

CHALMERS
UNIVERSITY OF TECHNOLOGY



Experimental Quantification of Drag Change of
Commercial Coatings Under the Effect of Surface
Roughness and Soft Fouling

Irma YEGINBAYEVA

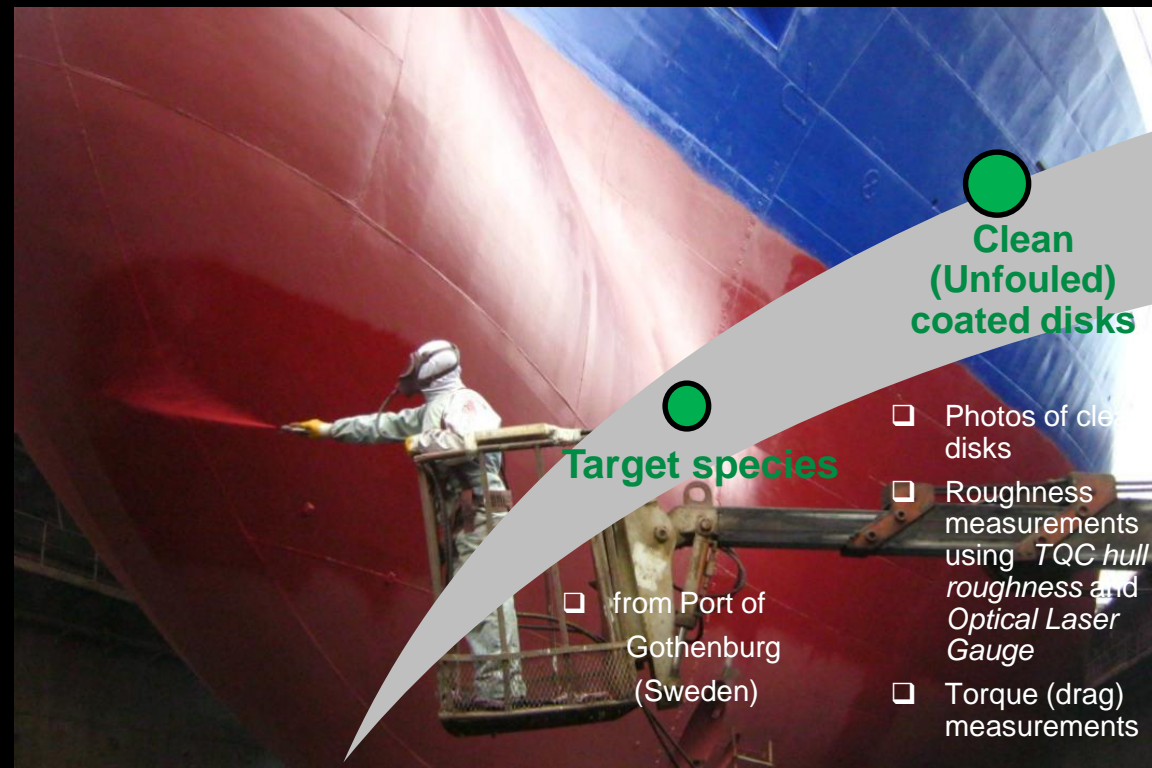
Lena GRANHAG

Valery CHERNORAY

The 19th ICMCF, June 25-29, 2018

Melbourne, Florida, USA

Objectives of the study



Target species

- ❑ from Port of Gothenburg (Sweden)

Clean (Unfouled) coated disks

- ❑ Photos of clean disks
- ❑ Roughness measurements using *TQC hull roughness and Optical Laser Gauge*
- ❑ Torque (drag) measurements

Coated disks with soft fouling

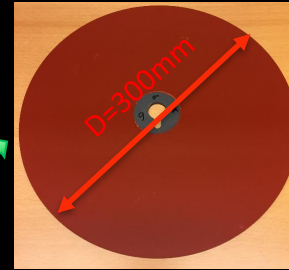
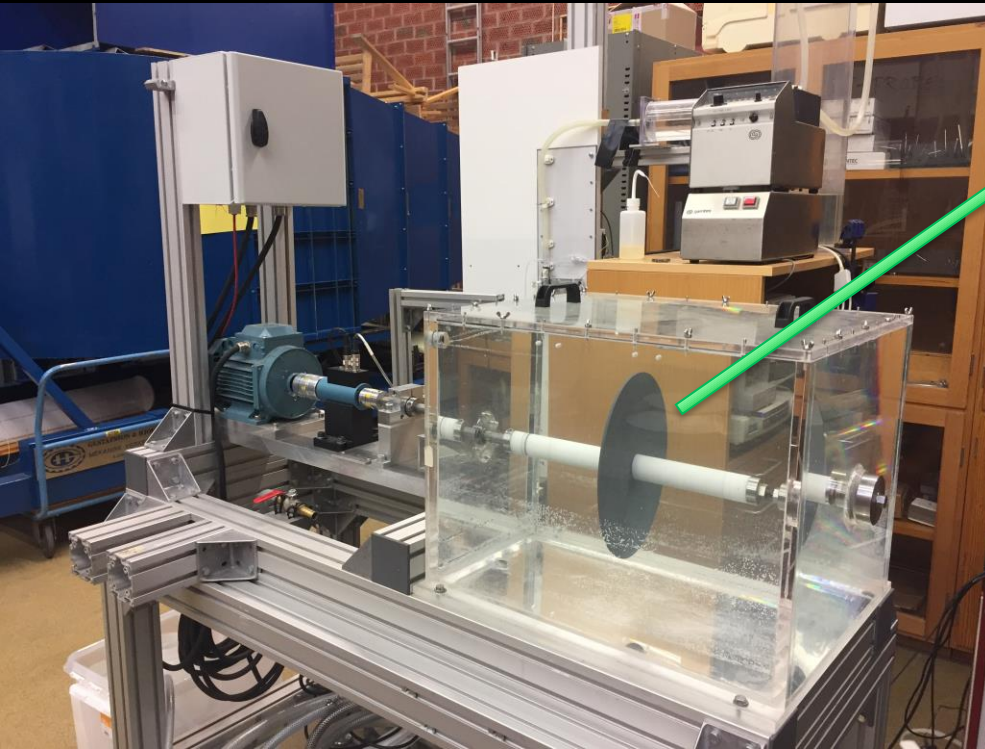
- ❑ Photos of disks before and after exposure to fouling;
- ❑ % fouling coverage assessment ;
- ❑ Identification of main species;
- ❑ Torque (drag) measurements

Drag Penalties

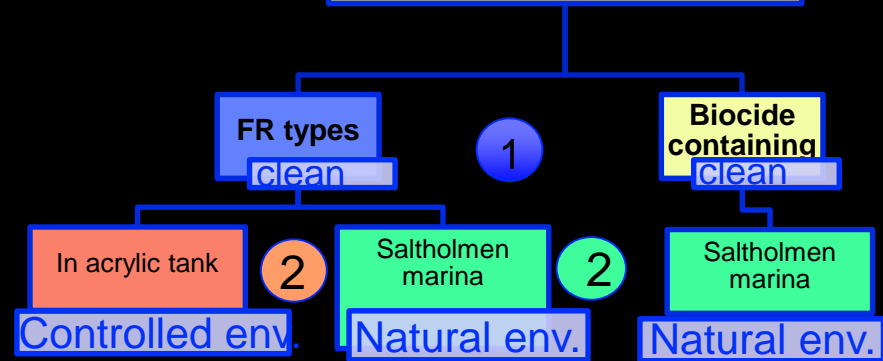
- ❑ Paint types;
- ❑ Paint roughness;
- ❑ Paint types+soft fouling;
- ❑ Paint roughness+soft fouling

Experimental studies
and methods

A rotating disk experiments

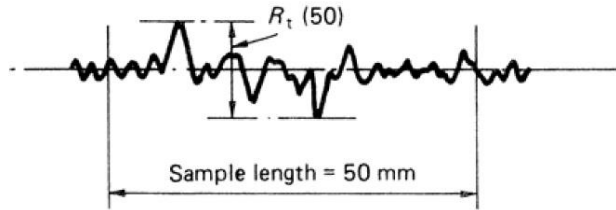


A campaign of rotating disk experiments

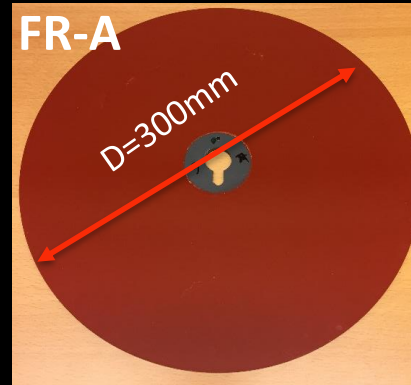


Foul-release (FR) type coated disks

- 4-types FR coating replicates with laboratory smooth application finish;
- Surface roughness (R_t50) measurements by TQC hull roughness gauge;



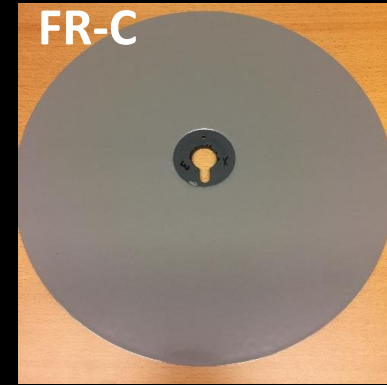
- A campaign of rotating disk measurements.



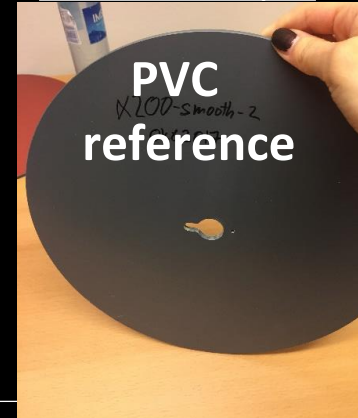
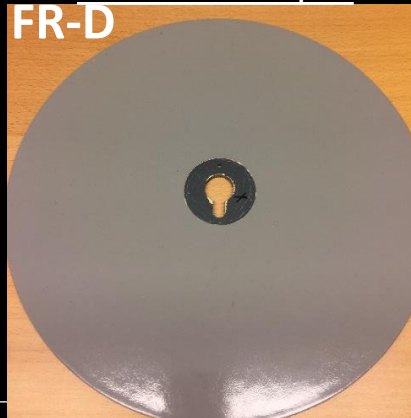
Rt50: 43~48 μm



Rt50: 48~60 μm



Rt50: 75~87 μm



Deployment of FR coated disks for fouling growth in the controlled environment

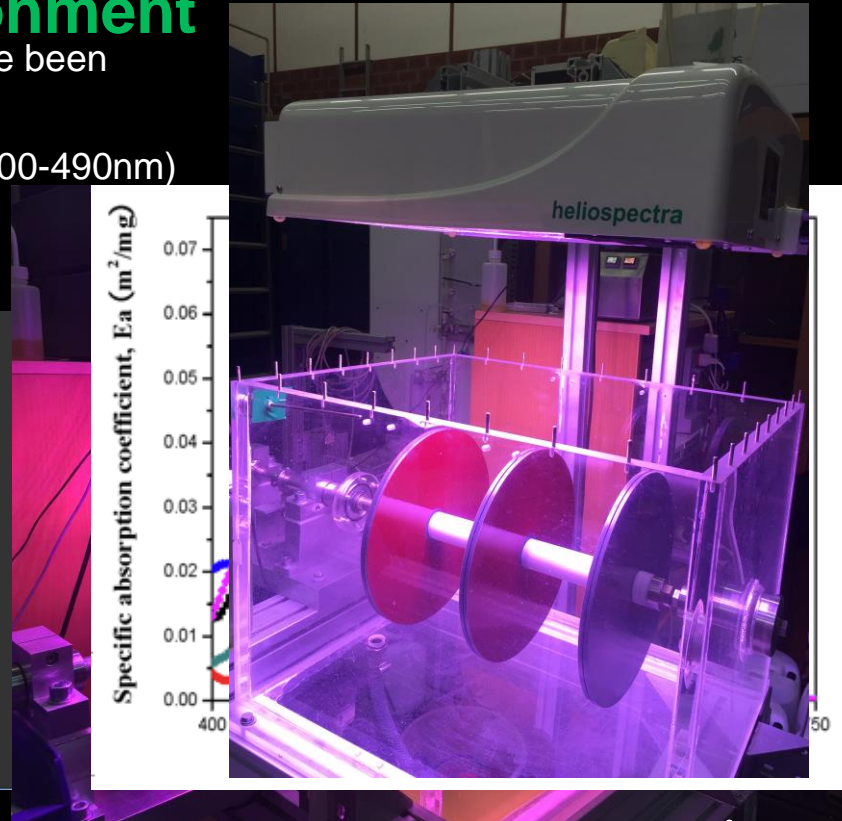
- ❑ Absorption spectra of pigments (based on Navicula) have been foundation for selection of LED wavelength;
- ❑ *Chl a* and *Chl c* in Navicula absorb light in blue region (400-490nm) and red regions (620-750nm);
- ❑ White light was also added.

SCHEDULE for Heliospectra LED light Show description

Stop schedule Browse... No file selected. Import Export CSV Delete schedule

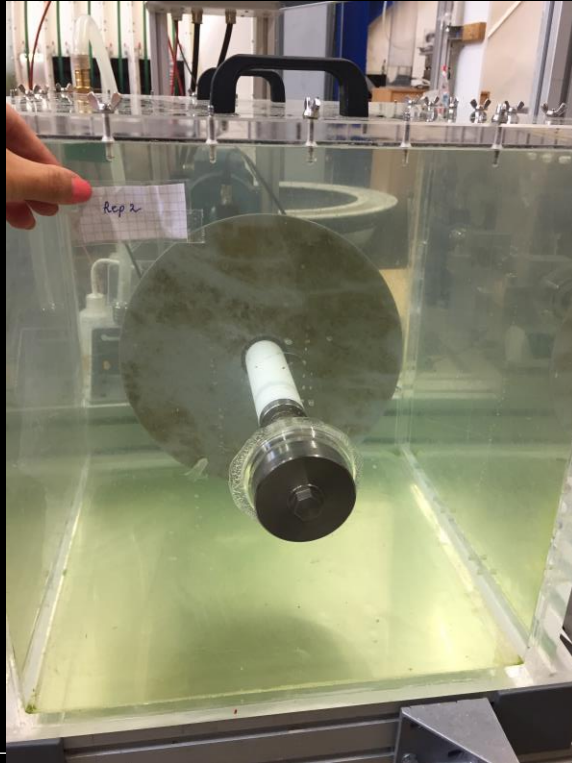
	hh	mm	ss	450nm	660nm	735nm	6500K	
+ CLR								
Edit -	08	00	00	200	200	0	200	•
Edit -	09	00	00	500	500	0	500	•
Edit -	12	00	00	1000	1000	0	1000	•
Edit -	15	00	00	500	500	0	500	•
Edit -	16	00	00	200	200	0	200	•
Edit -	17	00	00	0	0	0	0	•

MODEL 1.4 | CPU FW B2.2.27 | DRIVER FW 1.21



Deployment of FR coated disks for fouling growth in Saltholmen marina

Foul release coatings



Biocidal coatings



Biocidal antifouling coated disks

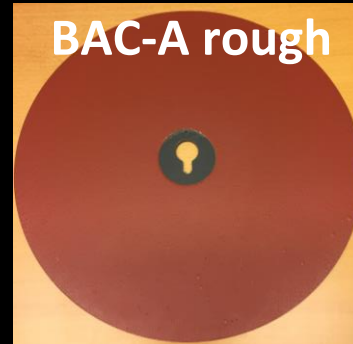
- ❑ 2-types of biocidal antifouling coating replicates (BAC-A and BAC-B) with laboratory smooth application finish;
- ❑ Additionally, BAC-A type replicates only have undergone rough application finish;
- ❑ Surface roughness measurements by TQC hull roughness gauge;
- ❑ A campaign of rotating disk measurements with clean BAC coated disks were carried out;
- ❑ [Measurements of Cu and Zn concentrations were done by XRF spectrometry;](#)



Rt50: 73~80 μm

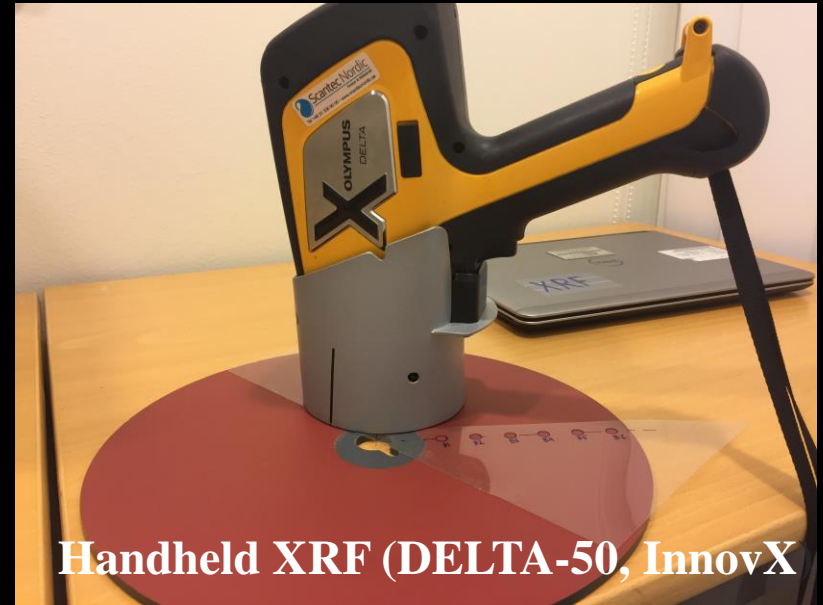
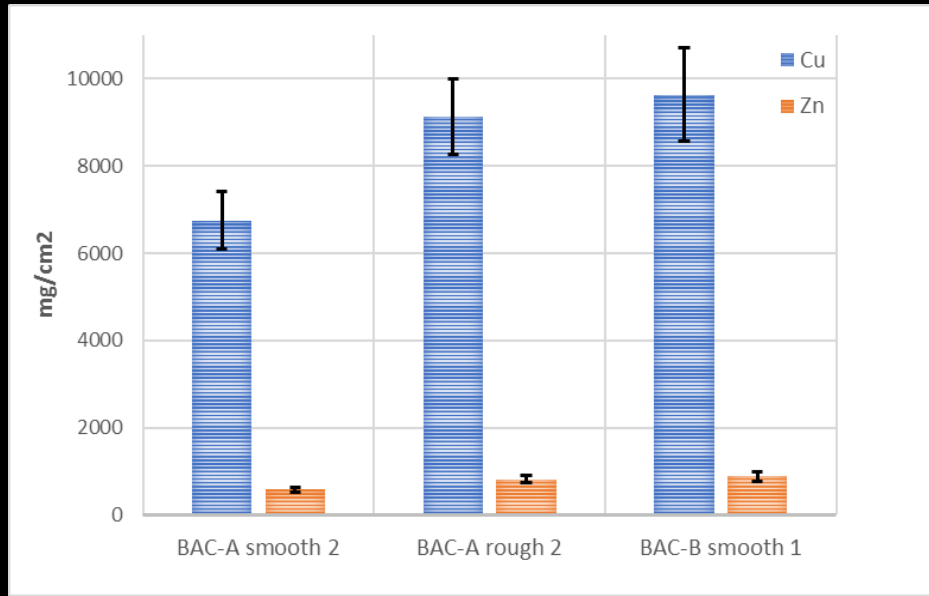


Rt50: 72~90 μm



Rt50: 116~123 μm

X-ray fluorescence (XRF) spectrometry results



Handheld XRF (DELTA-50, InnovX)

- Preliminary results show that *Cu* concentration in coatings is 6700 to 9600 $\mu\text{g}/\text{cm}^2$, whereas *Zn* results are under 900 $\mu\text{g}/\text{cm}^2$.

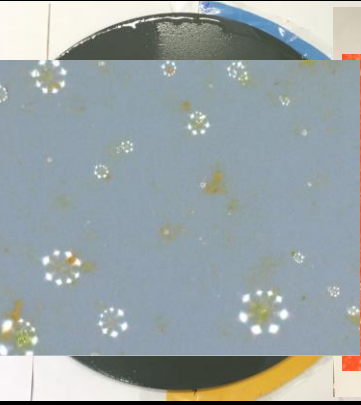
The method utilizing a handheld XRF analyser has been developed for the in-situ measurement of release of metallic biocides from antifouling paints, Ytreberg et al. (2017).

Results

Fouling coverage estimations (ImageJ) and identification of species

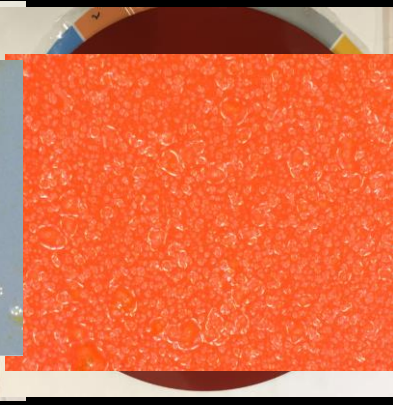
Laboratory fouling (1.5-month-old)

PVC



99% fouling coverage

FR-A



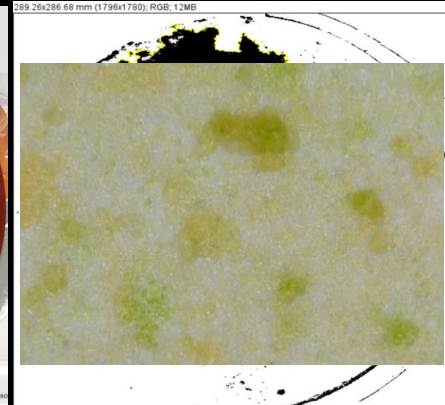
?%

FR-B



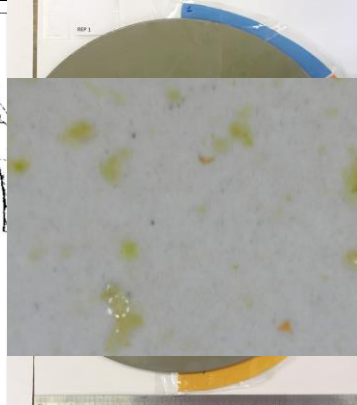
81%

FR-C



48%

FR-D



96%

Fouling coverage estimations (ImageJ) and identification of species

Field fouling (1-month-old)

FR-A



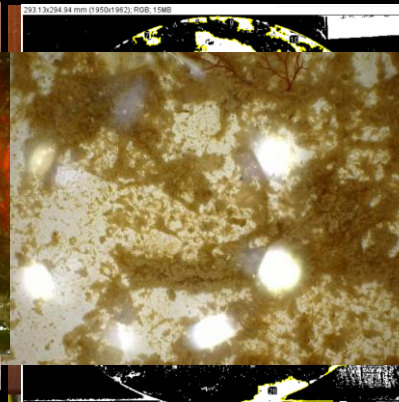
82%

FR-B



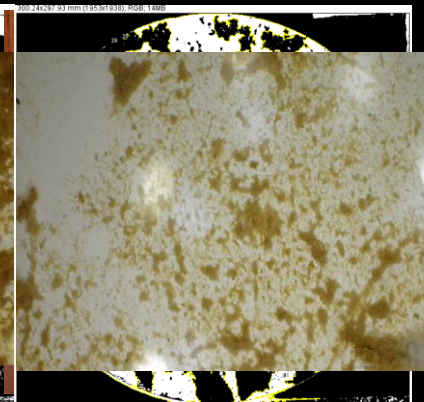
88%

FR-C



86%

FR-D



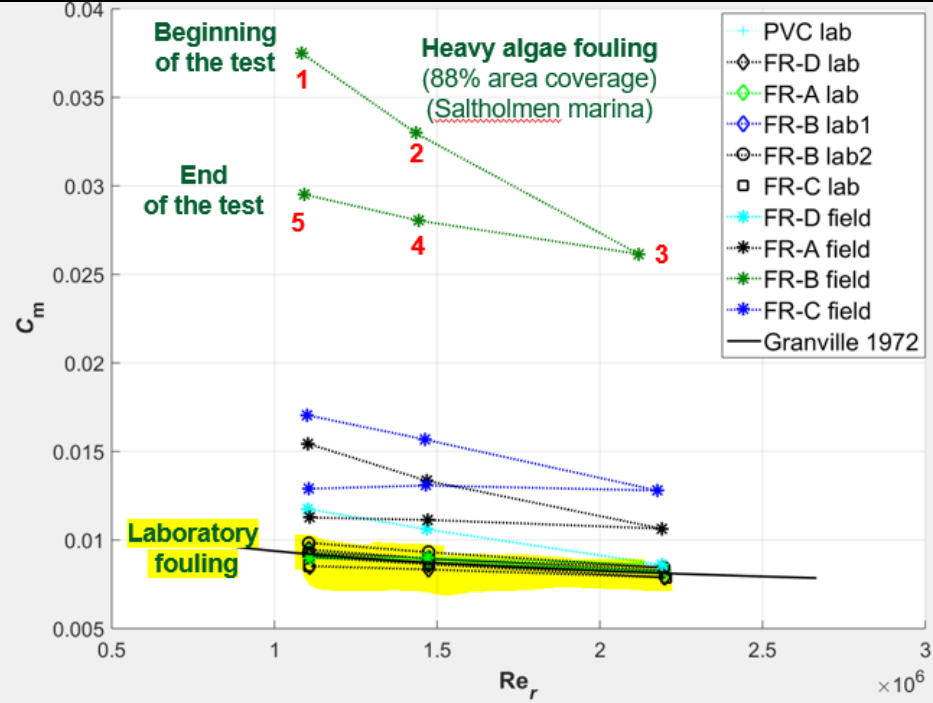
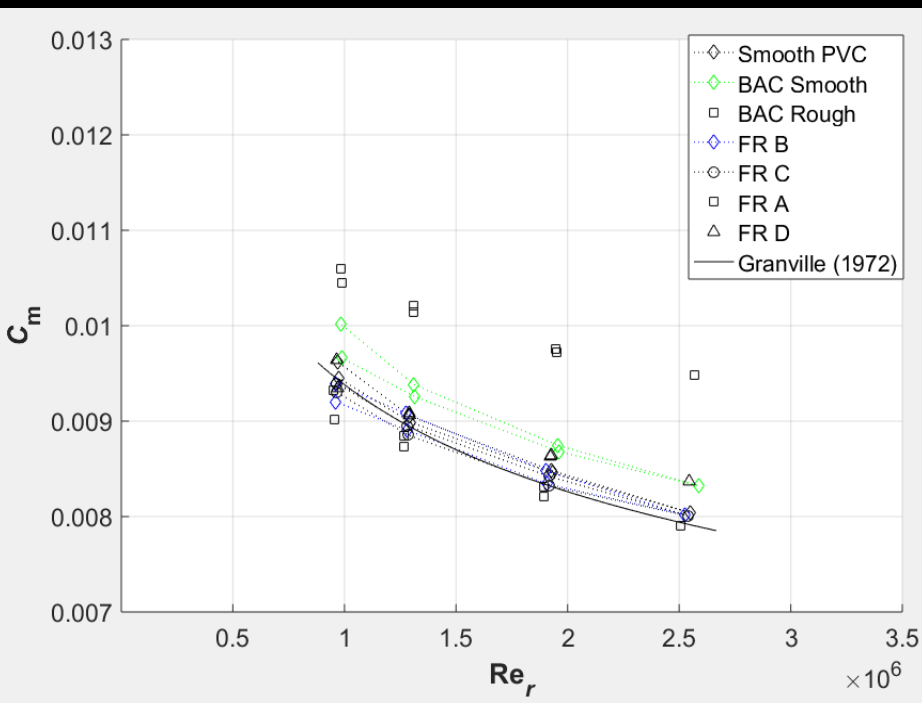
64%

Torque measurement results

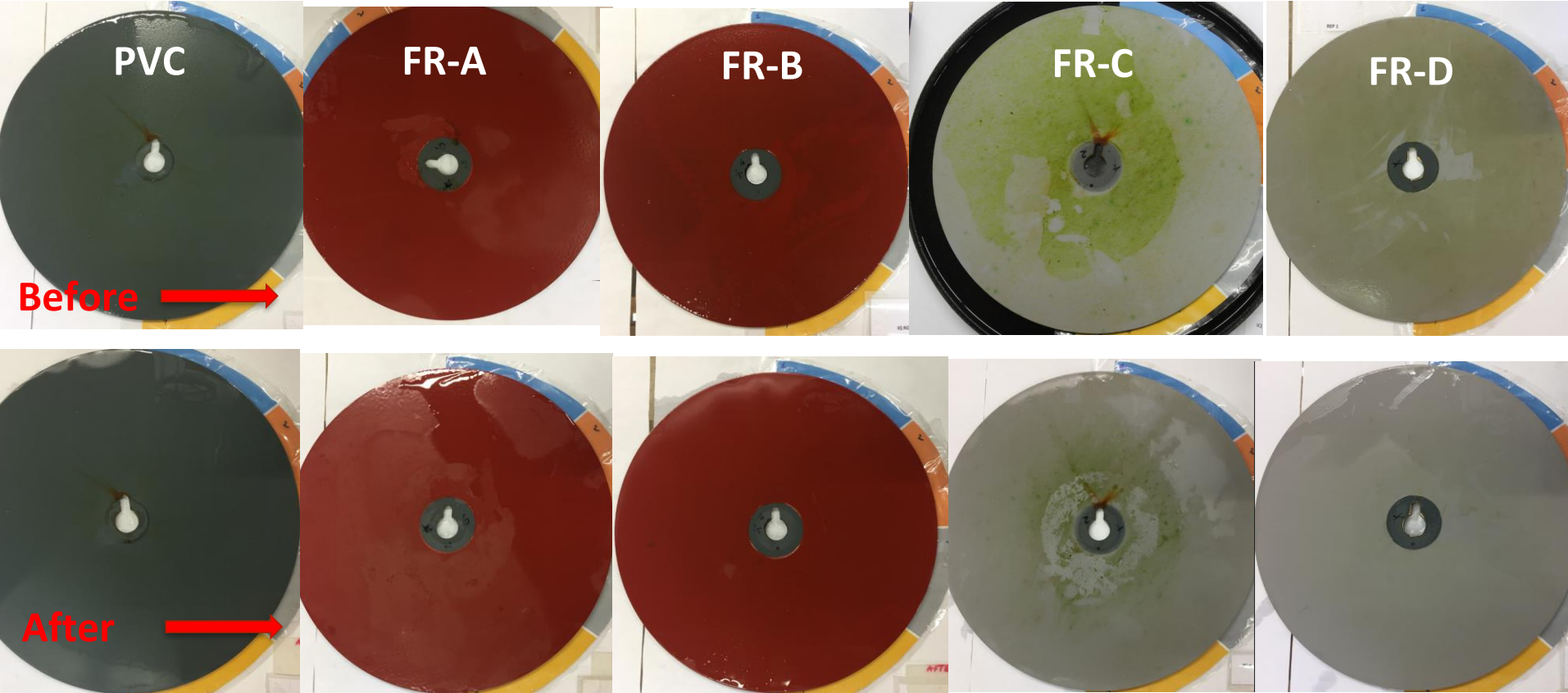
$$C_m = \frac{4M}{\rho r_0^5 (\phi \omega)^2}$$

C_m = moment coefficient
 M = torque of one side of a disk

r_0 = radius of the disk
 ω = angular velocity ρ = density of the fluid.

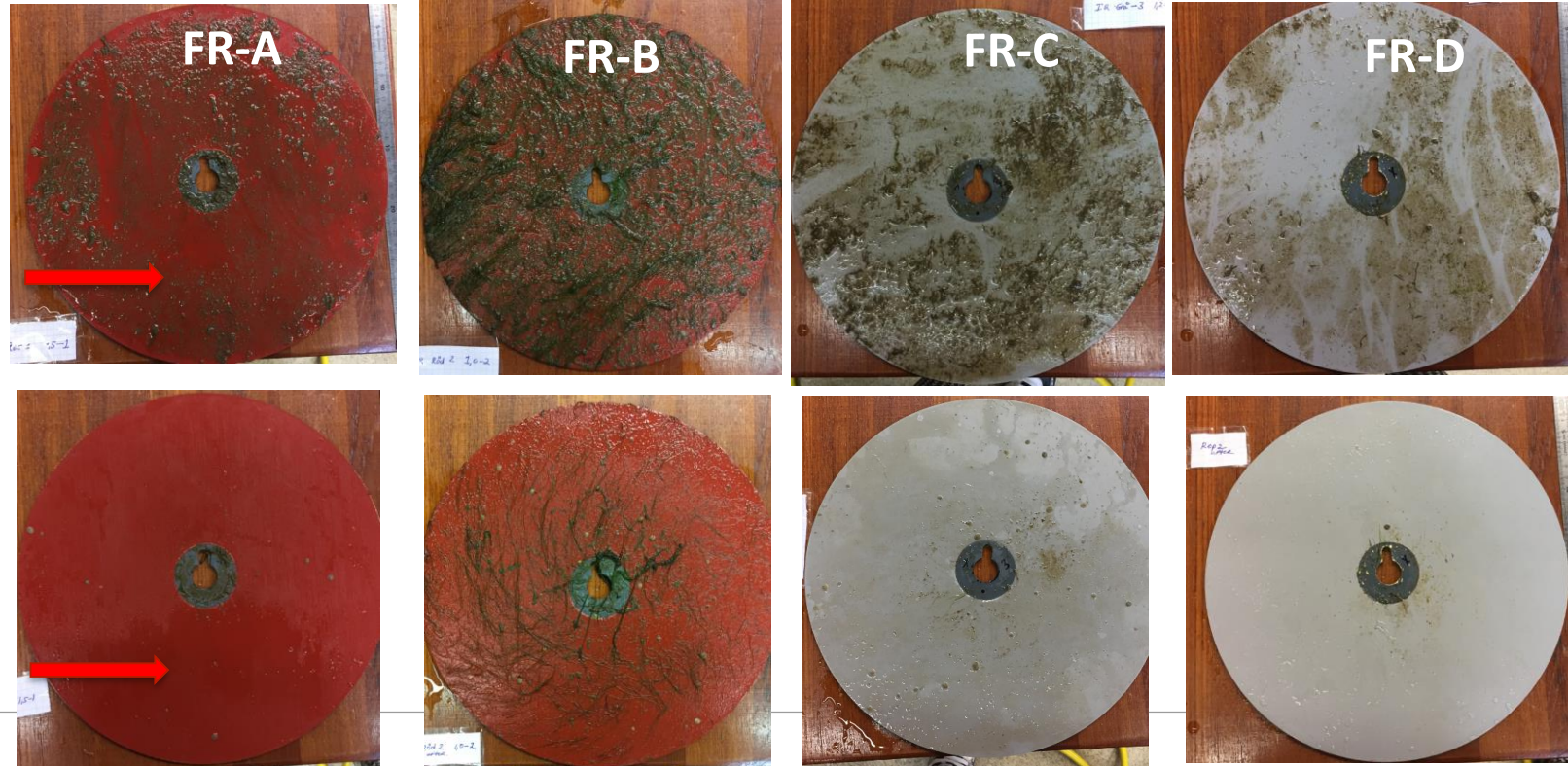


Fouling before/after the rotating disk tests (Lab fouling)



Fouling before/after the rotating disk tests

Field fouling (1-month-old)



Preliminary concluding remarks

- ❑ Fouling pressure for field fouling was greater than lab fouling;
- ❑ Biology tests will reveal the fouling community structure for the lab and field grown fouling species;
- ❑ During tests, FR-B type deployed at the port developed heavy fouling;
- ❑ Looking at the Cm trend, both lab and field fouling was easily removed from FR-B types;
- ❑ The rate of removal was high for field fouled tested disks;

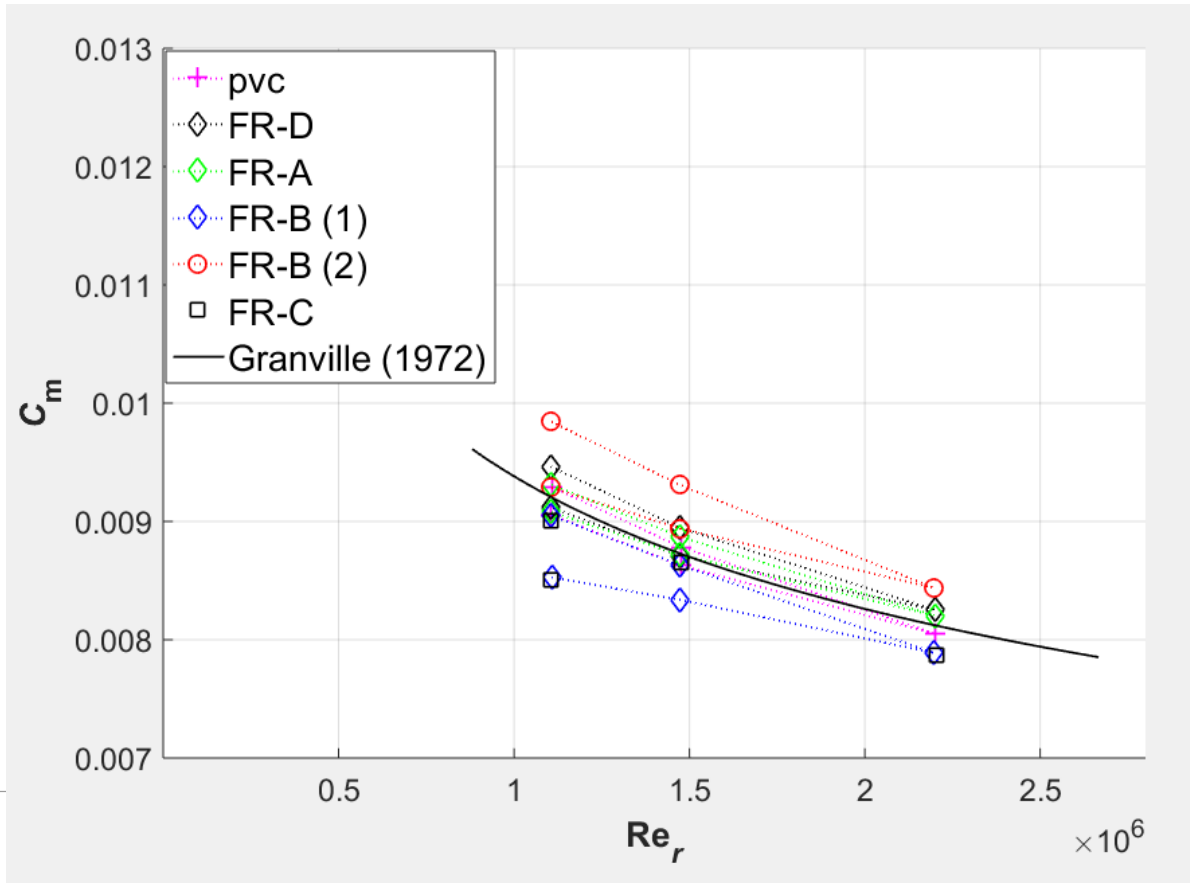


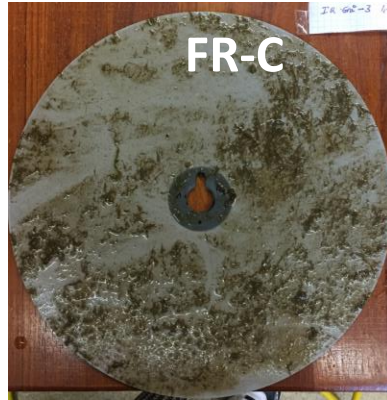
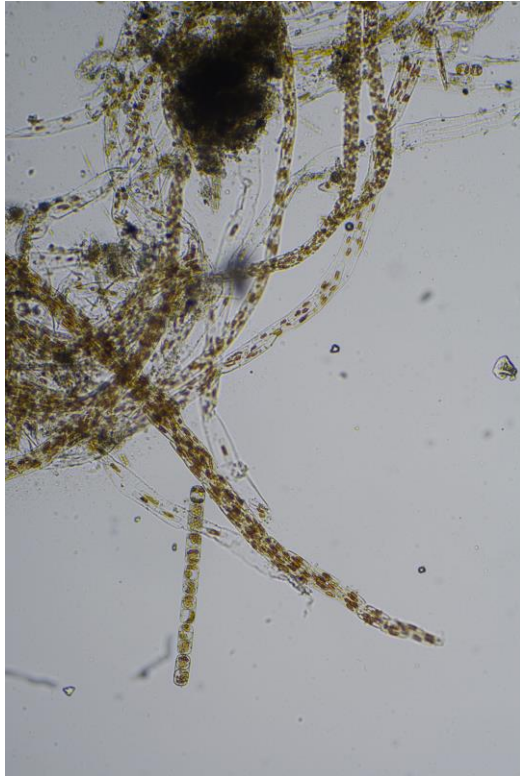
CHALMERS
UNIVERSITY OF TECHNOLOGY

References

YTREBERG, E.; LAGERSTROM, M.; HOLMQVIST, A.; EKLUND, B.; ELWING, H.; DAHLSTROM, M.; DAHL, P.; DAHLSTROM, M. (2017), *A novel XRF method to measure environmental release of copper and zinc from antifouling paints*, Environmental Pollution 225, pp.490-496

Cm for FR surfaces with laboratory fouling





Berkeleya, diatom that aggregates and looks like a filamentous algae