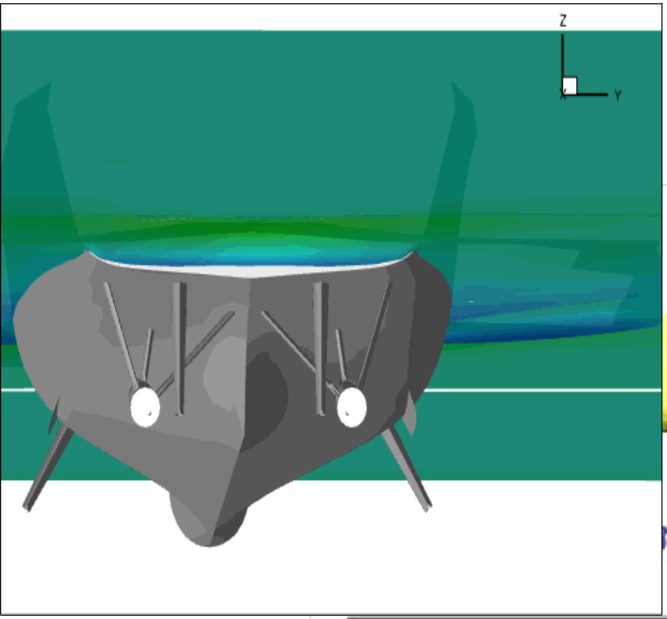




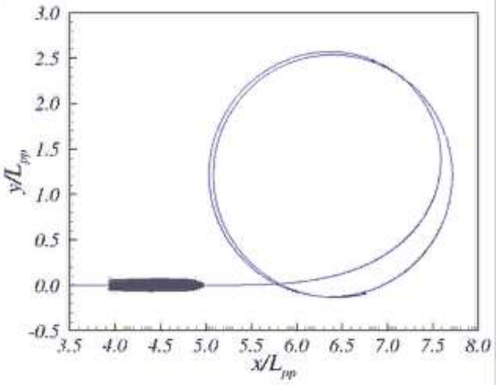
URANS, DES, D-DES, SPH, BEM, HOS

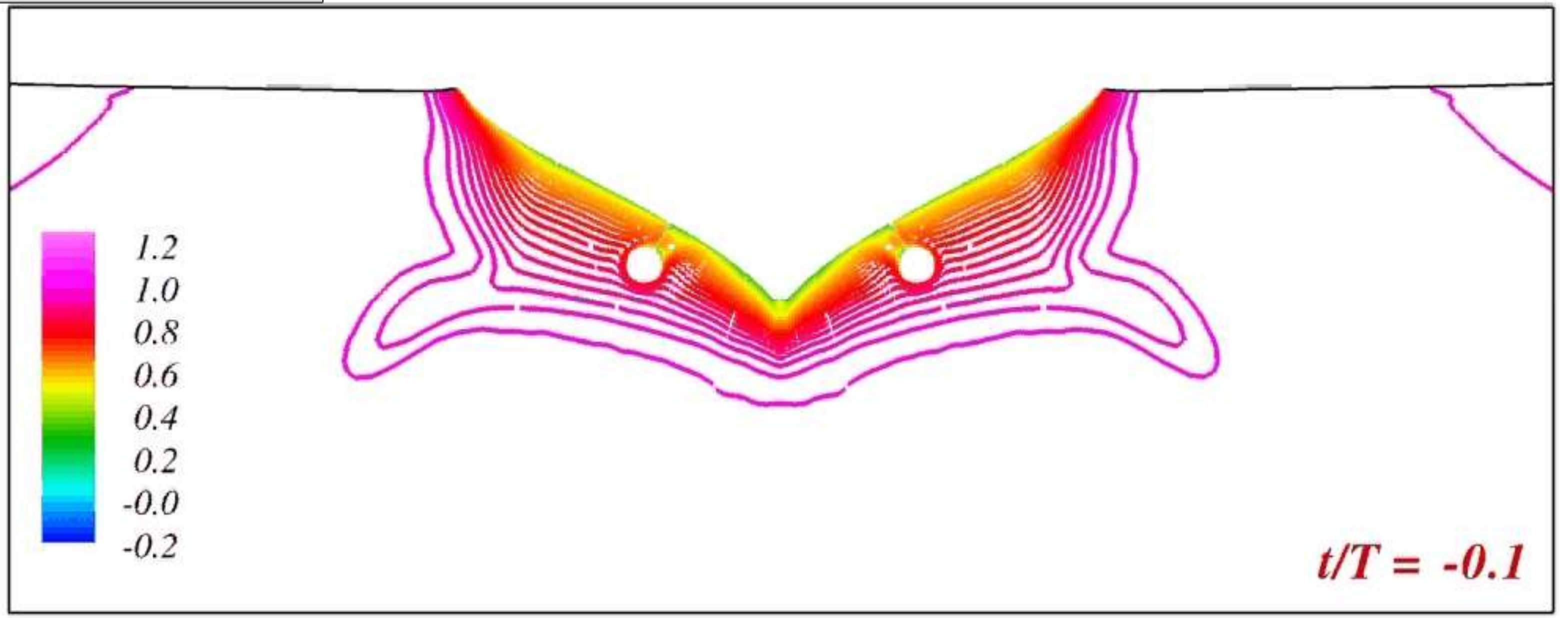
Validation: model test, full scale measurements

3. Current status – experimental and numerical approaches



Prediction the ship's behavior in maneuvering





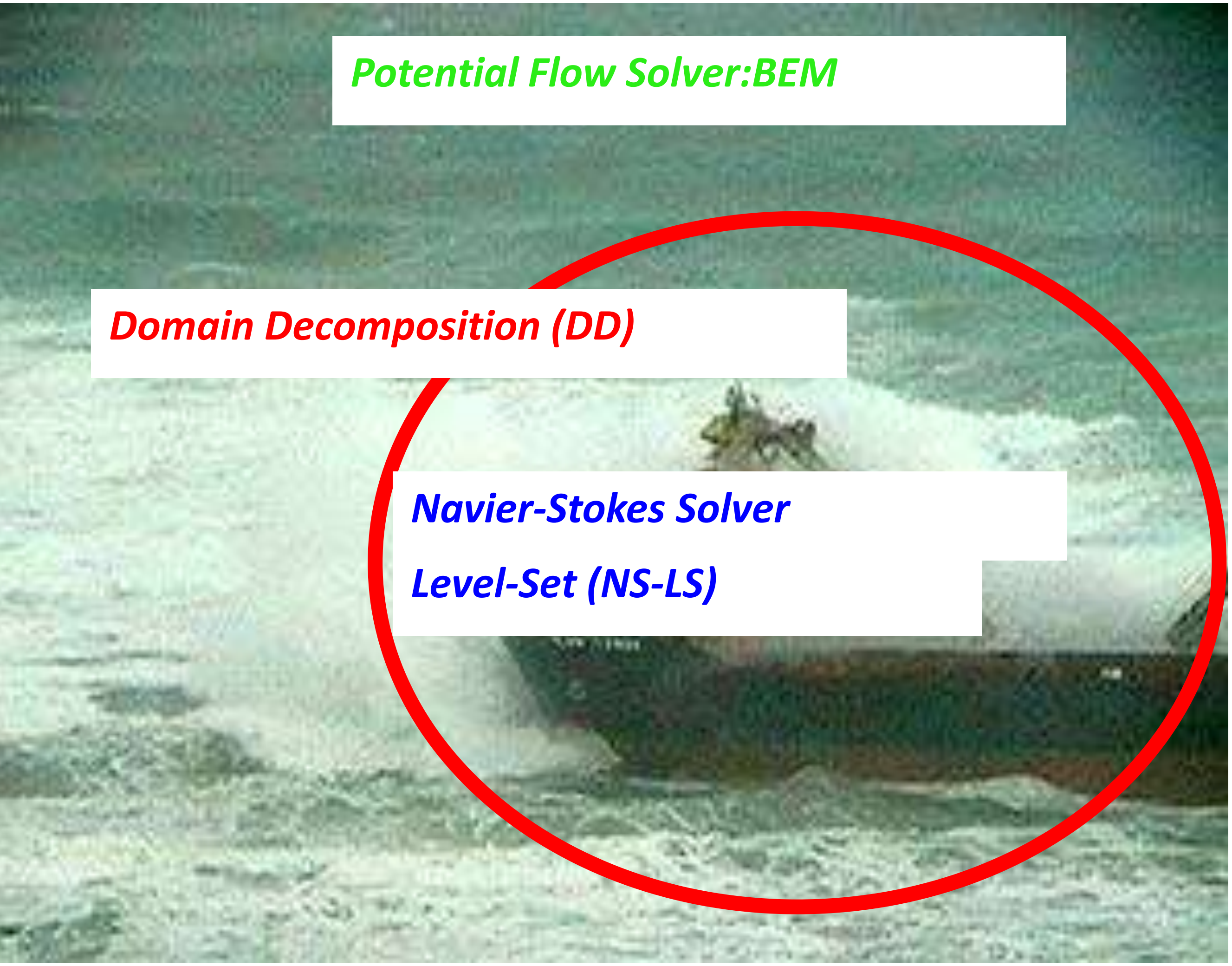
Muscari, Broglia, 2008

3. Current status – experimental and numerical approaches

***Coupling between seakeeping and maneuvering* - **Prediction the ship’s behavior in maneuvering: simulation with the rotating propeller, with and without rudder control

Current computational methods for solving seakeeping problems of ships with forward speed *Unsteady RANS, fully nonlinear potential flow, weak scatterer hypothesis, 2D + t, and blended methods. In general, the accuracy of the solution must be balanced against the computational effort. The advanced codes give more detailed and better solutions, but they require parallel clusters or the equivalent*

Domain Decomposition Method



An example of fluid flow where one region is interested by fragmentation and one is almost flat.

The modelling of the former requires the use of a complex model that takes into account phenomena of fragmenting interface, of air entrapment of viscous dissipation of vorticity, etc.

***The application of such a method in the whole fluid domain is computationally non-efficient for design purposes**. The use of a potential solver in the surrounding region would reduce the CPU time.*

3. Current status – experimental and numerical approaches

Physical / numerical methods and models: focus on Dynamics

- *Dynamic stability*
- *Heave and pitch motions*
- *Relative vertical motion*
- *Water-on-deck occurrence and its coupling whit dynamic stability*
- *Volume of shipped water*
- *Evolution of the shipped water*
- *Deck pressure*
- *Bottom-slamming occurrence*
- *Bottom-slamming pressure*
- *Flare pressure*
- *Added resistance in waves*
- *Wave radar signals*

CFD - EFD integration

CFD is fundamental in:

Filling the gaps between measured points and providing quantitative information where no data were collected

Allowing a complete physical understanding

X-Band radar systems (wave radar)

- Scan the sea surface with high temporal and spatial resolution
- Provides reliable information about wave fields and surface currents:

  wavelength, period and direction of dominant waves, significant wave height and high resolution surface and bathymetry maps.

With existent installations of nautical radar systems in all marine structures, platforms and ships, the measurements may be implemented in a very cost-efficient way.

Possible impacts

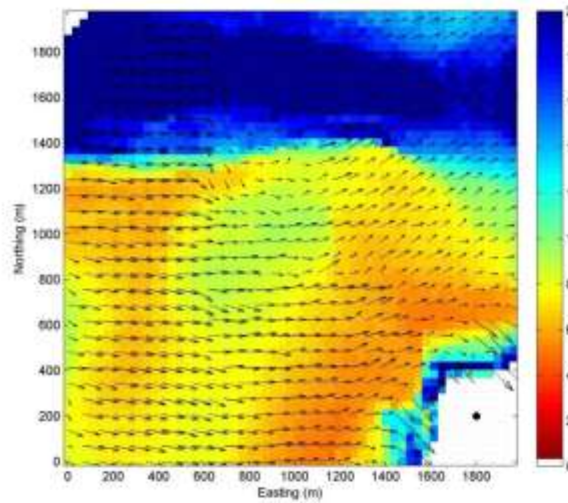
- **Improve the safety** of the fishing vessel (minimize the motions and the risk of dynamic instability)

- Reliable estimation of the sea-surface current allow an optimal strategy for low consumption and the best positioning of the net cages → **energy efficiency**

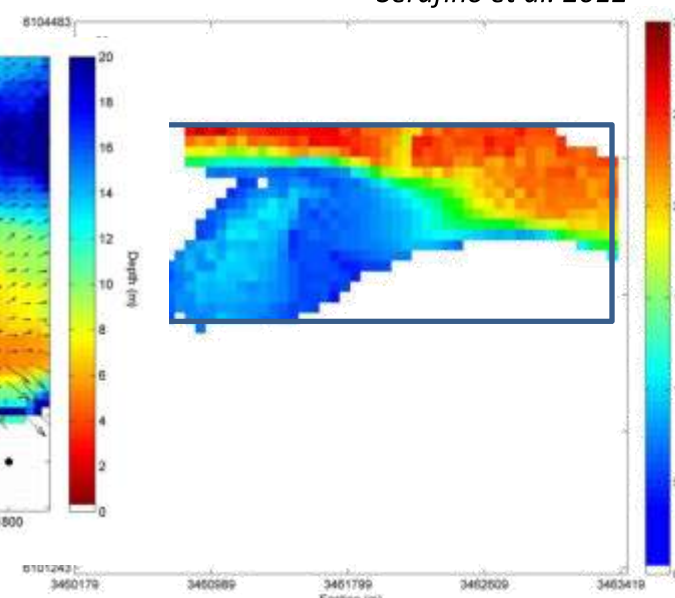
-Oil spill detection and propagation

- Facilitate rescue operations via real time knowledge of wind and currents

Serafino et al. 2012



Estimated Bathymetry with currents map overalpped



Multibeam echosounder bathymetric data

4. Where to concentrate future efforts ?

- **Hydrodynamics (1) : Simulation + EFD validation**
  numerical full 3D description / simulation of stochastic environment including waves, current and wind
- **Hydroelasticity (1) : Theory + EFD validation**
  methods for analyzing and designing large flexible construction (e.g. large fish farms) in a real marine environment.
- **Hydrodynamics (2) : Modeling**
  Develop models for predicting the stability and capsizing conditions of fishing vessels in real seas and during real operation in bad weather conditions (e.g. short crested waves and current)
- **Hydrodynamics (3) : Theory + Simulation**
  Develop a Simulation Based Design framework for using experimentally validated numerical tools in the design process
- **Hydrodynamics & Electromagnetism : theory + sea trial**
  Improve X-Band radar systems to provide information about the spatial-temporal behavior of wave fields and surface currents