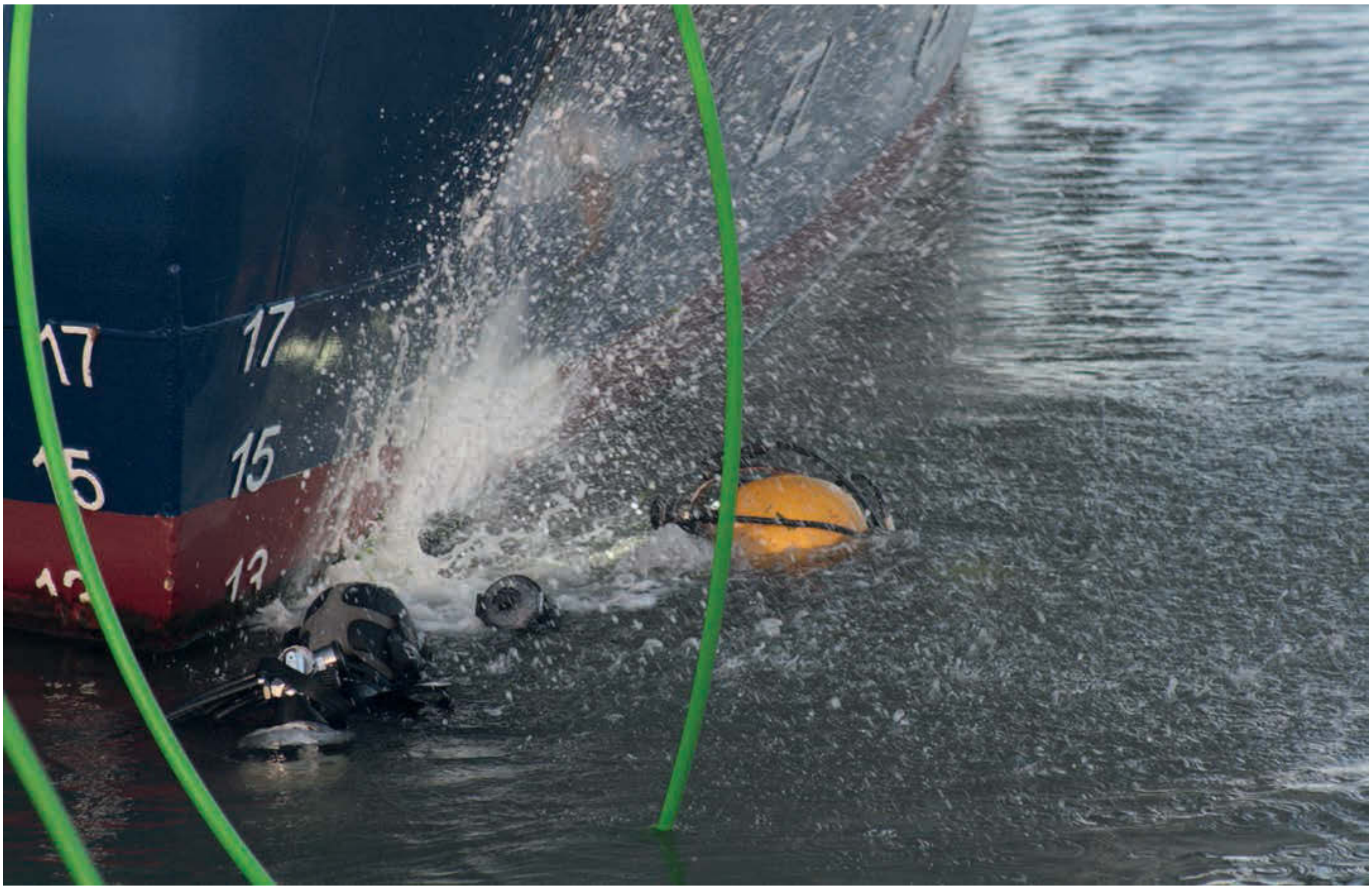
Hull performance management and biosecurity by cleaning


Underwater cleaning with cavitation

EMISSION REDUCTION Hull performance is a key factor in emission reduction and fuel economy, and can ensure biosecure global maritime transport. Especially on underwater parts which are exposed to currents, hull performance is crucial, writes Dr Burkard Watermann from LimnoMar, the Laboratory for Aquatic Research and Comparative Pathology in Hamburg.

Shipping companies are eager to operate their vessels keeping fuel consumption low. A key factor for this is hull smoothness which is essential to fuel economy. Antifouling paint specifications can be tailored according to the profile of the vessels indicated by the shipowner, including employment, speed, activity level, lay-up periods, fouling risk and water characteristics.

The liability of paint companies given on the basis of these data and assuring the good performance of the antifouling is closely tied to this trading profile. Paint companies can easily survey vessels painted with their products by AIS. When shipowners run out of the assumed profile due to extended lay-up periods e.g., off South American or West African ports, which cannot compete with the actual challenges, the hull will foul, the liability expires, and the shipowner hires a diving company to clean the hull. Unintended changes to a ship's profile lead to the common practice of cleaning antifouling coatings when fouling exceeds the biofilm stage.

A worldwide network of underwater hull-cleaning companies – some with divers; others using robotic technologies – is present in most major ports and regions of intense shipping activity. The companies offer hull inspections and cleaning with a range of techniques, skills and efficacy. As antifouling paints like self-polishing copolymers (SPCs) and controlled depletion polymers (CDPs) are not designed to be cleaned with brushes, an essential reduction in film thickness and service life of the paint may occur if the fouling is to be thoroughly removed. Up to now, no standards or common guidelines exist to gauge the various stages of fouling, the paint condition and the release of removed fouling organisms, paint particles and dissolved biocides [2].

Reactive cleaning strategies

Reactive in-water cleaning or treatment is used to remove or treat biofouling (macrofouling) from unmanaged or poorly maintained vessels, or in areas where antifouling coatings (AFCs) have failed or become damaged. Macrofouling is more difficult to remove and may contain a diverse range of organisms that are reproductively mature [4].

As mentioned above, the reactive cleaning or cleaning on demand is common practice even when the liability expires to save fuel and money. Many antifouling products and self-polishing paints are not designed to be cleaned and have permeable surfaces so that biocides can leach out whilst in service, leading to a soft consistency that is prone to abrasion. Cleaning companies apply rotating brushes, hydro-jetting, blades and hand-held brushes or pads to remove the fouling.

A hull of a vessel is not homogeneously fouled. The plane surfaces, flat bottom and shoulder might by covered by slime whereas the stern, boottop and vertical sides may expose filamentous algae scattered with barnacles or other encrusting organisms. Most underwater hull cleaning companies undertake an inspection and, if possible, select different tools for each fouling stage and type. Rotating brushes have the disadvantages of getting clogged by algae and acting like sanding tools if they accumulate shell debris from barnacles in between their fibres. Hydro jetting and cavitation techniques are hard to manage regarding collection of removed fouling organisms and paint particles although some systems now automatically collect waste material for appropriate disposal ashore. Where vessels have their hulls cleaned alongside, waste material is sometimes collected in bags or filtration units on the quay or in an adjacent barge.

Instead of shore-based cleaning, ship-based devices can be installed in different ways on the vessel, which should be handled and managed by the crew. Ship-based mobile cleaning enables operators to select proactive or reactive cleaning independent of the port infrastructure and at remote mooring stations.

If cleaning companies claim not to damage the antifouling coating, scientifically sound studies reveal hat 20 to 30µm of the upper paint layers of CDPs are often removed, with the leached layers leading to a refreshing of the paint. Regarding the collection of removed fouling, it is evident that bags inside remotely operated vehicles (ROVs) display a restricted volume and have to be changed frequently during the cleaning process. Filtration units are quite effective and can retain particles as small as just a few microns. The capture of dissolved biocides is rare and implemented by only a few companies.

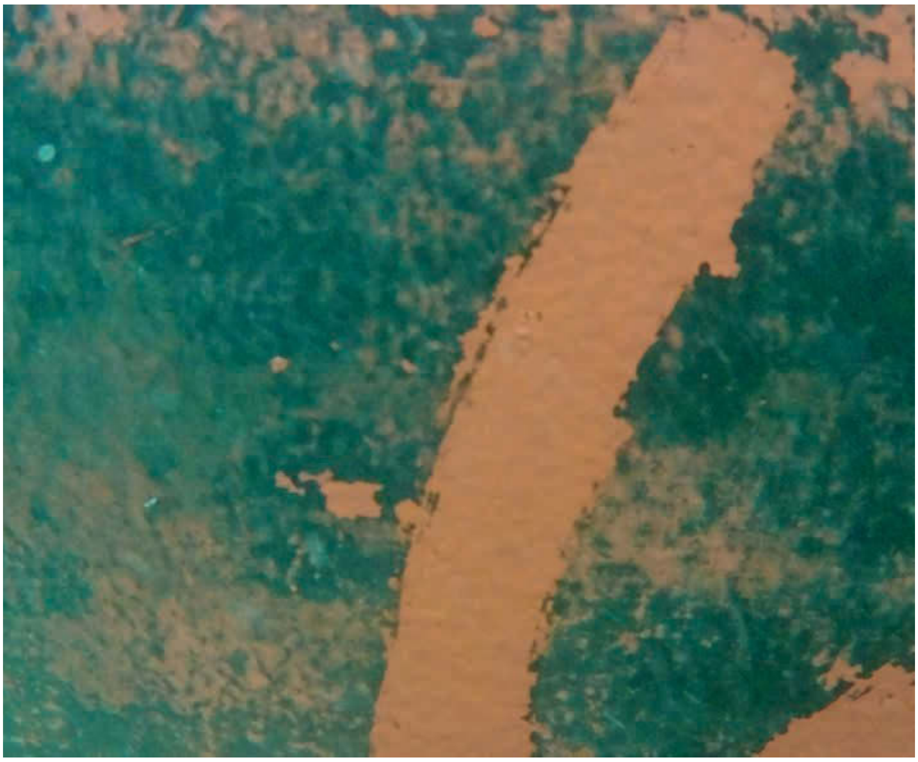
Regarding the release of biocides as a result of cleaning, scientific literature is limited. Some cleaning companies claim to apply such careful cleaning techniques that no biocides are released, they claim. However, serious investigations undertaken by the US Navy show that an immediate biocide release is certainly a strong possibility and should be taken into account. During tests, the US Navy recorded strong concentrations of copper as underwater hulls were cleaned. The concentration declined down to the ambient harbour concentration in distances of 10m to 50m [3, 6].

Reactive cleaning on biocide-free foul release or hard coatings

A couple of foul release coatings based on silicones were offered with promises of fuel savings of 7% to 8%. It turned out that those savings could seldom be achieved except on high-speed ferries or vessels with a high activity level. In most cases, during the first year of operation, a biofilm developed and later macrofouling became evident. The adhesion capability of these organisms was less than adhesion strength of anticorrosive paints such as epoxys, but was still strong enough for the fouling not to be removed by currents in service. As the biofilm alone induced an increased friction which resulted in higher fuel consumption, the company Jotun published an article to address these misconceptions [7]. Furthermore, silicone-based foul release coatings contain extruding silicone oils, hydrogels or waxes which may be depleted after two years, which could explain why some companies have limited their performance guarantee to no more than two years.

Biofilm formation and the decrease in performance led to a requirement to clean foul release coatings regularly. Diving companies developed soft tools to avoid coatings damage. But early cleaning is evidently much easier, faster and less critical for the condition of the coating. Paint companies have published lists of approved diving/cleaning companies using techniques which do not cause damage to coatings [1]. Thus, it is possible to use silicones and clean them proactively or reactively in line with the recommendations of the paint company.

The advantage of cleaning foul release coatings rather than hard coatings is the low adhesion strength, which can allow the removal of macrofouling organisms like barnacles without scraping away outer layers of the coating. On hard coatings based on pure epoxid, for example, barnacles ›



Demonstration of low adhesion of fouling on durable hard coating can only be removed by scraping the outer paint layers to which they adhere tightly.

Hybrids of epoxid and silicones which display both hardness and foul release properties can be cleaned at extended intervals without damaging the surface.

Underwater inspection and determination of cleaning cycles

Prior to each underwater cleaning exercise, a ship's hull can be inspected either by divers or drones. In manual inspections, the clarity of the water is a crucial factor. The quality of images or videos of underwater surveys is highly dependent on this factor. In turbid waters with high concentrations of suspended matter, divers may be restricted to feeling a ship's hull to see whether fouling is present. Up to now, no technique is available except for plant via fluorometry, to detect faunistic fouling. As drones require clear water, they must resist currents running parallel to the hull to maintain their position for the time required.

This is necessary for the inspection of niche areas including sea chests, bow and tunnel thrusters and stabilising fins. Most drones can easily move forward and backward but are not equipped with vectored thrusters. Furthermore, to inspect the flat bottom, especially for areas of the hull with previous docking blocks, uncovered by antifouling paints or foul release coatings, control of drones can be complicated. Some argue, therefore, that inspections undertaken by divers are still superior to those of drones.

Foul prevention strategies

Different cleaning strategies are used to maintain biocide-free hard coatings such as silicone coatings, glass fibre enforced epoxy, epoxy-silicone hybrids.

Grooming or proactive cleaning

A fundamentally different approach in relation to cleaning on failing antifouling paints consists in the fouling prevention strategy of "grooming". "Underwater grooming, as used refers to the gentle, habitual and frequent mechanical maintenance of submerged ships' hulls in order that they remain free from extraneous matter such as fouling organisms and particulate debris, with minimal impact to the coating" [5].

Proactive in-water cleaning or treatment is used to reduce the accumulation of microfouling (slime) on the vessel as part of biofouling management programme. Proactive in-water cleaning or treatment, also known as hull grooming, is considered best practice for ongoing hull maintenance.

The process has been developed to manage biofouling and prevent the build-up of slime to optimise vessel operational efficiency and to prevent the accumulation of any further biofouling [4].

This proactive technique performed on biocide-free, hard coatings has several advantages. No waste such as fouling organisms or paint particles is generated and therefore no collection or filtration procedures are necessary. There is no immediate release of biocides (visible like plumes or clouds of dissolved biocides or paint particles) and a minimal risk of alien invasive species.

This technique is restricted to vessels in service with short port calls, high activity levels and high service speeds.

Until now, grooming seems not to be appropriate for vessels with low activity, extended lay-up periods in ports or moored off the coast. In regions of high fouling risk, it is necessary to groom every week or develop an effective fouling sensor which should regularly scan hull sections for fouling development. Thus, grooming or, better, cleaning on demand may be applied.

In marine regions with short fouling seasons, relatively low water temperatures and drifting ice in winter time, a type of grooming has been in practice for decades. Ferry lines in the Baltic Sea, for example, are faced with regular drifting ice in winter which can remove antifouling paint and sometimes the anticorrosive paint as well. On the eastern side of the Baltic Sea, the fouling risk is limited due to low salinity and lasts for only about four months. It is common practice to coat the hull with abrasion resistant coatings and control the fouling development by divers using rotating brushes.

Another example is the cooperation between Ecosubsea and Wallenius-Willemsen. As a research project, two vehicle carriers are coated with test patches which are to be cleaned at each port on the ships' itineraries. So far, cleaning has only been carried out in Southampton, but was also due to be undertaken at Bremerhaven and several Japanese ports on the ships' schedule. Port installations for vehicle carriers offer the advantage of plenty of quay space for cleaning, collection and filtration equipment. Container terminals, on the other hand, do not.

Conclusions and points of discussion

- Biofouling management plans are in force at country level, state level or have become the responsibility of local regulatory bodies like port authorities or lower water authorities;
- A global regulation by IMO may take at least another ten years;
- There are templates for different types of cleaning strategies which should be compiled and may be condensed in direction of the IMO recommendations to achieve acceptance;
- Reactive cleaning on biocidal antifouling paints which are not designed to be cleaned may remain critical with regard to paint damage and biocide release, and they deserve sophisticated collection, filtration, flocculation, precipitation facilities to avoid the escape of paint compounds and organisms;
- Sophisticated collection systems are also required for reactive cleaning on biocide-free hard coatings to avoid the escape of marine organisms;
- Proactive cleaning and grooming at the biofilm stage is the easiest and quickest technique with the lowest risk of damage to coatings over many cycles;
- Standardisation, certification and approval of cleaning techniques are lacking even though there are numerous hull cleaning companies operating in many of the world's major ports;
- Monitoring systems should be put in place, where hull cleaning takes place, for the monitoring and measurement of efficacy including the release of paint particles (microplastics) and biocides and the retention of adult viable organisms, larvae and spores;
- The efficacy of all hull- and coating-related cleaning procedures should be recorded in the biofouling record book and the requirements harmonised.

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