Haptocheck

Development of a standardized test procedure for the evaluation of the foul-release effect of coatings against biofilms

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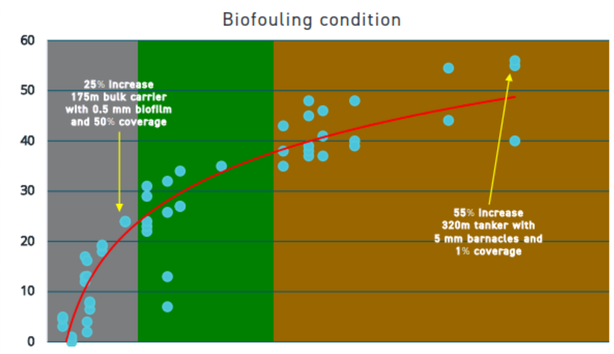
Measurement of marine Biofilms

Marine growth is fascinating in the natural environment, but very undesirable on technical underwater surfaces such as ship hulls. It is undeniable that macrofouling has a huge impact on the frictional resistance of vessels. But even a biofilm causes an increase of friction. The extent of increase depends on thickness, composition and adhesion of the biofilm. Since 2021 the German Ministry for Economic Affairs and Climate Action is funding a R&D project on the measurement of the adhesion of biofilms under dynamic conditions. A dynamic test bench („Mini-RotoMarin") was developed to measure the adhesion of biofilms on different coatings. Additionally several methods for the lab analysis of biofilms are presented.

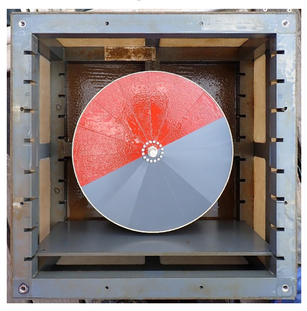
Biofilm and Macrofouling on ship hulls



Increase of fuel consumption and GHG emissions [%] at increasing fouling stages. (from Glofouling 2022).

The test panels are immersed in a protective cage with a mesh size of 50 µm in order to exclude the growth of macrofouling larvae

Testpanels

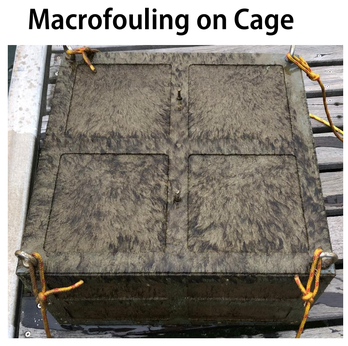


Protective Cage

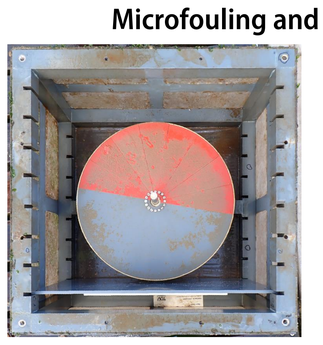
Immersion

After three weeks of immersion at the harbour Norderney in August 2023

Macrofouling on Cage



Microfouling and Silt on Testpanels inside



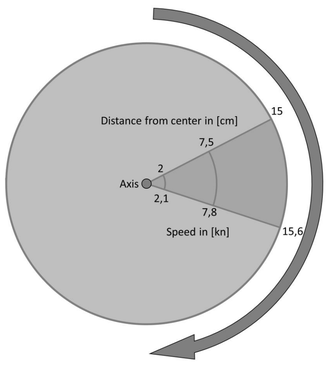
How to evaluate the biofilm?

Within the validation of anti-fouling systems, five independent methods can be used to quantify or estimate the residual fouling.

Additionally, Microbiome analysis can be used to qualify the microorganisms grown in the biofilm. These methods to be considered as suitable in this context are presented below.

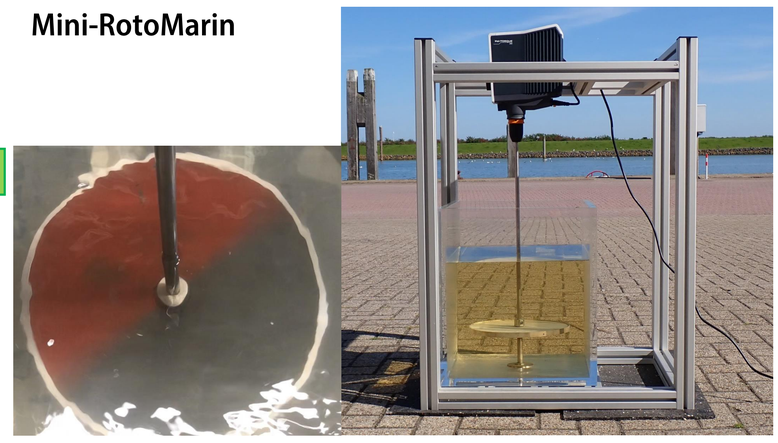
An oncoming flow up to 15.6 kn at the outside removes silt and biofilm

Minor Microfouling and no Silt anymore after incident flow



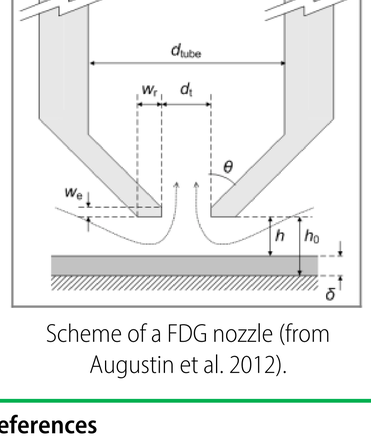
Panels get exposed to incident flow in test bench

Mini-RotoMarin



Fluid Dynamic Gauging

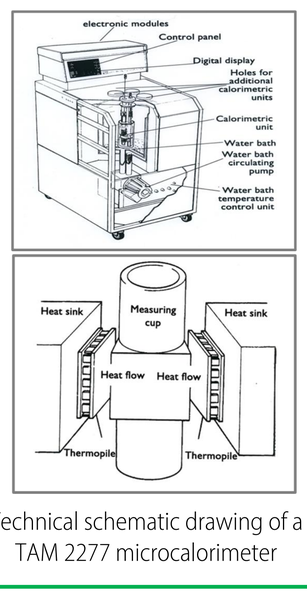
The technique of Fluid Dynamic Gauging (FDG) allows the thickness and strength of soft fouling layers, i.e. of biofilms and protein deposits, to be measured in situ and in real-time under different flow conditions. Diverse operating modes and nozzle designs enable deposit specific investigations.



Scheme of a FDG nozzle (from Augustin et al. 2012).

Microcalorimetry

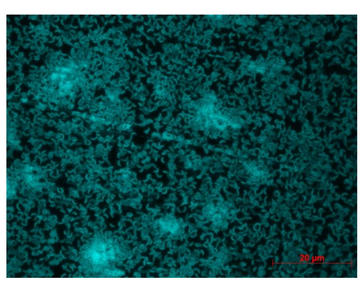
A microcalorimeter measures the metabolic heat released in a biofilm and provides a sum parameter for the total microbial activity on the test surface. The caloric data can also be correlated with cell counts, provided that the cell density is not much less than 10,000/cm^2 (Krok 2016).



Technical schematic drawing of a TAM 2277 microcalorimeter

Fluorescence Microscopy

The extent of area occupancy of a test surface by microorganisms can first be visualized by selectively staining biological structures like DNA and RNA with fluorescent dyes such as DAPI under a fluorescence microscope and then calculated by PC-software (e.g. ImageJ) based on a photograph of the microscopic image.



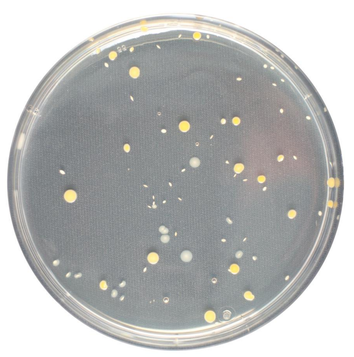
Epifluorescence microscopic image of a test surface after exposure of the test specimen to a sulfate-reducing bacterial culture (cellular occupancy level 69 %)

TOC

The organically bound carbon is detected in accordance with DIN EN 1484 after thermocatalytic oxidation of the sample on a carbon analyzer by infrared spectrometry as Total Organic Carbon (TOC) by the difference between Total Carbon (TC) and the Total Inorganic Carbon, TIC). In principle, the TOC value includes not only water-soluble but also undissolved organic constituents such as colloidal carbon-based cellular structures, so that the contamination of a sample by microorganisms can be assessed with sufficient accuracy using this measurement parameter.

Cell Counting

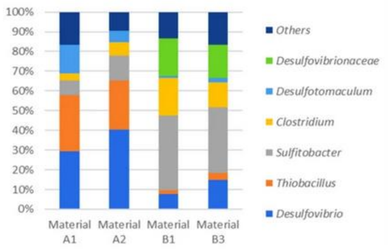
The microbial live cell counts on the test surface were determined by using a standardized selective solid culture media (e.g. R2A agar for bacteria) via dilution series by counting the colonies grown on the agar plates after about 1 week at an incubation temperature of 28 °C (CFU, Plate casting method according to DIN EN ISO 8199, 2008).



Bacterial colonies on an agar plate. Each colony represents one CFU.

Microbiome Analysis

Microbiome analysis provide insight into the microbial community structure grown on the test surfaces. This approach allows to track the differences from the bacterial community during the succession and later stages of the biofilm development. Moreover, correlations between different test surfaces and distinct community characteristics can be observed. The gained knowledge helps to understand modes of action of the different tested surfaces on biofilm development.



Taxonomic characterization of biofilms by microbiome analysis

References

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Acknowledgements

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