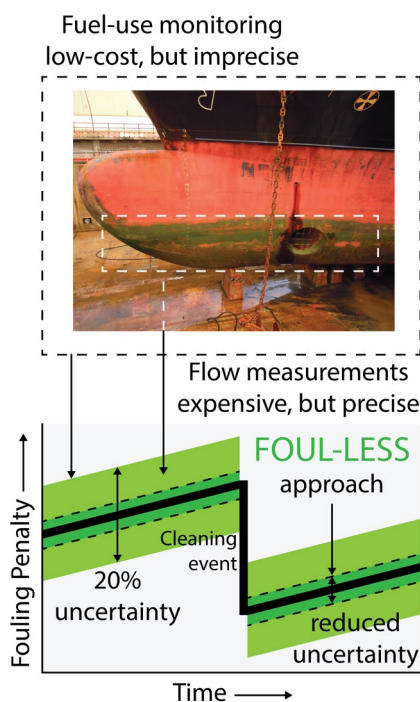




# FOUL-LESS JIP

## Fuel savings through biofouling monitoring and prediction

An international, multidisciplinary initiative to quantify, predict, and mitigate the impact of biofouling on ship performance. It combines experiments, hydrodynamics, innovative onboard biofouling sensors deployed on real ships, and data science, integrating sensor and operational data to enable fuel-efficient and sustainable shipping and support informed operational decision-making.

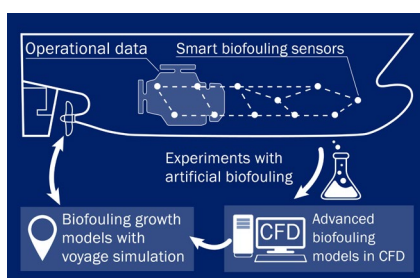


### The Challenge

Biofouling can increase fuel consumption by over 100% due to added hull resistance, yet its impact remains difficult to quantify and predict. This is due to the multidisciplinary nature of the problem, involving marine biology, coating technology, and ship hydrodynamics. Fouling growth depends on interacting factors such as environmental conditions, coating condition and vessel operation, while its impact varies strongly with location on the hull, affecting flow, propeller inflow, efficiency and cavitation behaviour.

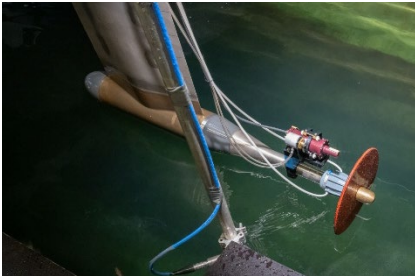
Even the earliest stage of fouling, slime formation, can already lead to measurable performance penalties. However, the underlying mechanisms are not yet fully understood and cannot be reliably modelled using current Computational Fluid Dynamics (CFD) approaches for ship performance prediction. Moreover, the typical scatter in operational speed power data is over 20%, significantly more than the expected differences due to anti-fouling strategies. A critical capability is missing robust industrial solutions to monitor hull fouling during operation. As a result, reliable assessment of efficiency is limited, leading to suboptimal antifouling strategies.

Addressing this challenge requires a coordinated, multidisciplinary effort, combining expertise in biology, coatings, fluid dynamics, sensing, and data analysis to enable understanding, monitoring, and prediction of biofouling.

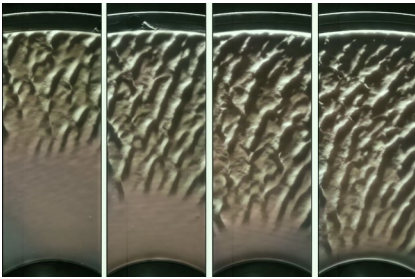


### Our Mission

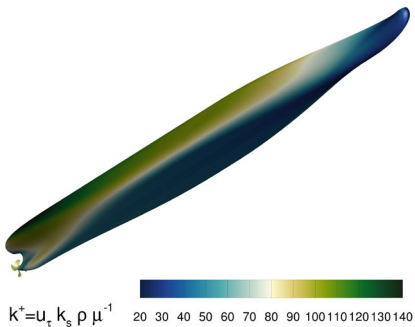
This Joint Industry Project aims to transform how biofouling is understood, monitored, and managed in practice. It connects **physical understanding**, **onboard measurement**, and **advanced modelling**, including Computational Fluid Dynamics for ship design and performance, to **quantify performance loss**, **detect fouling during operation**, and **predict its impact on ship efficiency**. The ultimate goal is to support **reliable, data-driven decisions** for coating selection and hull maintenance, leading to **improved fuel efficiency**.



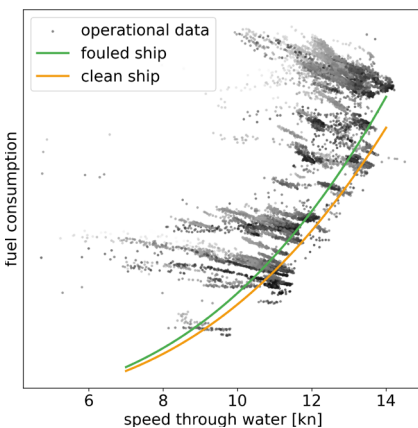
MARIN's rotating disc experimental setup for quantifying frictional resistance of ship coatings and fouled surfaces.



Artificial soft biofouling patterns at increasing flow velocities, leading to an increase in hydrodynamic drag.



Biofouling-induced hull roughness distribution used for CFD-based ship performance prediction.



Measured fouled-ship operational data, a machine-learning-derived performance curve, and the predicted clean-hull reference, illustrating the fuel penalty due to biofouling.

For more information contact MARIN:  
 department Performance at Sea  
 E [secretariaatPaS@marin.nl](mailto:secretariaatPaS@marin.nl)

## Our Approach

The project will combine model-scale testing, CFD simulations, sensor development, full-scale fouling monitoring, and data science to quantify and predict the impact of biofouling on ship performance.

The various forms of biofouling will be analysed and characterised, and subsequently represented through controlled artificial fouling experiments. These experiments enable systematic and repeatable assessment of the impact of different fouling types and severities, and provide high-quality input data for the development and validation of CFD models for both slime layers and hard biofouling.

Methods will be developed to detect and monitor fouling during operation, combining dedicated biofouling sensors with existing onboard sensors and data analysis to quantify its impact on ship performance. The addition of dedicated sensors improves the ability to distinguish fouling effects from variations due to environmental conditions and vessel operation, thereby enhancing the reliability of performance assessment from operational data.

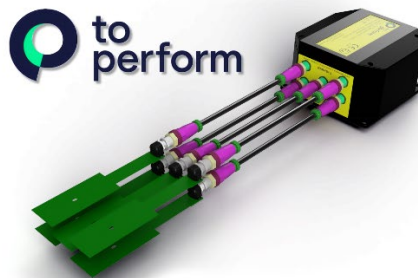
In parallel, modelling approaches, including CFD and biological growth models, will be improved and validated to predict performance degradation under varying operational conditions, supported by hindcast data and ship operational routing. By combining measurements, models, and full-scale data, the project will establish a consistent and validated framework to reduce uncertainty. These developments will be brought together in a decision-support toolbox that predicts biofouling growth for specific routes, quantifies its impact on ship performance, and supports informed decision-making for hull maintenance and anti-fouling strategies.

## Why Participate?

Participation in this project provides direct access to validated methods, data, and tools to better understand and manage biofouling in practice. It will improve the accuracy of ship performance assessments and enable reliable, data-driven anti-fouling strategies.

Participants will contribute to and benefit from the development of a decision-support toolbox that supports coating selection, optimisation of hull cleaning schedules, and improved fuel efficiency.

By combining experimental research, advanced modelling, and full-scale operational data, participants gain early insight into emerging technologies, reduce uncertainty in performance evaluation, and strengthen their ability to make informed, cost-effective operational decisions.



Innovative heat-transfer (left) and ultrasound (right) biofouling sensors enabling non-intrusive, in-situ monitoring from within the vessel.

