

Field measurements of interaction between fluid flow and a fish farming cage of the gravity type typically used in the Faroe Islands

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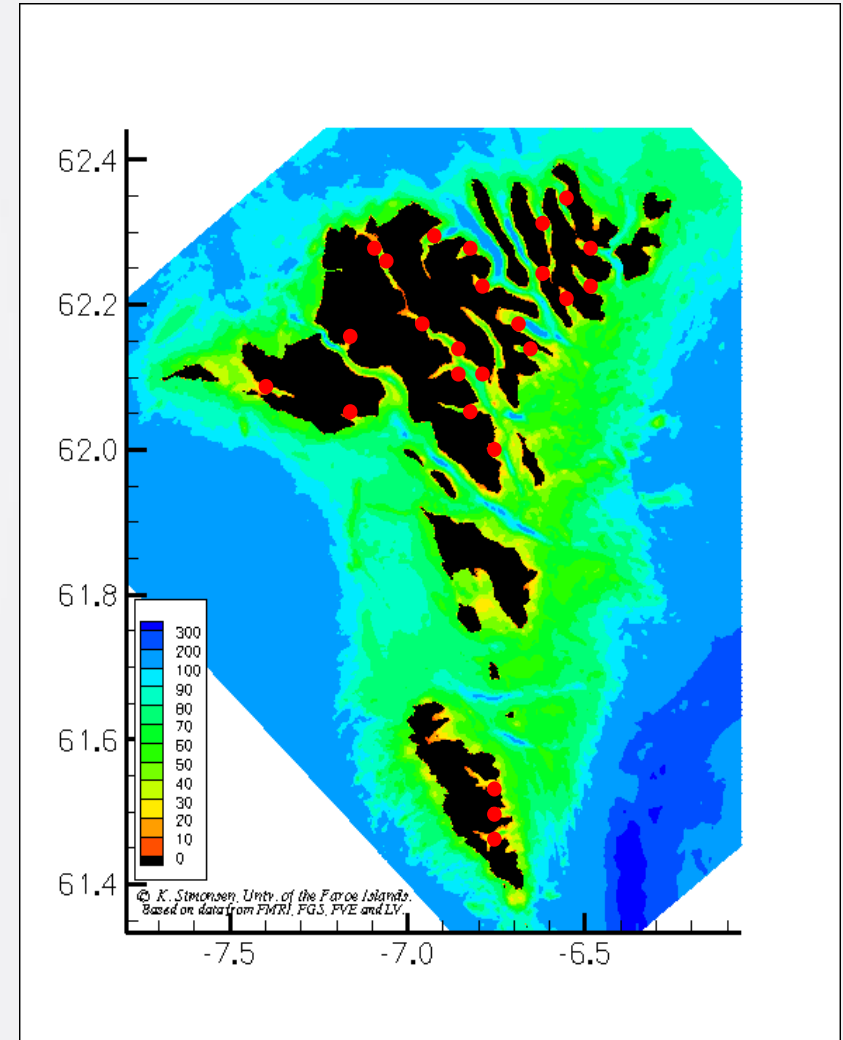
Faroe Islands

www.fiskaaling.fo

DEMaT'11
Split, Croatia
October 26-28, 2011

Introduction

- Fish farming in the Faroes
 - Atlantic salmon
 - Large gravity cages
 - 96 – 128m circumference (testing 160m)
 - Up to 500t in each cage
- Large production in a small area (50,000t/year)
 - Shortage of sites
 - Using both very sheltered sites and highly exposed



Fluid structure interaction in fish farming

Highly exposed sites

- Deformation of cages
- Large loads

Sheltered sites

- Exchange rates

Several cages

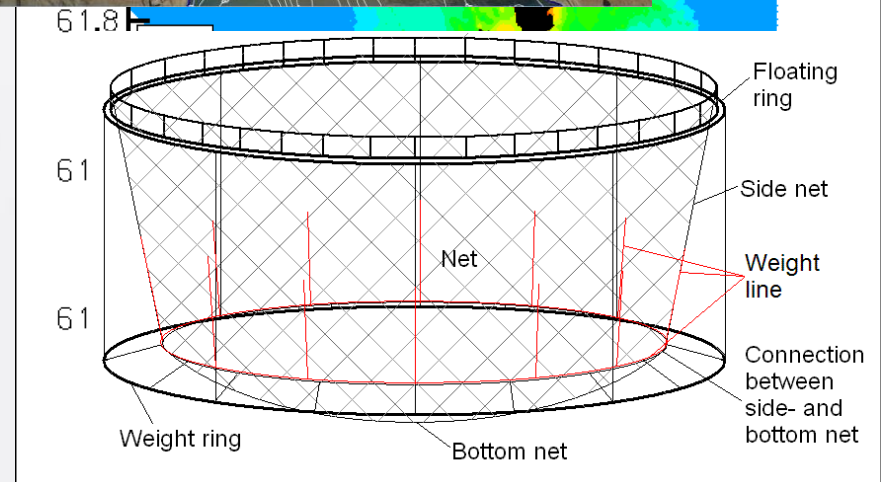
- Wake effects

Present study

- Measure deformation of a gravity cage due to strong current
- Measure velocity reduction inside the cage and in the wake

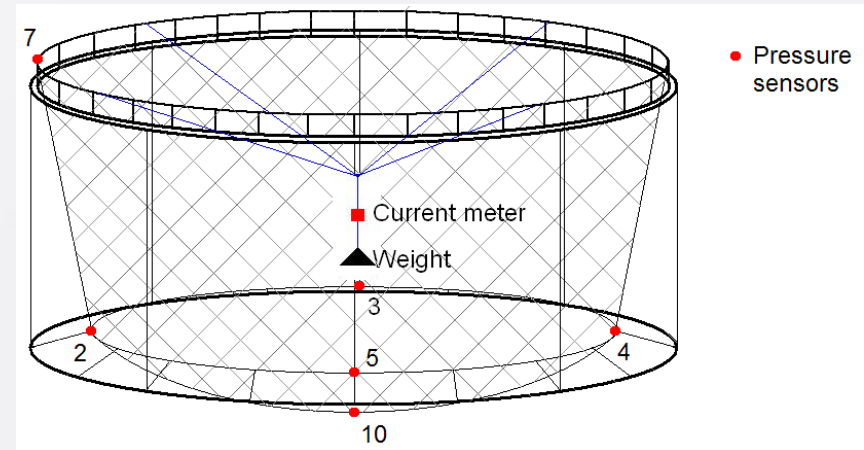
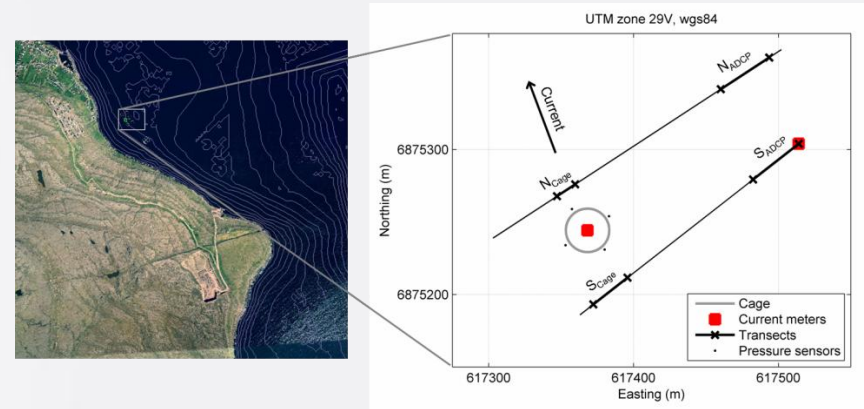
Study site

- Strong current site
 $< 60 \text{ cm/s}$ during the experiment
- One single cage
- Cage 96m circ. With weight ring
- 11m deep sidenet
- Net solidity 0.16
- Total weight added:
 2.8t



Present setup

- Current meters
 - Inside the cage
 - Bottom mounted ADCP
 - Boat mounted ADCP
- Deformation
 - Pressure sensors



Data processing

- Converting pressure to depth $d = p / (\rho g)$.

- Cage volume

$$V = \frac{\pi r^2}{3} (2d_l + d_c).$$

- Reduced volume

$$R_V = \frac{V}{V_{Max}}.$$

- Average velocity

$$U = \sqrt{E^2 + N^2}.$$

- Velocity reduction

$$U_R = \frac{U_0 - U}{U_0}$$

Unexpected events

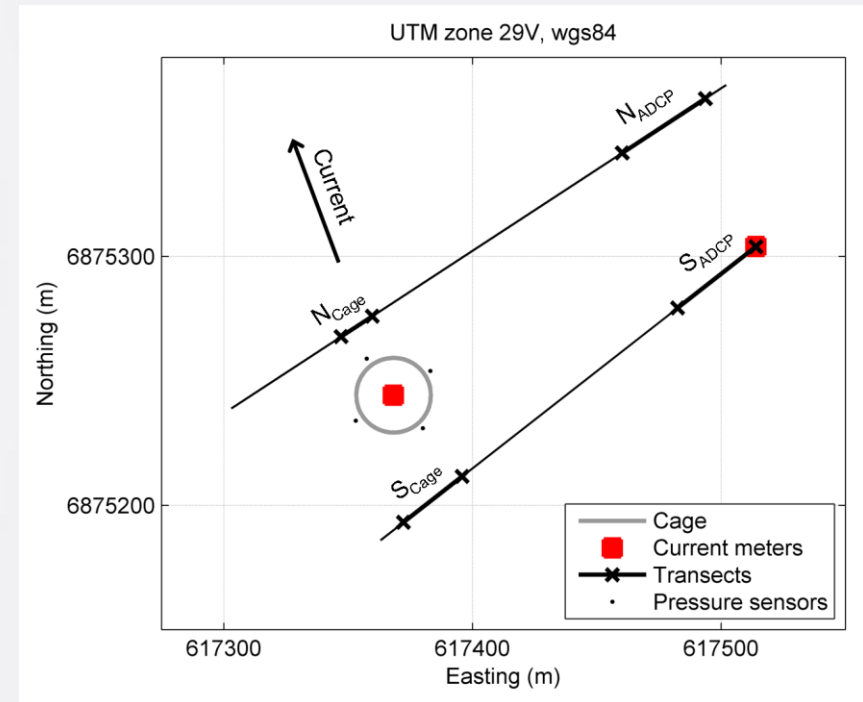
Jellyfish

- Assume 4 jellyfish of around 0.3m in diameter per m² of the net
- Adding solidity of 0.28.
- The total solidity on the upcurrent net is then $S = 0.44$.

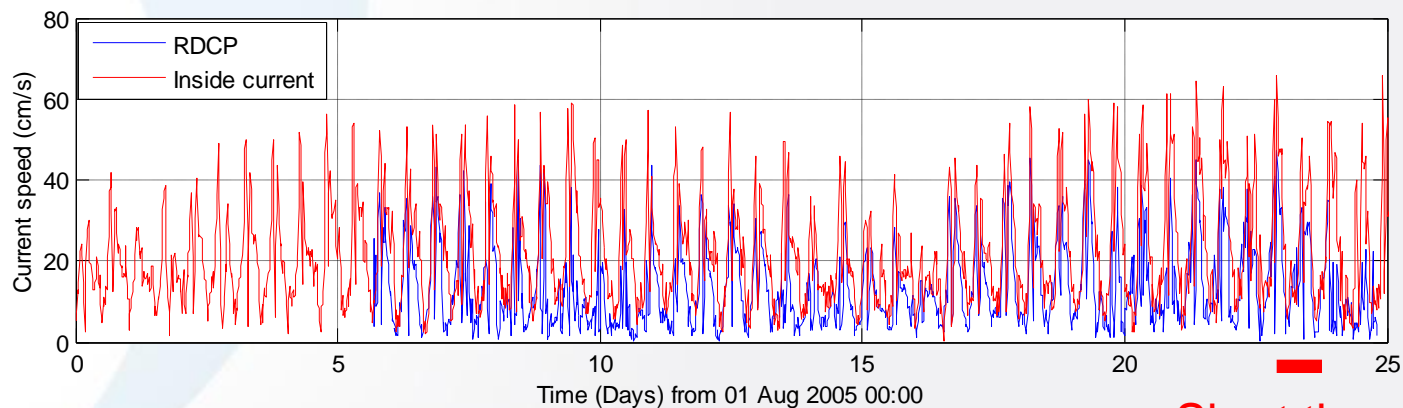
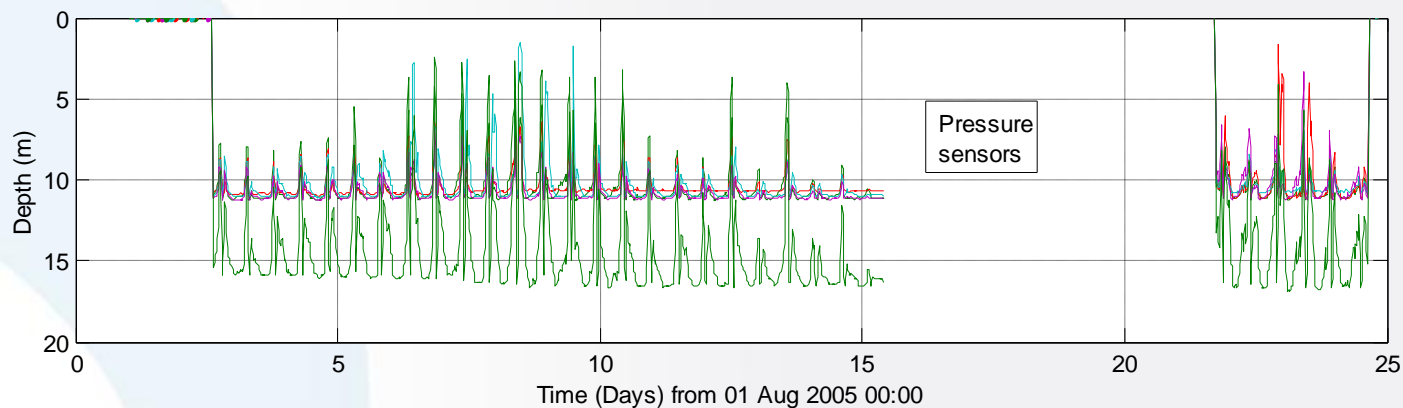
- Large deformations of the net interfered with the inside current meter
- Removed the measurements with large difference between the inside current and the outside current

Results

- Long timeseries of
 - Volume reduction from pressuresensors
 - Current outside the cage
 - Current inside the cage
- Short timeseries
 - Current upcurrent of the cage
 - Current downcurrent of the cage



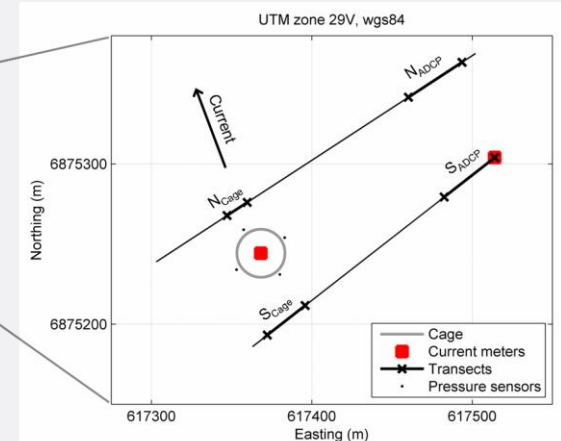
Results



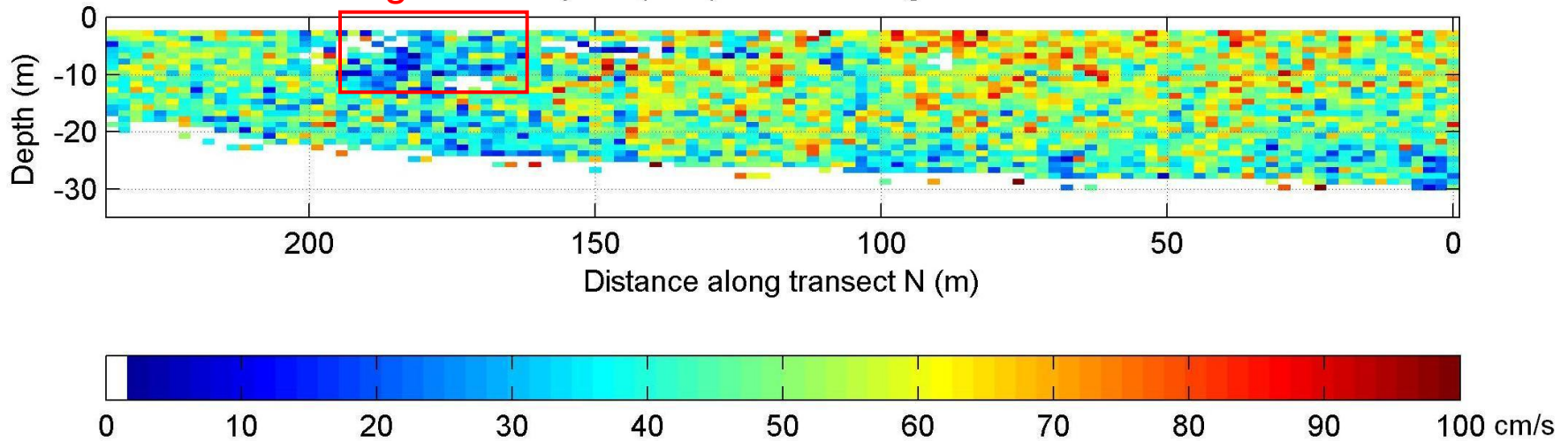
Short timeseries

Results

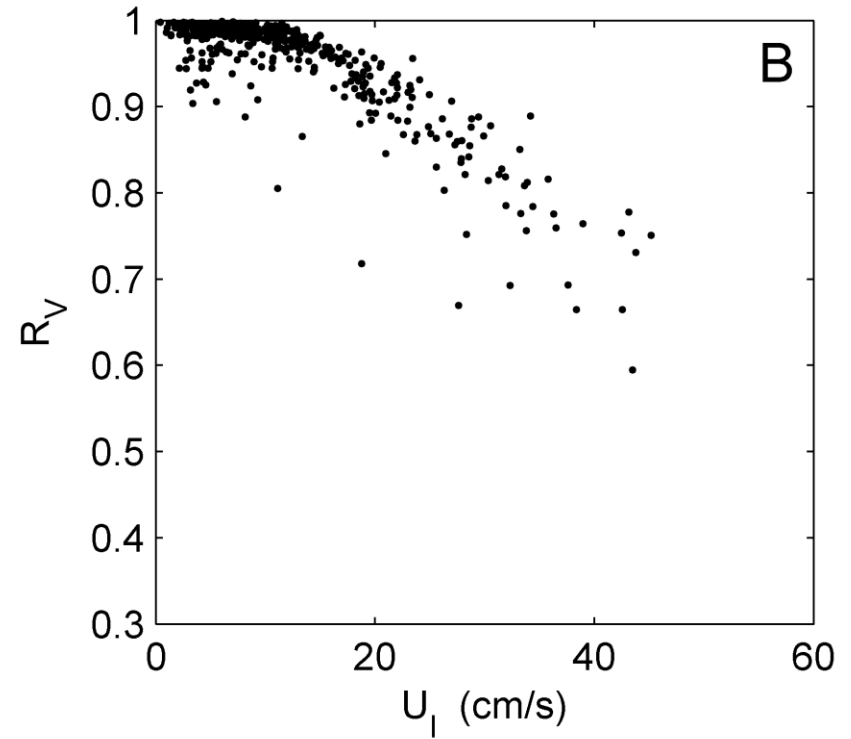
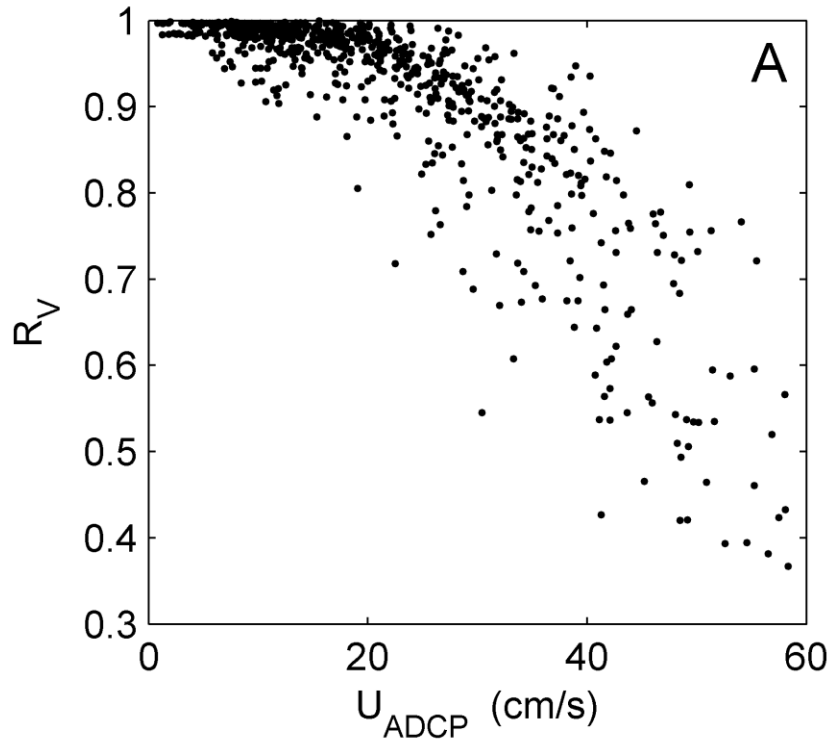
Sample of current speed along the transect downcurrent of the cage



Cage Current speed (cm/s) at time 23-Aug-2005 21:14:42

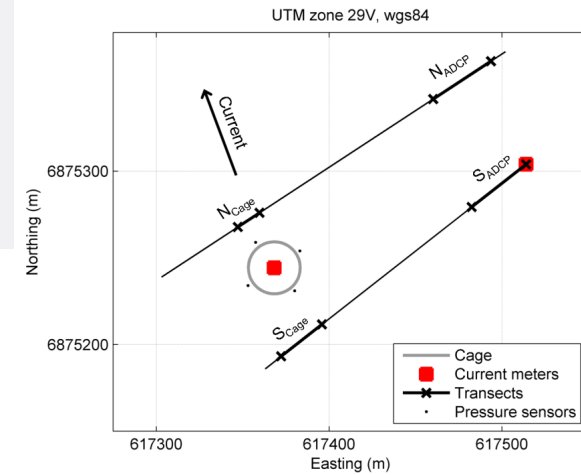
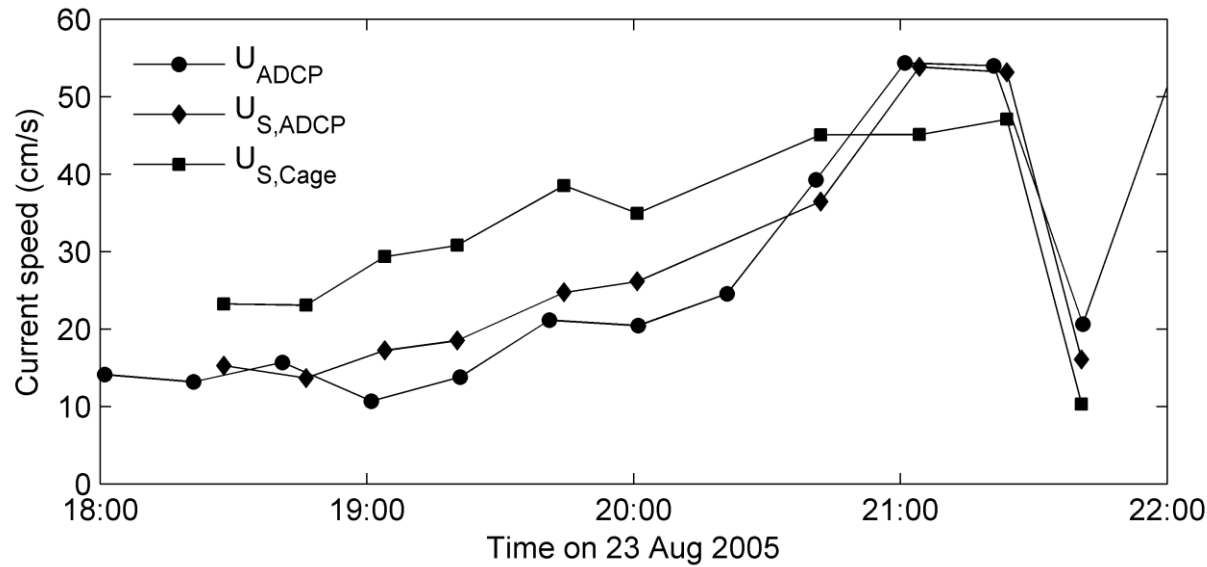


Results



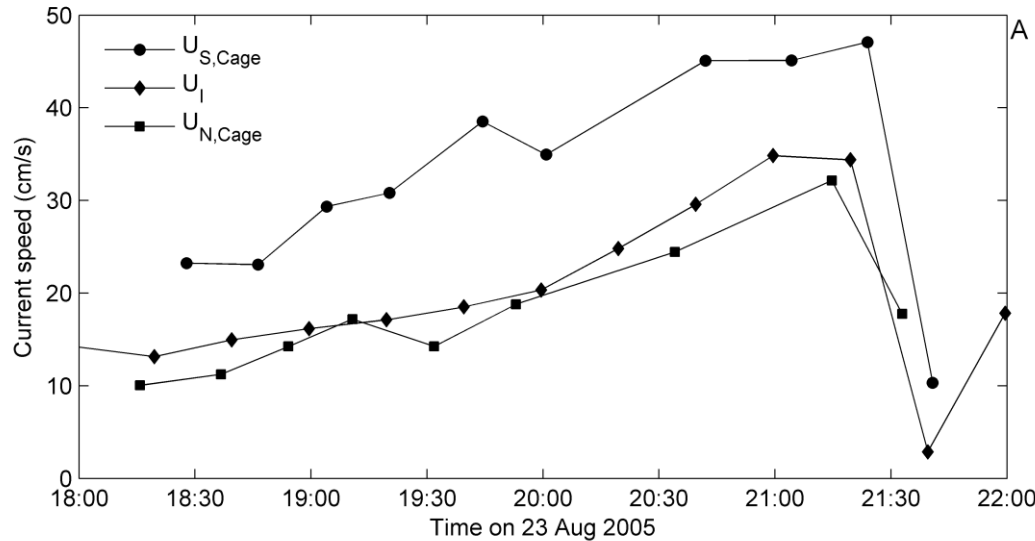
Volume as a function of current speed outside (A) and inside the cage (B)

Results



- Current speed upcurrent of the cage
- At the ADCP location, the speeds are similar
- Upcurrent of the cage the speed is different

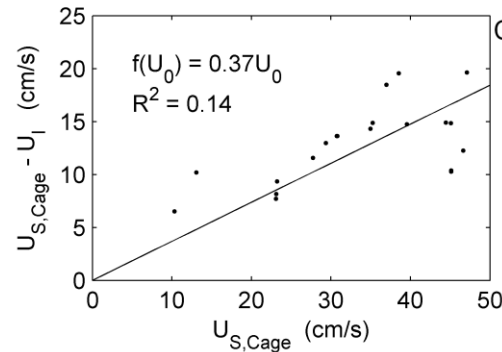
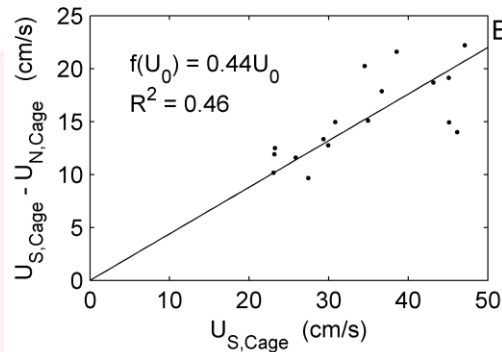
Results



Current speed upcurrent of the cage ($U_{S,Cage}$), inside the cage (U_I) and downcurrent of the cage ($U_{N,Cage}$)

Curevefits demonstrate the current speed reduction inside the cage and in the wake region

Across the upcurrent net $U_{R,UC} = 0.37$ and across the entire cage $U_{R,Cage} = 0.44$. The reduction across the downcurrent net is then



$$U_{R,DC} = 1 - \frac{1 - U_{R,Cage}}{1 - U_{R,UC}} = 0.11.$$

Discussion

According to Løland (1991)

$$U_R = 0.46C_d$$

This gives

Upcurrent net: $C_d = 0.80$ ($S \sim 0.44$)

Downcurrent net: $C_d = 0.24$ ($S \sim 0.16$)


According to Rudi et al. (1988) at $u_0 = 31.6\text{cm/s}$

A net with $S = 0.184$ has $C_d = 0.295$

A net with $S = 0.317$ has $C_d = 0.714$

Conclusion

- Method for measuring current reduction seems useful.
- Gravity cages of the type investigated can experience large deformations especially if the nets are fouled.
- Next step is to perform more detailed investigations including the far wake.

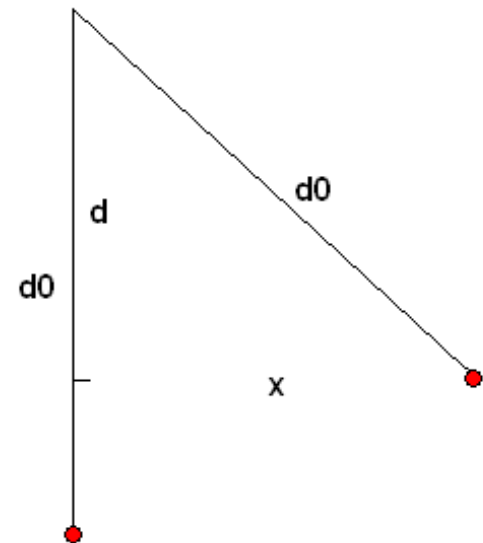


Thank you for you attention

Questions?

Pressure sensors

- 10 pressure sensors have been used to measure the movements of the fish farming net pens in current
- Housings are made to protect the sensor
- The pressure measurements can after correction for atmospheric pressure be transformed to depth
- A simple model of the net can be made from the depth measurements
- Measurements are made on 2 fish farming sites: Gulin and Funningsfjørður.



Circular HDPE cages in strong current

Full scale measurements - Gulin

Cage circumference: 96 m

Net depth: 10 – 15 m

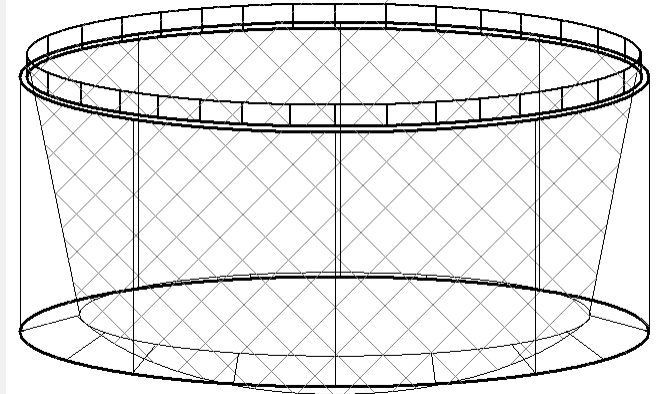
Weight ring: 18 kg/m

Weight in net: 9 kg/m



Trýst á mynd
fyri animering

Full size measurement



Diameter: 30m
Depth: 11m
Weight: 2700kg

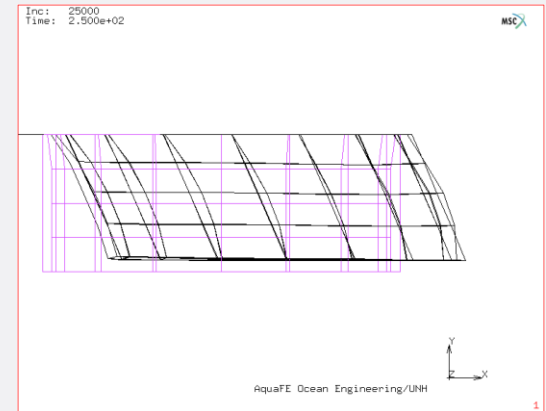
Mesh size: 25mm
Twine thickness: 2.2mm

Max measured current:
60cm/s ~ 1.2knots

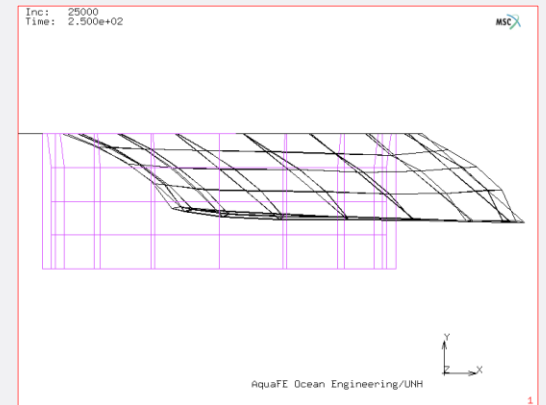
Numerical modeling

Checking AquaFE against physical model tests

Current 0.25 m/s
No waves
Volume 90%



Current 0.45 m/s
No waves
Volume 59%



Comparing results

