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

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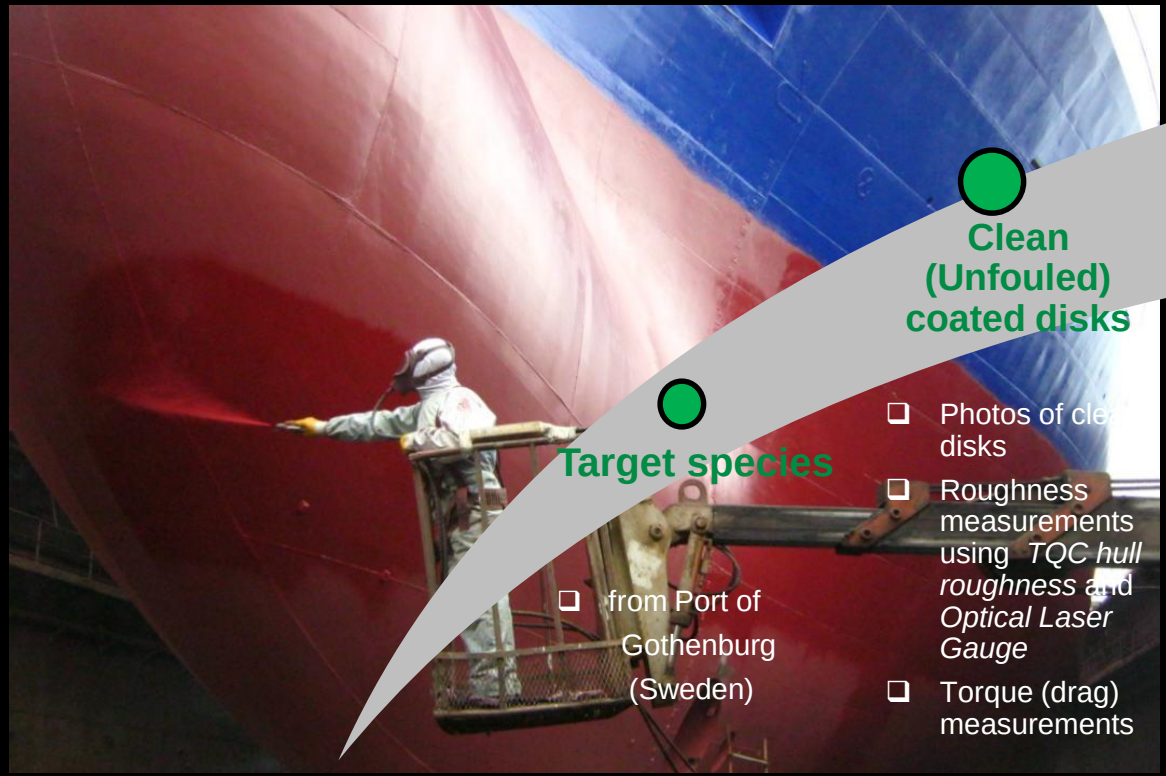
Objectives of the study



Target species

- from Port of Gothenburg (Sweden)

Clean (Unfouled) coated disks

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

Coated disks with soft fouling

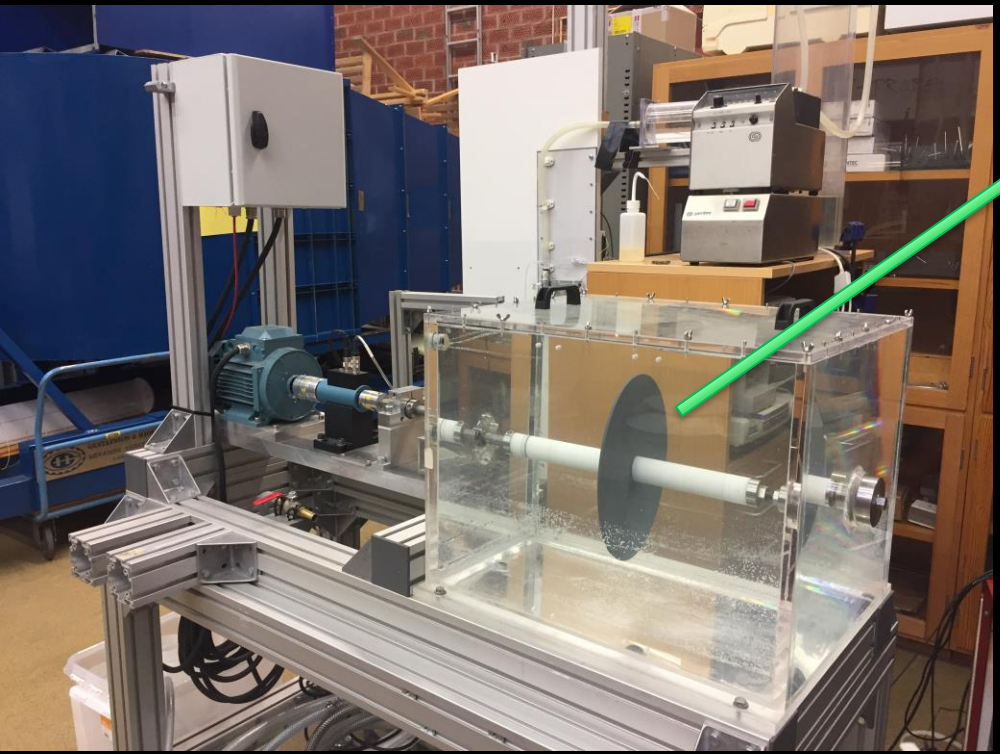
- Photos of disks before and after exposure to fouling;
- % fouling coverage assessment ;
- Identification of main species;
- Torque (drag) measurements

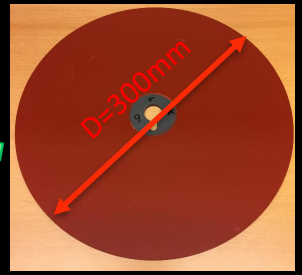
Drag Penalties

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

Experimental studies and methods

A rotating disk experiments



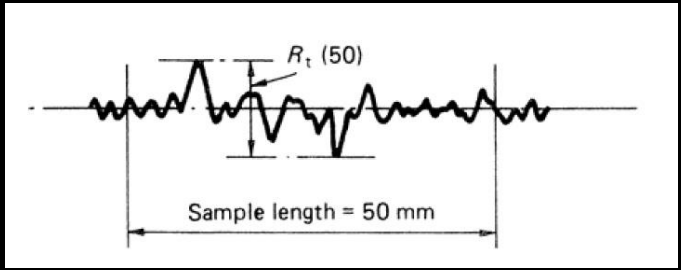


A campaign of rotating disk experiments

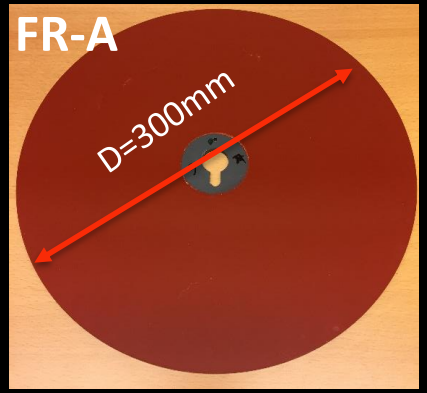
- **FR types** — clean
  - In acrylic tank — Controlled env.
  - Saltholmen marina — Natural env.
- 1
- **Biocide containing** — clean
  - Saltholmen marina — Natural env.
- 2
- 2

Foul-release (FR) type coated disks

- 4-types FR coating replicates with laboratory smooth application finish;
- Surface roughness (Rt50) measurements by TQC hull roughness gauge;

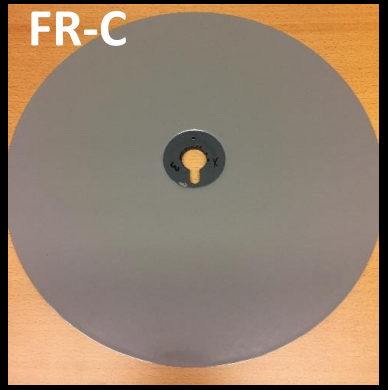


- A campaign of rotating disk measurements.

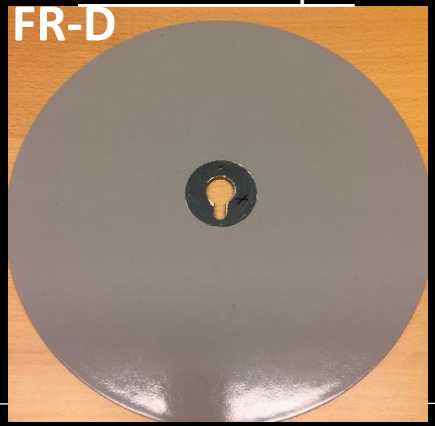


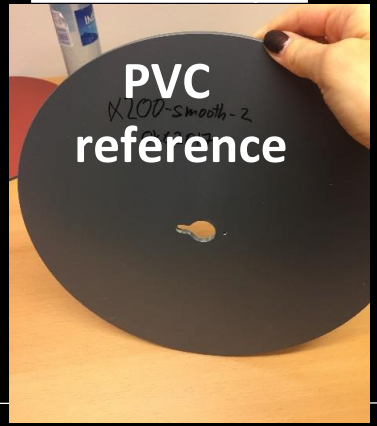
Rt50: 43≈48 µm

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.

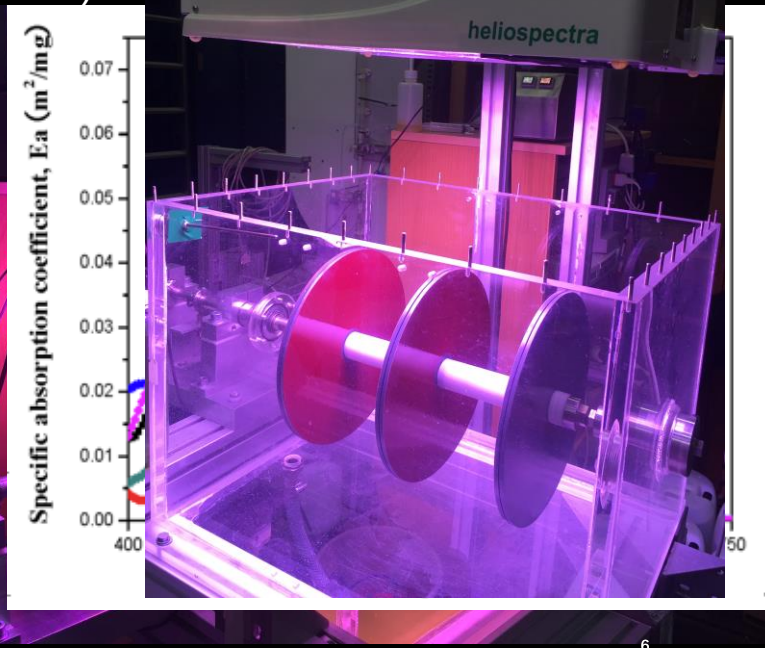
SCHEDULE for Heliospectra LED light

Show description

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

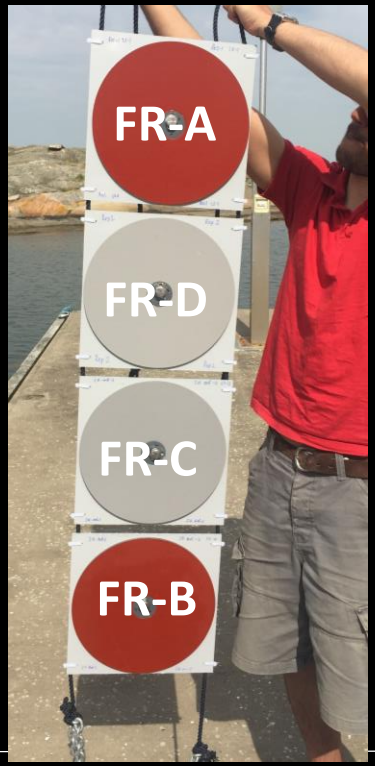
		hh	mm	ss	450nm	660nm	735nm	6500K	
+	CLR								
Edit	-	08	00	00	200	200	0	200	•
Edit	-	09	00	00	500	500	0	500	•
Edit	-	12	00	00	1000	1000	0	1000	•
Edit	-	15	00	00	500	500	0	500	•
Edit	-	16	00	00	200	200	0	200	•
Edit	-	17	00	00	0	0	0	0	•

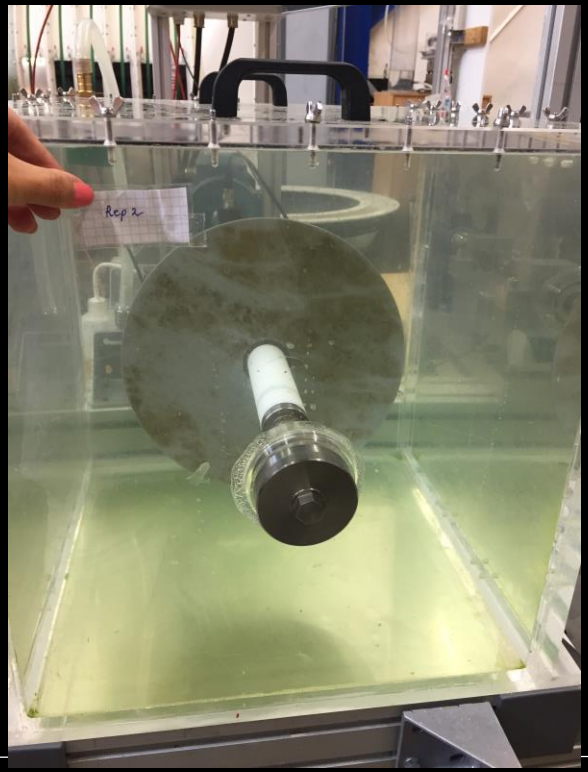
MODEL L4 | CPU FW R2.2.27 | DRIVER FW 1.21



Deployment of FR coated disks for fouling growth in Saltholmen marina

Foul release coatings





Biocidal coatings

Biocidal antifouling coated disks

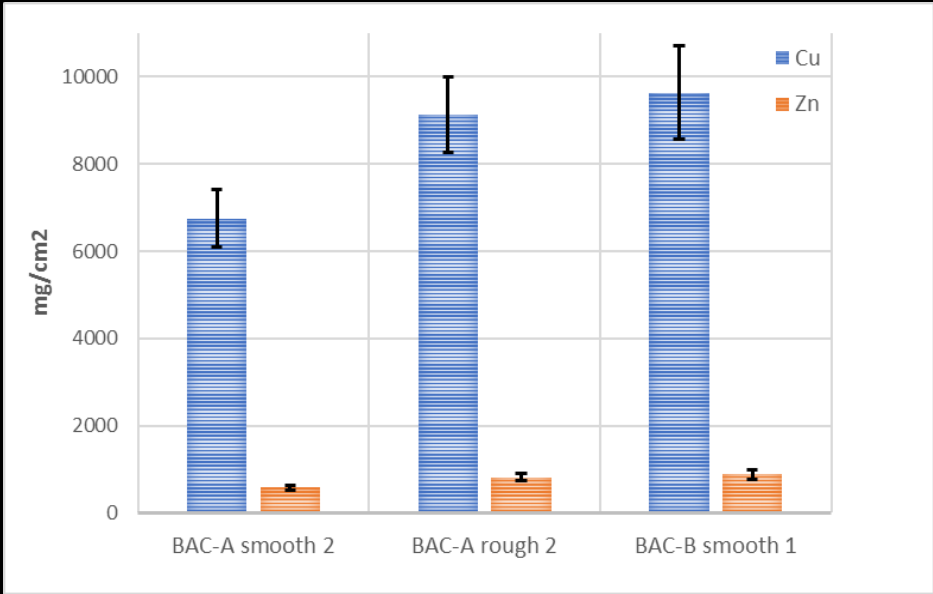
- 2-types of biocidal antifouling coating replicates (BAC-A and BAC-B) with laboratory smooth application finish;
- Additionally, BAC-A type replicates only have undergone rough application finish;
- Surface roughness measurements by TQC hull roughness gauge;
- A campaign of rotating disk measurements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

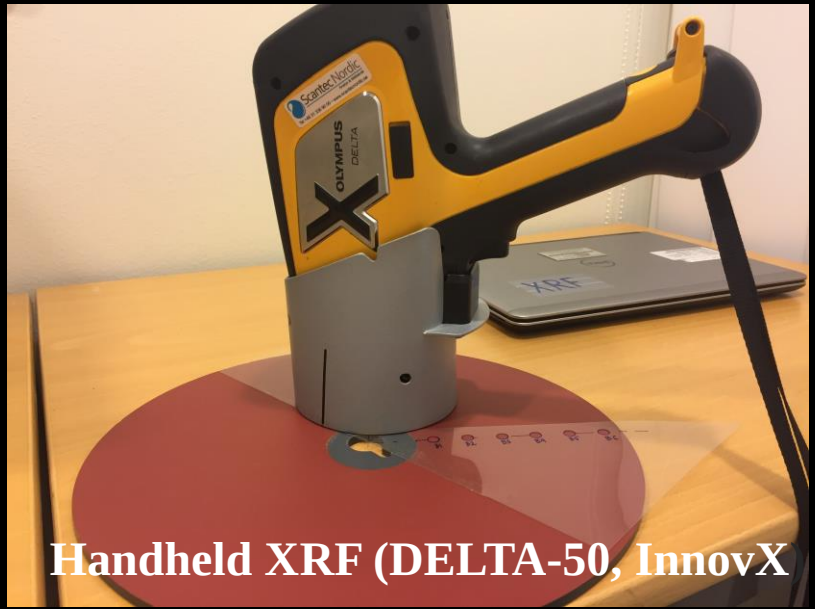
Rt50: 73≈80 µm

Rt50: 72≈90 µm

Rt50: 116≈123 µm

X-ray fluorescence (XRF) spectrometry results





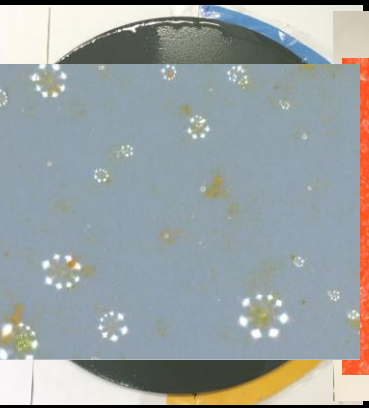
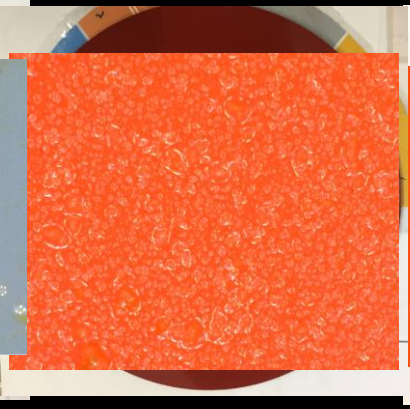
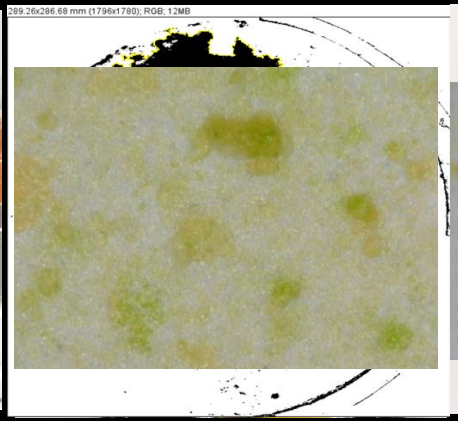
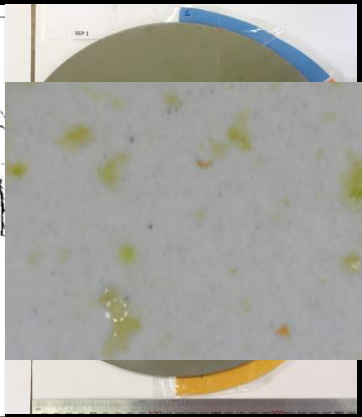
- Preliminary results show that *Cu* concentration in coatings is 6700 to 9600 µg/cm^2, whereas *Zn* results are under 900 µg/cm^2.

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	FR-A	FR-B	FR-C	FR-D
				
99% fouling coverage	?%	81%	48%	96%

Fouling coverage estimations (ImageJ) and identification of species

Field fouling (1-month-old)

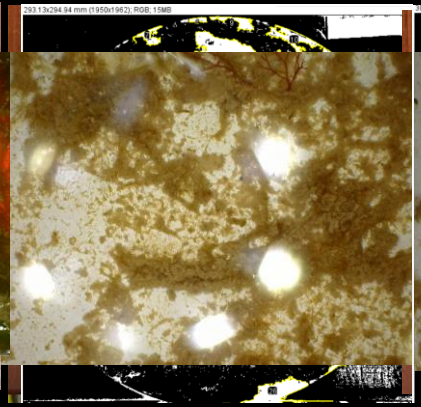
FR-A

82%

FR-B

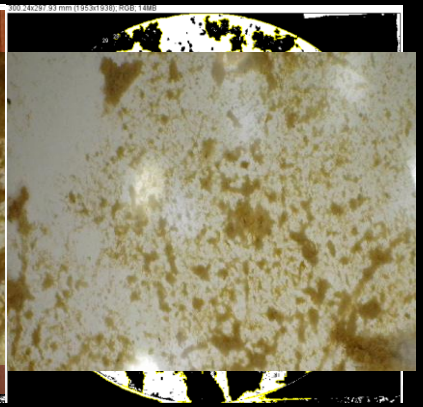
88%

FR-C



86%

FR-D

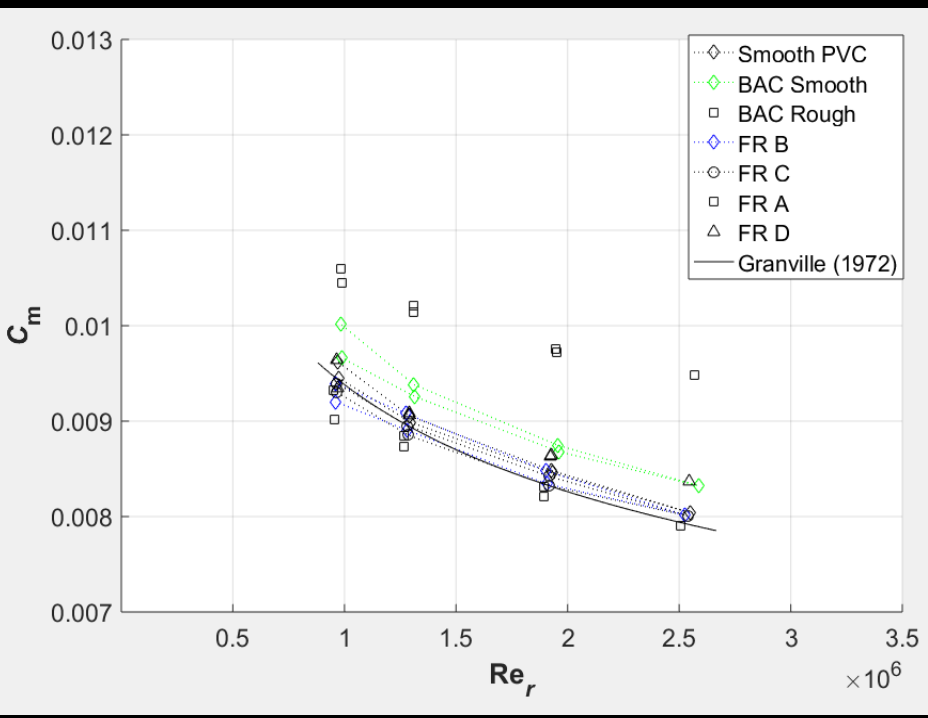


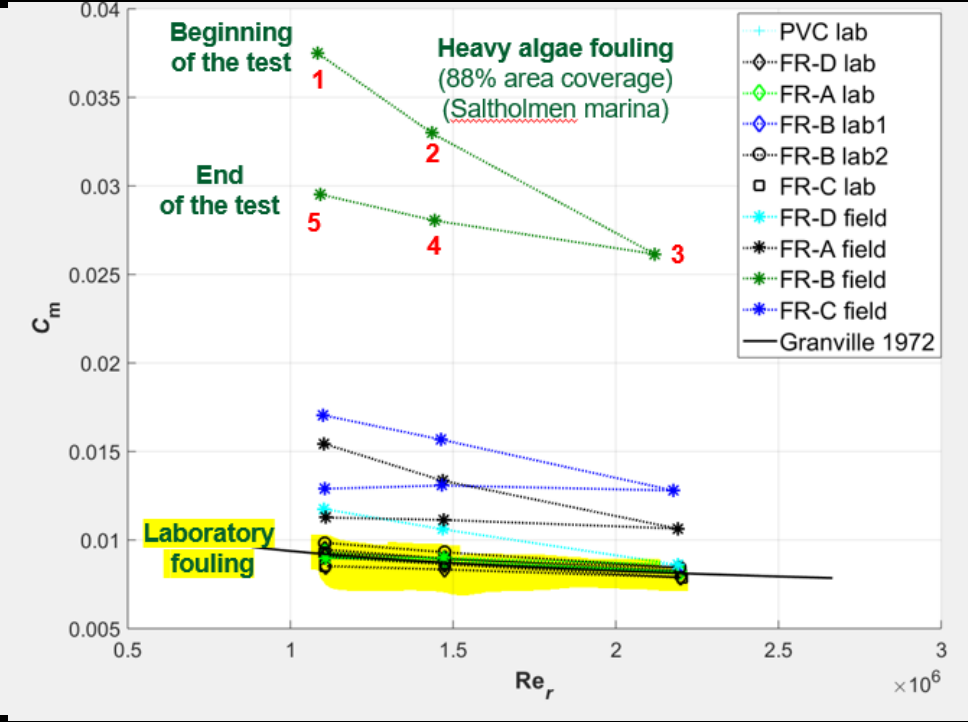
64%

Torque measurement results

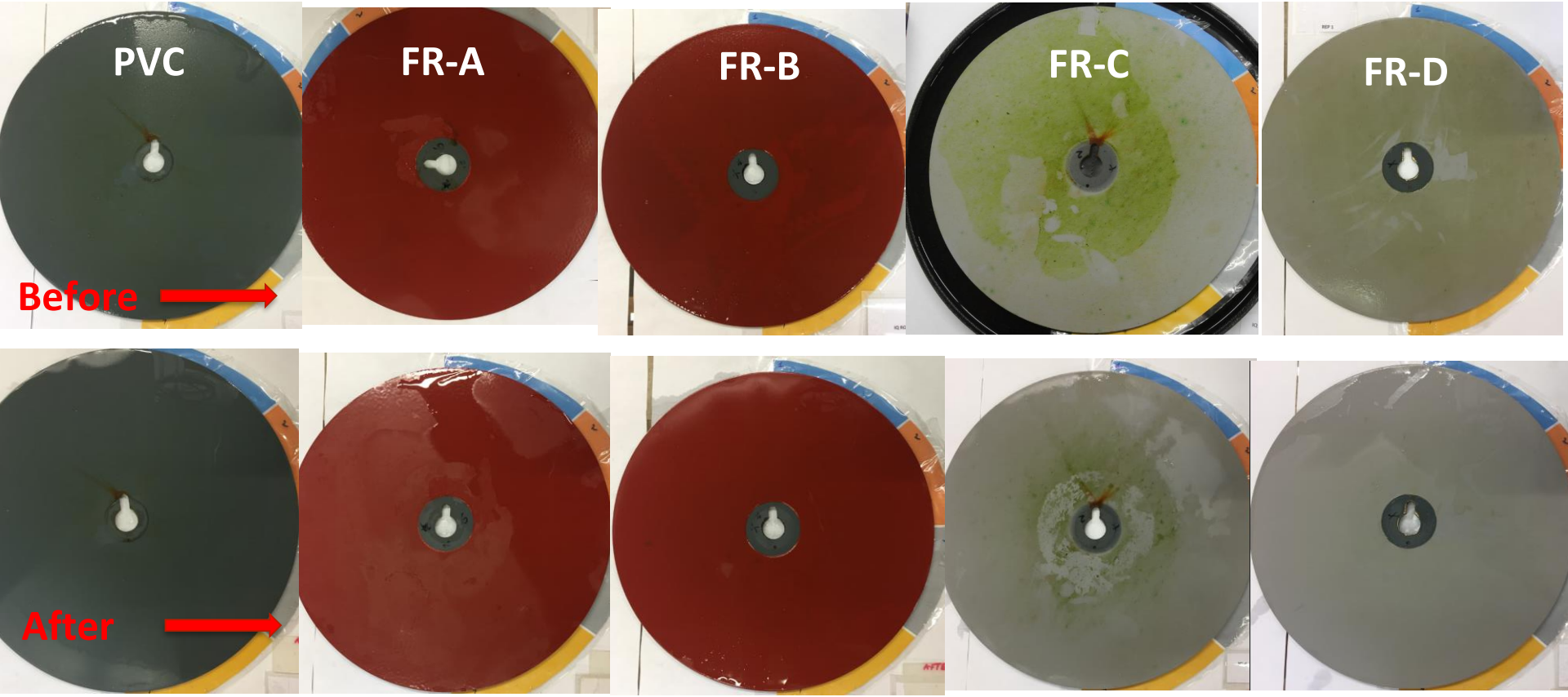
$$C_m = \frac{4M}{\rho r_0^5 (\phi\omega)^2}$$

$C_m = moment\ coefficient$
$M = torque\ of\ one\ side\ of\ a\ disk$
$r_0 = radius\ of\ the\ disk$
$\omega = angular\ velocity\ \rho = density\ of\ the\ fluid.$





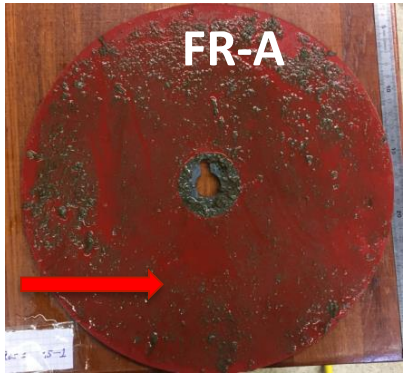
Fouling before/after the rotating disk tests (Lab fouling)

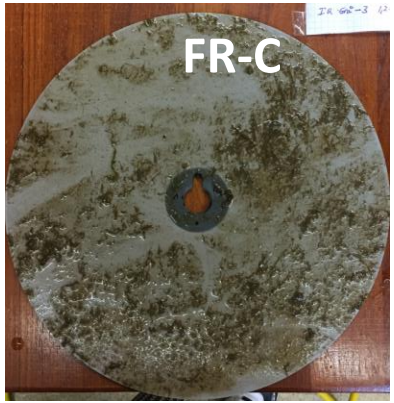


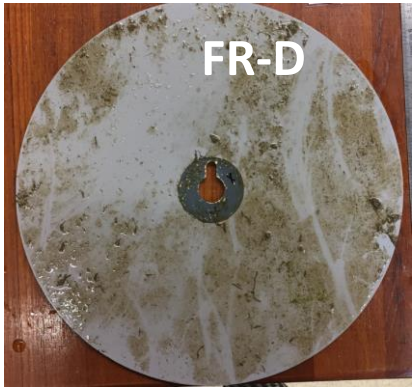
Fouling before/after the rotating disk tests

Field fouling (1-month-old)

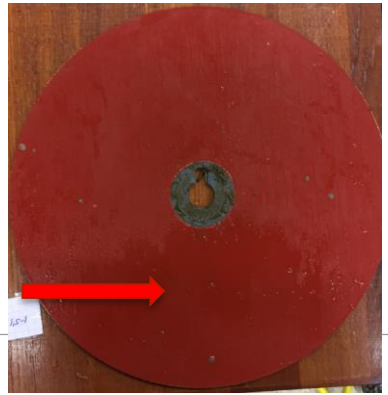
Before

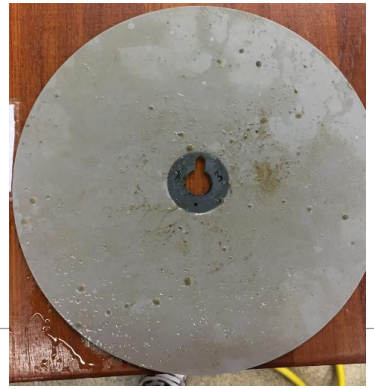


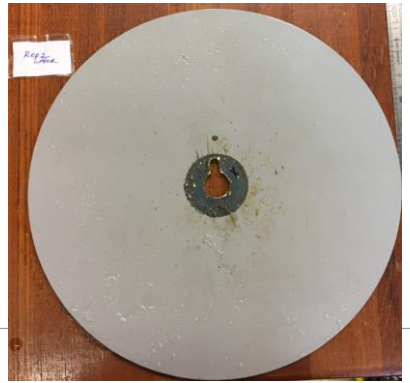




After







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;

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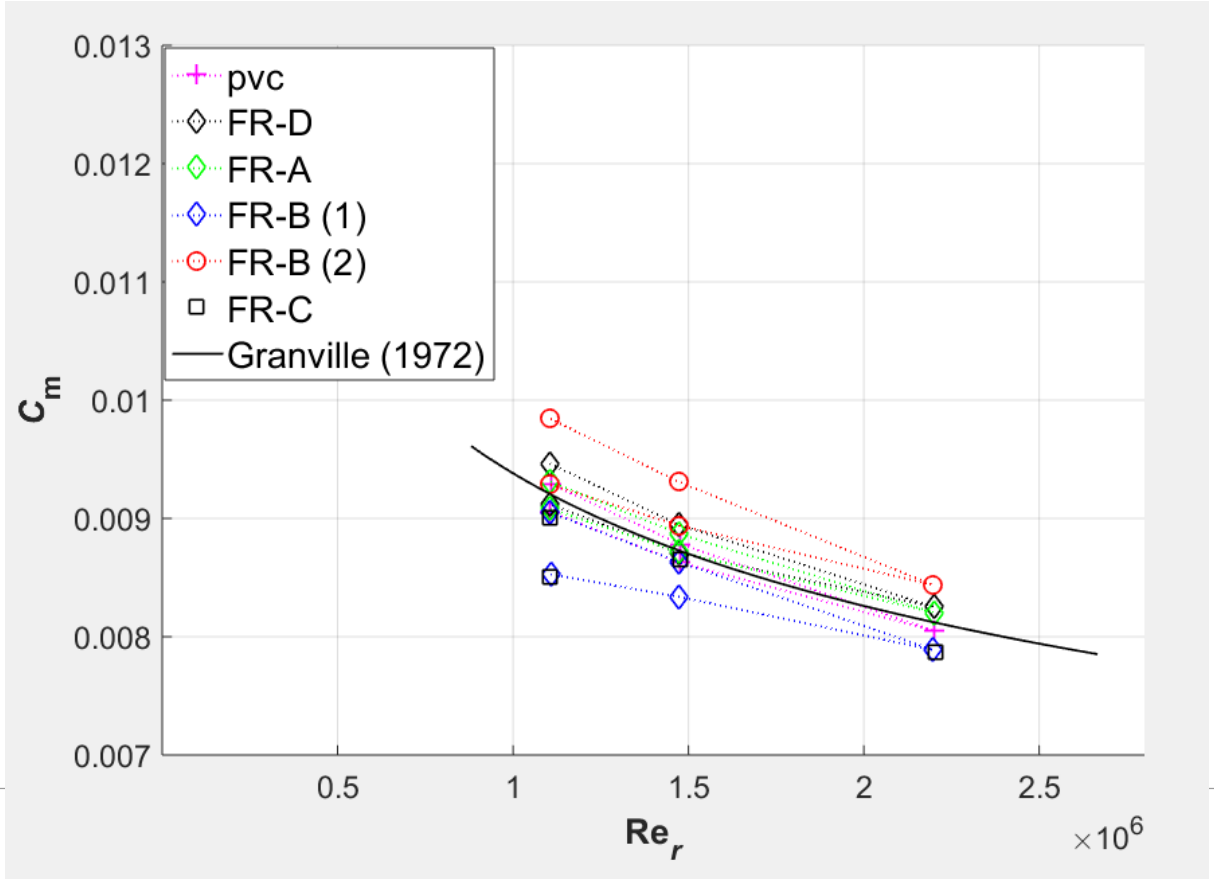
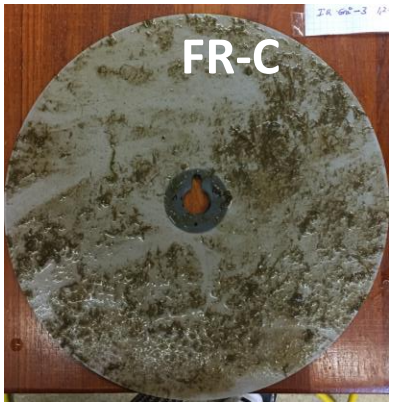
References

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