SMART MARITIME

FRICTIONAL RESISTANCE AND HULL ROUGHNESS

PHD PROJECT OF JON COLL MOSSIGE

SAC MEETING 20-09-2018

sfi Centre for Research-based Innovation
The Research Council of Norway

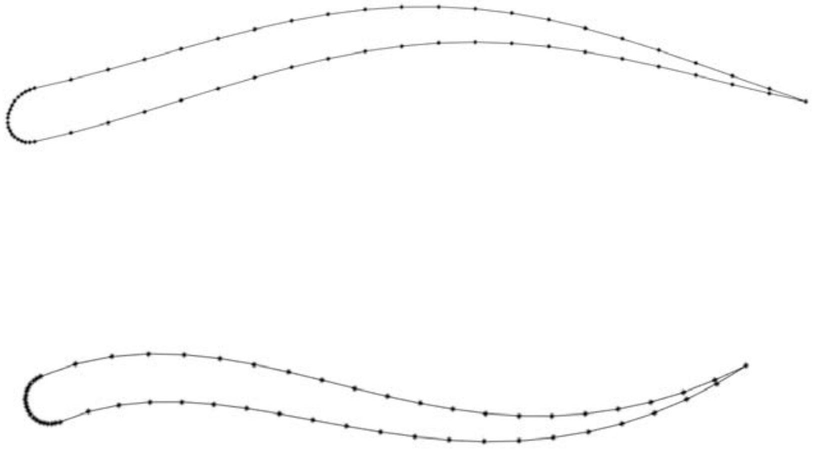
www.smartmaritime.no

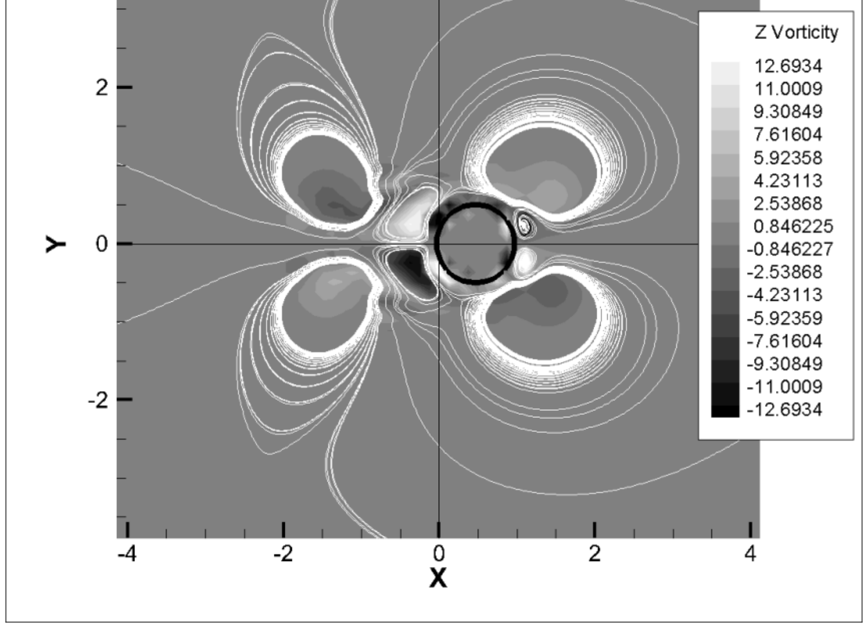
Jon’s background

Numerical Simulations of Swimming Fish

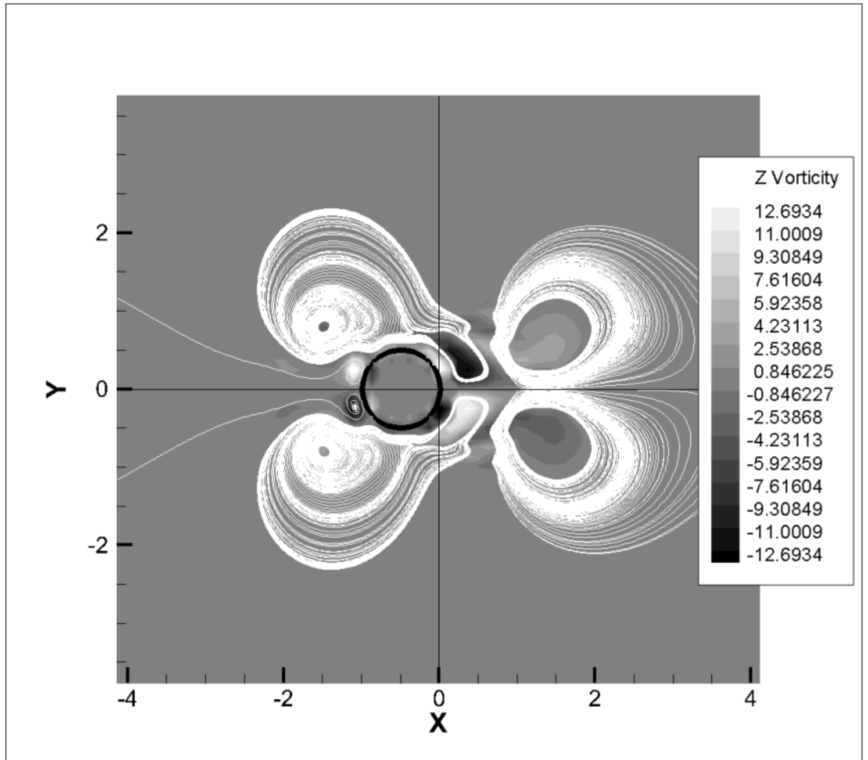
Developed a Navier-Stokes solver that implemented the Immersed Boundary Method for fluid-structure-interaction analysis.

Here represented by two fish-models (below) , and a simulation of an accelerated cylinder(right).





(a)



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PhD – the first year

Courses within...

- Non-linear surface waves
- Boundary layer flow and separation
- Free shear flows
- Turbulence, instability and transition
- Foil theory
- Maneuvering

Litterature studies

Duties at the university:

- Scientific assistant in Oceanography
- Member of the PhD-committee (08-18-present)

Research questions - Fundamental understanding

In the problem of ship-friction, **turbulence is key**, and the realizations of turbulence are extremely sensitive to perturbations. The following questions arise:

How is turbulent behavior affected by ship-related perturbations?
(roughness, waves, vibrations, …)

Can we isolate and investigate specific turbulent structures one by one?

How do we quantify to which extent isolated turbulent structures affect the increase in frictional resistance?

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Applications

Answers to the previous questions may support improvements and innovations...

Friction Reduction:

Coating technology design, hull shape design (Of interest for Industrial partners, e.g. JOTUN)

Prediction and monitoring:

If we can classify which roughness structures creates which kind of turbulence pattern, we can generalize roughness into simpler descriptions, which may be used in fast computational tools. These can be used for **prediction** and for assessing the impact of **monitored** fouling-conditions on full scale ships.

Currently, Jon is working on

A 1D time marching solver for boundary layer flow

- Gives a quick friction prediction with roughness accounted for

(O(seconds) of computation on a laptop)

- Can handle oscillatory flow components and high Re-flow

--> Applicable to ship-problems

A simulation tool for early design phase resistance prediction,

as well as for estimates of added roughness given a ship's fouling conition.

1D Boundary Layer solver

But...

$$\frac{u}{u_*} = \frac{1}{\kappa} ln\left(\frac{zu_*}{\nu}E\right)$$

The solver is based on the *logarithmic velocity profile*

$$u_* = \sqrt{\frac{\tau_w}{\rho}}$$

where roughness is only described by a single factor, E

(E ≈ 9.0 for hydraulically smooth flow)

To be able to generalize <u>any</u> type of roughness into a single parameter like this...

Detailed study of turbulence-roughness effects

…the fundamentals of turbulence and roughness must be studied in detail.

Though we cannot achieve Reynolds numbers as those for ships, high-resolution CFD-analysis can give us detailed insights in the behavior of turbulent structures in a boundary layer.

This may enable us to **isolate** and **quantify** specific effects of roughness on turbulent dissipation on a fundamental level.

Such knowledge is valuable in the **design** of friction-reducing coating technologies, as well as for the **prediction** of added resistance due to fouling

We have an in-house DNS code which we are eager to use for this purpose.

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Detailed studies by use of DNS

Isolate caracteristic types of turbulent structures and study their effect on the frictional resistance.

Compare turbulent structures in smooth walls to those of wall flows with different types of roughness.

Work towards a set of subgeneralizations of the typical hull conditions into the roughness parameter in the logarithmic profile. (Coated hull -- slime -- shelling -- weed)

Isolated results can thereafter be combined to estimate more realistic hull conditions through use of the 1D BL-solver mentioned earlier.