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# Ship&Offshore

## Special GreenTech

SUSTAINABLE GLOBAL SHIPPING

FUTURE FUELS

BALLAST WATER

PROPULSION & ENGINE TECHNOLOGY

OPERATIONAL OPTIMISATION

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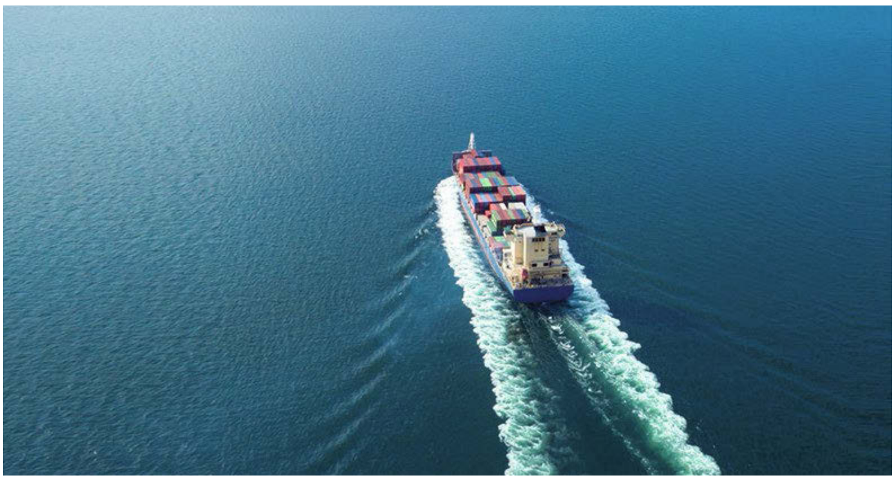

Kathrin Lau
Editor in Chief
kathrin.lau@dvvmedia.com

# Need for creative power

It may currently seem as if the world is becoming more and more unhinged – the pandemic is by no means over, there is no end in sight to the Russian war of aggression on Ukraine and Western democracy, and last but not least, the consequences of climate change, which can now no longer be negated, are clearly being felt. It might be time to bury our heads in the sand, some people might think – but that won't get us anywhere.

Quite the contrary – never has the need been greater to display a pioneering spirit and creative power. And the maritime industry continues to demonstrate this.

We present a few of the promising and forward-looking technologies and concepts in this GreenTech Special Edition. This year, six different categories again testify to the breadth of innovation opportunities and relevance of the sector.

The maritime energy transition – the decarbonisation of shipping – plays the leading role throughout. Which propulsion concepts or alternative fuels are most suitable and available for this? Which systems can be operated in a more energy-efficient way? And which are the best and affordable technologies for a sustainable future?

In particular, I would like to draw attention to the article that begins on page 10. Here, for once, the benefits of nuclear power for ship propulsion and floating energy are exclusively highlighted – a controversial topic, not only in the shipping industry. We would be pleased to hear or read your opinion or further thoughts on this. Please get in touch!

# The efficacy of capture

**IN-WATER CLEANING** In order to verify the efficacy and compliance with threshold values of in-water cleaning of ship hulls, one option is to examine the relation between fouling stage and weight of fouling, write Burkard Watermann, and Anja Thomsen from the Hamburg-based research institute LimnoMar; and Jens Wallis and Bernd Daehne from Dr Brill + Partner, Institute for Antifouling and Biocorrosion, Norderney

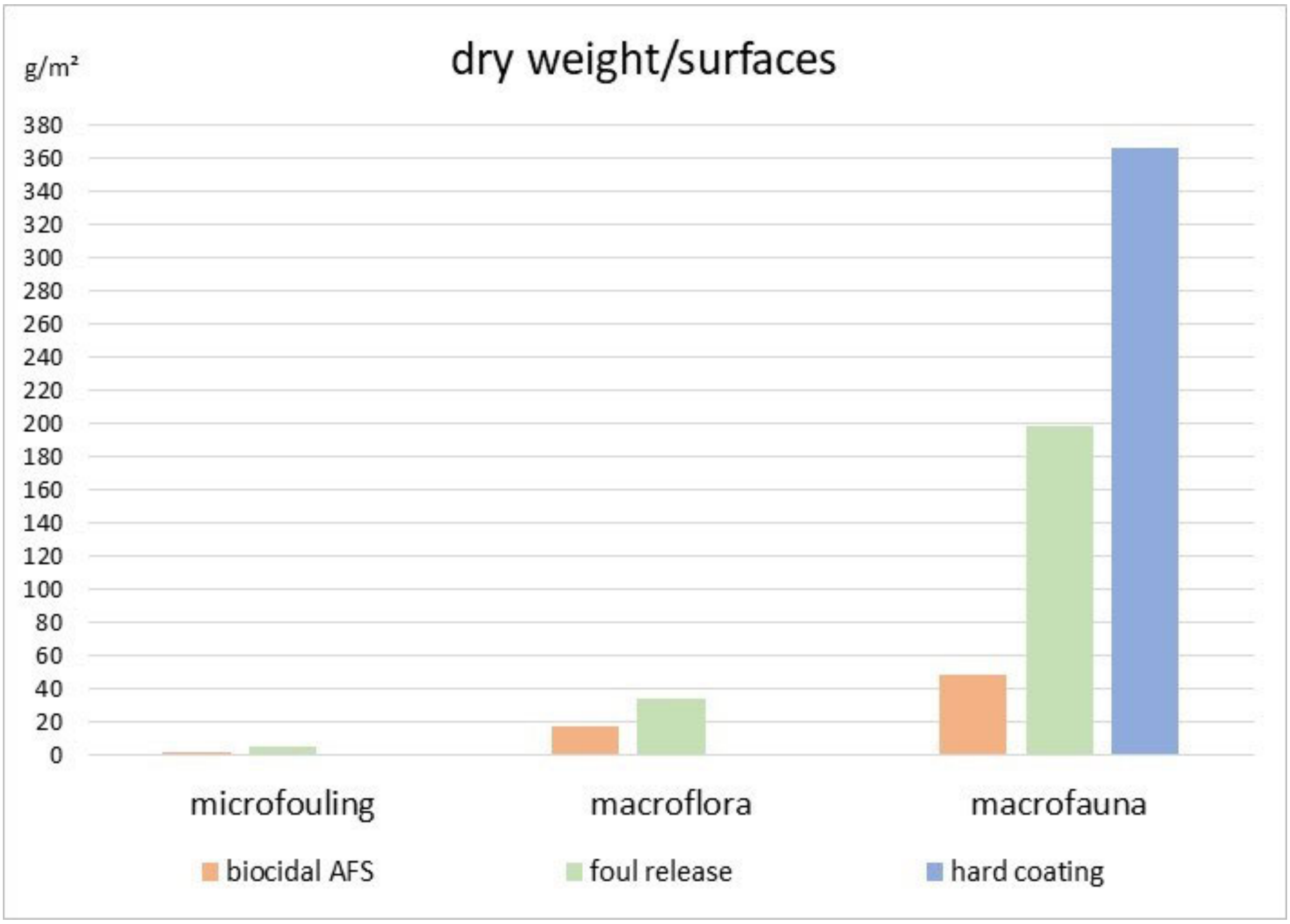


Figure 1: Relation between dry weight of fouling (arithmetic mean) on biocidal antifouling paints, foul release and hard coatings. On hard coatings, microfouling and macroflora weight was not measured. Source: LimnoMar

In-water cleaning of ship hulls is widely carried out to increase ship performance, and is under intense discussion regarding regulations, quality improvement and technologies in use [2]. One critical aspect is the common practice of cleaning biocidal antifouling paints, which is incompatible with national and EU water legislation, and the impact of abrasion on antifouling coatings that are not designed for cleaning.

Additionally, the majority of cleaning operations do not filter or capture the fouled material. Furthermore, there is usually no control or verification of the quality of the cleaning technology applied. Fluorometric technologies are used to control the efficacy of capture. Ideally, the removed fouling should be captured and sucked up by the cleaning machine using a vacuum system.

In waters with high visibility, optical methods like front and aft cameras can be used. Dyes can be injected to control the efficacy photometrically [9]. Unfortunately, in ports along the North Sea and most ports of the Baltic Sea, the visibility is low and optical control methods cannot be applied, requiring other verification methods.

One option is to use the relation between fouling stage and weight of fouling as an indicator of the amount of fouling which has to be captured. Taking samples of the fouling accumulation prior to cleaning may provide a guide to the volume of fouling present on the hull and the amount to be captured.

In this way, the captured material can be compared with the earlier estimate and may provide a reasonable estimation of efficacy. To explore the validity of the relationship between fouling stage and fouling weight, data from previous fouling studies were compiled and scrutinised regarding their usefulness for such an estimation.

| Fouling stage | N (45) | Biocidal antifouling paints | |
|---|---|---|---|
| | | Dry weight (g/m²) Arithmetic Mean (min - max) | Ash dry weight (g/m²) Arithmetic Mean (min - max) |
| **Microfouling** | 12 | 1 (1 - 1) | n.d. |
| **Macroflora** | 23 | 18 (1-105) | 4 (1-8) |
| **Macrofauna** | 10 | 49 (1-210) | 14 (5-21) |

Table 1: Dry and ash dry weight in relation to fouling stage on biocidal SPCs

Source: LimnoMar

| Fouling stage | N (163) | Foul release coatings | |
|---|---|---|---|
| | | Dry weight (g/m²) Arithmetic Mean (min - max) | Ash dry weight (g/m²) Arithmetic Mean (min - max) |
| **Microfouling** | 8 | 5 (1 - 25) | 1 (1-1) |
| **Macroflora** | 10 | 34 (9-81) | 3 (1-5) |
| **Macrofauna** | 145 | 199 (1-2,221) | 18 (1-53) |

Table 2: Dry and ash dry weight in relation to fouling stage on foul release coatings

Source: LimnoMar

## Materials and methods

In total, 363 datasets taken during research projects between 1998 and 2002 were evaluated with respect to fouling stage and dry weight of fouling [3], [10]. In these projects, test patches were applied on ships' hulls, using a large variety of paints and coatings. They comprised epoxy-based hard coatings, silicone-based foul release coatings, and biocidal and non-biocidal self-polishing co-polymers (SPCs).

Three fouling stages were categorised as microfouling (e.g., biofilm, slime), macroflora (eg. filamentous algae), and macrofauna (eg. hard calcareous macrofouling). The fouling was removed by hand, scraping a surface of 10 x 75cm from the upper waterline downwards. Most vessels had a draught of 1 to 5m with minimal variation in depth of immersion. The draught of the ocean-going vessels varied between 6 and 12m.

The removed fouling was collected and stored for subsequent drying. The drying was carried out at 60°C until the weight remained constant. This procedure took 14 days in most cases. The dried sample was ceased glowing at 485°C to get the weight as ash-free dry weight. The samples of fouling were collected from test patches on vessels operating exclusively in the North Sea (N = 323) and worldwide (N = 40). The fouling present on the hull of the inspected ships developed over different periods of between three and 25 months.

## Results

The evaluations of dry weight and ash dry weight on hard coatings are shown in Table 1 and Figure 1. Hard coatings displayed after exposure of at least six months showed macrofouling only; no dry weight could be measured for microfouling and macroflora. ›

| Fouling stage | N (121) | Foul release coatings | |
|---|---|---|---|
| | | Dry weight (g/m²) Arithmetic Mean (min - max) | Ash dry weight (g/m²) Arithmetic Mean (min - max) |
| **Macrofauna** | 121 | 366 (10-2,298) | 39 (3-59) |

Table 3: Dry and ash dry weight in relation to fouling stage on hard coatings Source: LimnoMar

| Vessel type | Mean wetted surface m² | microfouling kg | macroflora kg | macrofauna kg |
|---|---|---|---|---|
| **Tanker** | 35,000 | 35 | 630 | 1,715 |
| **Bulker** | 23,000 | 23 | 414 | 1,127 |
| **Container ships** | 16,000 | 16 | 288 | 784 |
| **Cruise ship** | 27,000 | 27 | 486 | 1,323 |

Table 4: Dry weight of fouling from hulls of representative vessel types to be captured on failing antifouling paints Source: [12]

The mean dry weight of macrofauna resulted in 329 g/m² (min = 1, max = 2,298). It was evident that the fouling weight increased with each stage, but the variation increased as well. A similar pattern was evident when evaluating the dry weight on foul release coatings (Table 2 and figure 1). The mean weight of microfouling was 5 g/m² with variation from 1 to 25 g/m², the mean weight of macroflora was 34 with variation of 9 – 81, and of macrofauna with 199 and variation 1 – 2,221 g/m².

As expected, the fouling development and fouling dry weight on biocidal SPCs was reduced in relation to hard and foul release coatings (Table 3 and Figure 1). The mean dry weight was 1 g/ m² with no variation. Dry weight of macroflora resulted in a mean of 18 g/m² with an extreme variation of 1 – 105 g/m². An even higher variation was found on SPCs with macrofauna with a mean of 41 g/m² and a variation of 1 – 210 g/m².

## Discussion

The evaluation of the dry weight of fouling also shows a strong relationship to the specific fouling stage on all substrates on foul release coatings and biocidal SPCs. These findings correspond well with investigations on the drag increasing from the microfouling to the macrofouling stage [4], [6] [11]. In addition, there are first indications that the variation in weight increases with fouling development [1]. The actual practice of cleaning failing antifouling paints presents challenges in capturing the removed fouling.

In Table 4, the dry weight of fouling per square metre is calculated for the wetted surface of representative types of vessels. It is evident that even on biocidal paints with low performance, very high mean weights can occur and are to be expected prior to cleaning. From those calculations it may be possible to estimate the amount of fouling which should be captured.

In most North Sea and Baltic ports, water visibility does not enable the scale of hull fouling to be checked by the optical methods which can be used in clear water [9]. In cases when the biofouling management records of the vessel provide insufficient data on the fouling type and coverage of the hull, samples from some representative areas of the hull can be collected and the amount of fouling which should be captured can be predicted.

In some ports such as Bremen, for example, high efficacy rates of capture are required [5]. By taking samples prior to cleaning, the port authority has a tool to survey the efficacy of capture. The estimation of the dry weight can deliver another chance for the control of high quality in-water cleaning.

The increasing weight of fouling from microfouling to macrofouling displays also demonstrates the benefits of cleaning at microfilm stage. It is easier and faster, and fouling can be achieved at a satisfactory level. Comparing the surfaces of biocidal antifouling paints, foul release and hard coatings, it is evident that hard coatings need to be cleaned at short intervals of approximately once every week or two weeks. Otherwise, the amount of fouling and the increasing adhesion force of fouling organisms will cause additional resistance, and efficient filtration and capture of fouled material will be harder to achieve.

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PUBLISHER
DVV Media Group GmbH
Postbox 10 16 09, D-20038 Hamburg
Heidenkampsweg 73-79, D-20097 Hamburg
+49 40 23714 - 02

MANAGING DIRECTOR
Martin Weber

PUBLISHING DIRECTOR
Manuel Bosch
manuel.bosch@dvvmedia.com

EDITORIAL STAFF
Editor-in-Chief
Kathrin Lau
+49 40 23714 237 | kathrin.lau@dvvmedia.com

ADVERTISING
Advertising Director
Markus Wenzel
+49 40 23714 117 | markus.wenzel@dvvmedia.com
Advertising Sales
Gerald Ulbricht
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