

Proactive Grooming Validation & Efficacy Across Coating Categories

Tom Loeffler, Hullbot, Sydney/Australia, Tom@hullbot.com

Ben Dwyer, Hullbot, Sydney/Australia, Ben.Dwyer@hullbot.com

Anna van Nieuwland, Hullbot, Sydney/Australia, Anna.vanNieuwland@hullbot.com

Abstract

As the IMO moves toward a legally binding biofouling management framework, the design choices and incentives built into that framework will shape how ambitiously the industry can act on biofouling. A common concern in emerging regulations is coating compatibility, the assumption that gentle brush grooming is only appropriate for certain antifouling categories and should be limited accordingly. This paper challenges that assumption, drawing on operational data from over 2,000 commercial cleans, alongside in-situ water quality testing and submerged panel testing. The same data also challenges prevailing assumptions about cleaning cadence: keeping fouling at manageable levels requires grooming intervals of weeks, not months. At this frequency, fouling stays light and coating integrity is maintained throughout the grooming service.

1. All coatings are groomable

Coating compatibility has become a recurring point of contention in the development of in-water cleaning standards, including in the IMO's In-Water Cleaning Guidance (MEPC.1/Circ.918) and the correspondence group process currently developing a legally binding Biofouling Management Convention. This assumption shapes the regulatory choice ahead.

One way is to regulate by coating category. This approach is broad by design. It does not account for how adjustable modern grooming technology already is. Brush hardness, contact pressure, and cleaning frequency can all be set per clean. A category-based rule cannot capture this. It risks limiting which technologies reach commercial use, without a clear link to the outcome regulators care about.

A better way is to focus on outcomes: undamaged coatings, minimal biofouling. Proposition: utilise technology to make grooming very adjustable, and regulate for outcome rather than category. Through operational and empirical evidence, this paper shows that proactive grooming, when gentle and con- trollable, is compatible with all coatings:

- Operational field data: +2,000 commercial cleans over 3 years across global fleets and range of industry leading coatings
- In-situ water quality testing grooming on self-polishing copolymer (SPC): with independent third-party (SGS Marine Services) during proactive grooming operations
- Tailored operations: adjusting variables to ensure compatibility on all coatings

These data points show that various coating categories, both hard and soft, are groomable over months and years with measurably minimal risk. This is reinforced by Hullbot's accelerated life cycle testing presented at last year's PortPIC (2025), which simulated five years of proactive grooming on hard coatings, foul release coatings (FRCs) and ablative coatings, with no measurable change in coating integrity.

Coating damage risk is also driven by how much fouling has built up, not only coating type itself. How often a hull is cleaned determines how much fouling has built up, and that level of fouling then determines the brush type and pressure needed to remove it. Because fouling load is largely a function of cleaning frequency, regulation is better targeted at the fouling level a hull is allowed to reach, rather than at coating type or cleaning methodology directly.

2. Fleet-Scale Real Life Operational Data

2.1. Dataset across 2,000 cleans under real-life conditions

To date, more than 2,000 proactive commercial hull-grooming operations have been completed across ferries, cruises and commercial vessels operating in Australia, Asia-Pacific, Europe and North America (as of August 2026). Grooming has been carried out on vessels using all major coating brands, with no coating-damage incidents recorded by proactive grooming, Table I.

Table I: Headline figures from Hullbot's grooming dataset, as of August 2026

Documented cleans	Cleans/Month	Unique vessels	Cleaning coating damage	Coating damage (not caused by Hullbot, section 2.2)	Fuel reduction measured	CO2e reduction measured
+2,000	+100	91	0	25	2,676,883 L	8,298,153 kg

Table II summarises a documented subset by coating category, alongside the fuel-efficiency improvements measured and reported after adopting proactive grooming. Efficiency variation is not a reflection of cleaning or coating success, but due to a range of variables, including different global fouling pressures.

Table II: Grooming data by coating category, showing number of vessels, documented cleans, and reported fuel efficiency gain from fouling removal

Coating category	Vessels	Documented cleans	Max Months of Cleaning	Total average hours groomed	Fuel efficiency gain
Hard	7	927	36 months	2,533	11 - 23%
FRC	41	893	40 months	6,866	7 - 26%
Ablative	18	214	13 months	1,225	9 - 14%

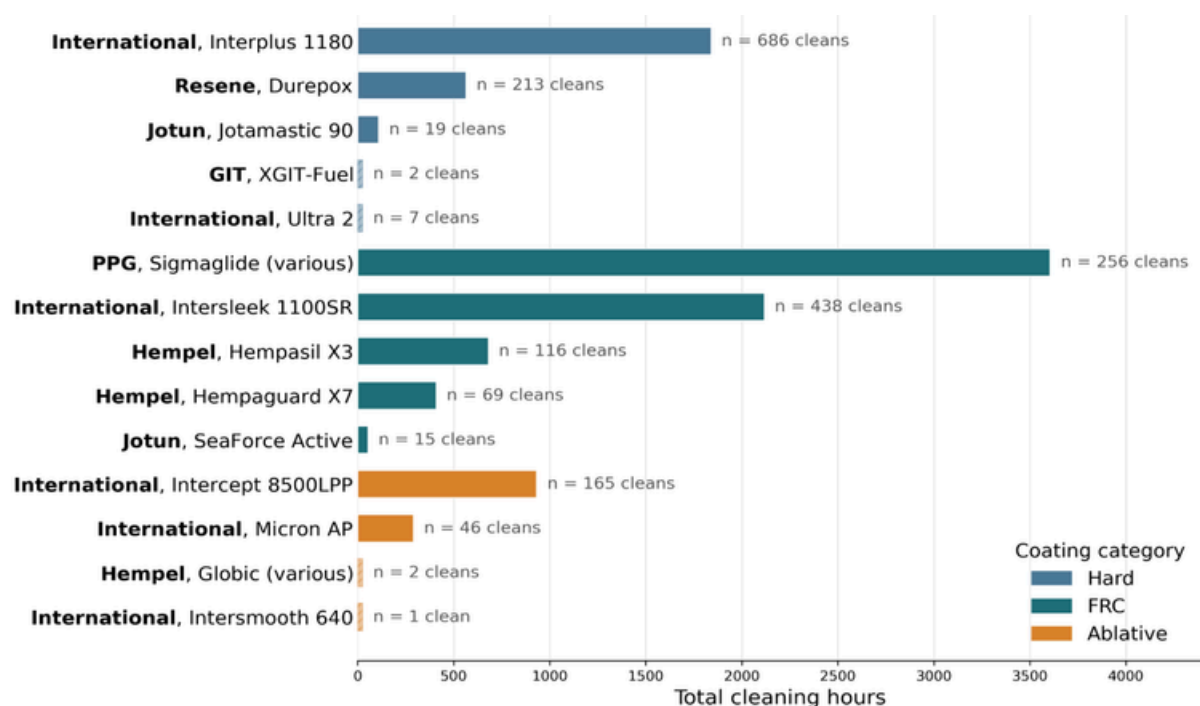


Fig.1: Documented cleaning history by coating product. Hatched bars are fewer than 80 hours of cleaning

Adjustable cleaning speed, brush type, and brush pressure allow the same grooming platform to be precisely adjusted per coating and fouling condition, rather than requiring a different tool for each coating category. Across the full grooming dataset, no coating damage has been attributed to grooming by the fleet operator or Hullbot. Where coating degradation has been observed at inspections, the cause has been documented. Examples include coating reaching end of life, dry dock blocks, or impact damage from grounding, fender contact, or anchor chain contact (Section 2.2)

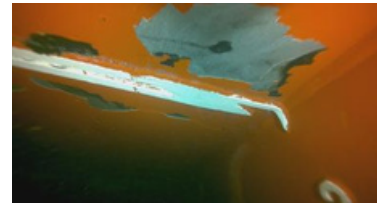
2.2. Subset examples of damage detection and coating degradation tracking



Marking paint failure



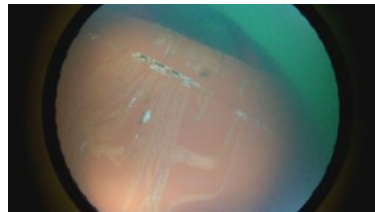
Docking block mark



Impact damage



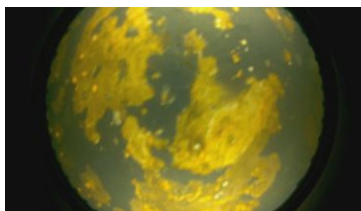
Transom Damage



Anchor chain scoring



Coating adhesion failure



Impact damage



Ablative failure



Diver brush scoring

3. Water quality testing results for ablative (SPC) coating grooming

Water quality testing was conducted during a proactive grooming operation on a SPC coating (Inter-smooth 460), an antifouling type that relies on a controlled release of copper and zinc as its active ingredients. Fourteen water samples were taken at four stages of the trial, at the start, one third through, two thirds through, and at the end. Samples taken within 1m from the active cleaning system and 20m away were compared. Copper and zinc remained below detection limits throughout the whole cleaning operations in all samples, indicating that no measurable active ingredients were released from the coating, Fig.2.

In addition, suspended solids were measured as a proxy for cleaning residue. Values varied across the trial, with no consistent pattern. Because elevated solids show up in both background and near-operation samples, not just where cleaning happened, there is no clear link between the cleaning activity and the level of solids in the water, Fig.2.

Results show grooming does not strip or release measurable amounts of active ingredient from an SPC coating.



Fig.2: In-Situ water quality test results: Proactive grooming of an SPC coating

4. Compatibility is set by cleaning configuration, not coating

4.1. How cleaning variables and fouling level set the force required

Wear on a coating is a function of the force applied to it. Cleaning frequency, brush, contact, and coverage settings are all adjustable for every clean, Fig.3. Cameras and sensors monitor the clean as it happens. These settings are designed to apply the lowest force and abrasiveness needed at the coating surface. Fouling level on the hull matters too, since more fouling generally requires more force to remove. Fouling builds up between cleans, and cleaning frequency is the main lever that controls how much fouling builds up.

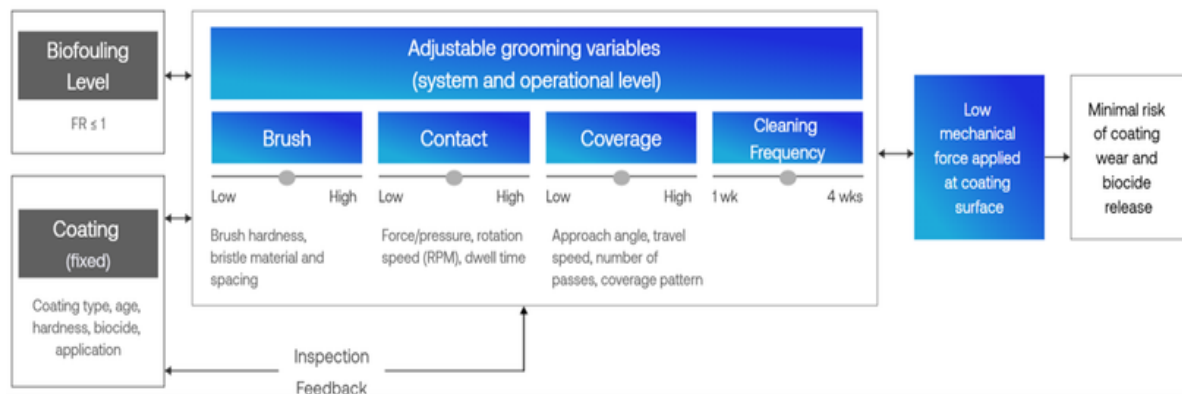


Fig.3: How adjustable cleaning variables and fouling level minimize force at coating surface

4.2. Fouling happens in weeks, not months or years

Without cleaning, slime forms within weeks on every coating category. This is supported by three years of field data and over 2,500 inspections from active vessels. Fig.4 shows a subset of vessels with fouling forming across water temperatures from 4°C to 29°C. These vessels span a range of coatings and are high-activity, regularly groomed vessels.

Fig.5 shows a submerged panel test of freshly painted coupons, tracking fouling formation over different grooming schedules. Four panels are tested, one per cleaning interval: two weeks, four weeks, eight weeks, and never cleaned, as a control. Each panel holds two coupons of each of seven industry leading coatings. This test does not compare which coating performs best. It tests whether a coating can be cleaned at these intervals, at the fouling level each interval produces, without damage. Eight weeks in, no panel shows statistically significant change in dry film thickness readings (DFT). The trial is ongoing. Further results upon completion of milestones in Q4 2026.

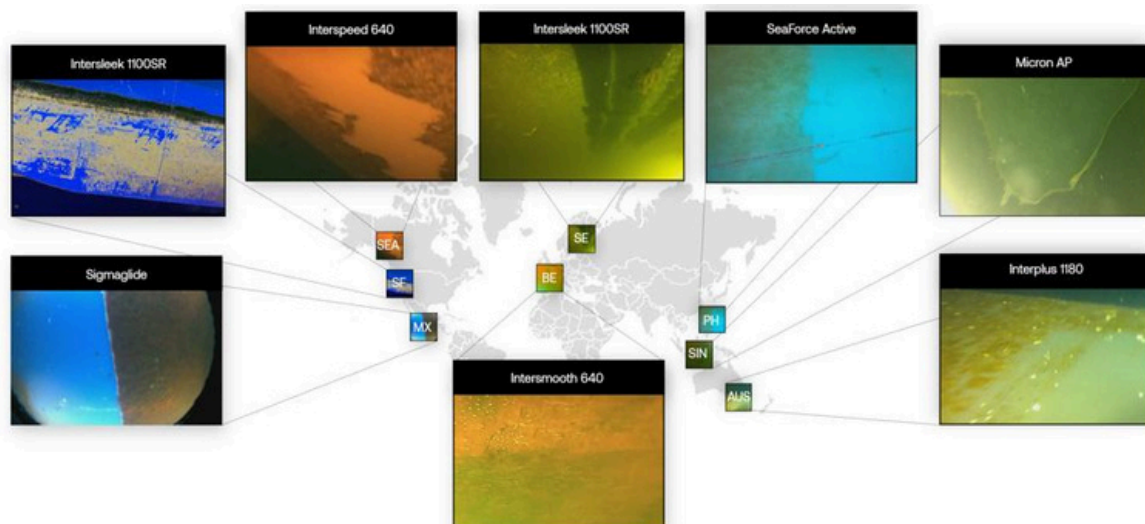


Fig.4: Slime detected on hulls globally on all coating categories

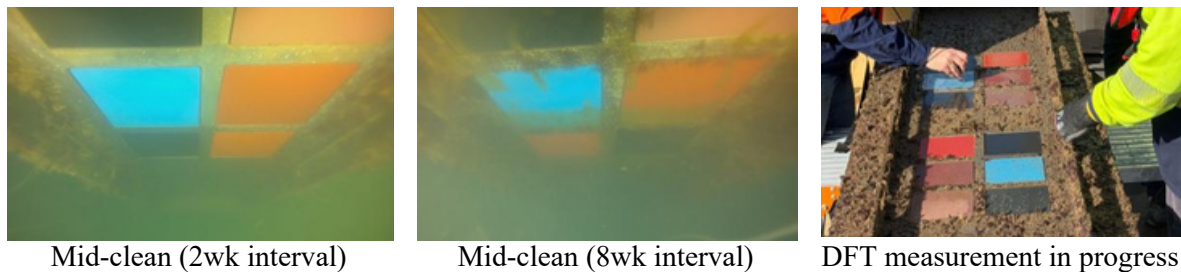


Fig.5: Panel fouling and inspection across grooming intervals

4.3. Frequent cleaning keeps force within range every coating can tolerate

Frequent cleaning keeps fouling from reaching levels that demand aggressive force. A hull cleaned every two weeks ensures only light biofilm is cleaned, not an established shell layer. This has a direct bearing on what regulation should target. A common assumption is that some coatings can tolerate grooming and others cannot. Where fouling is kept light through frequent cleaning, the force needed to remove it stays within the range coating categories are able to handle.

4.4. A wide range of settings is available, including brushes

Compatibility depends on two variables: how much force is applied, addressed in 4.1–4.3, and which brush is selected for a given coating, addressed below. A soft brush at low pressure suits a softer abrasive or silicone system, a firmer brush at higher pressure suits a hard coating, Fig.6.



Fig.6: Subset of the 40 brush designs developed, varying in angle and Shore hardness to suit different coating types, increasing range from low abrasiveness to high abrasiveness.

We propose to assess coating damage risk from grooming using a decision matrix based on the vessel's biofouling level and coating type, to which the grooming characteristics can be adapted to minimise the risk, Fig.7. Light biofilm can be removed with a soft brush at low pressure on any coating, hard, FRC, or ablative.

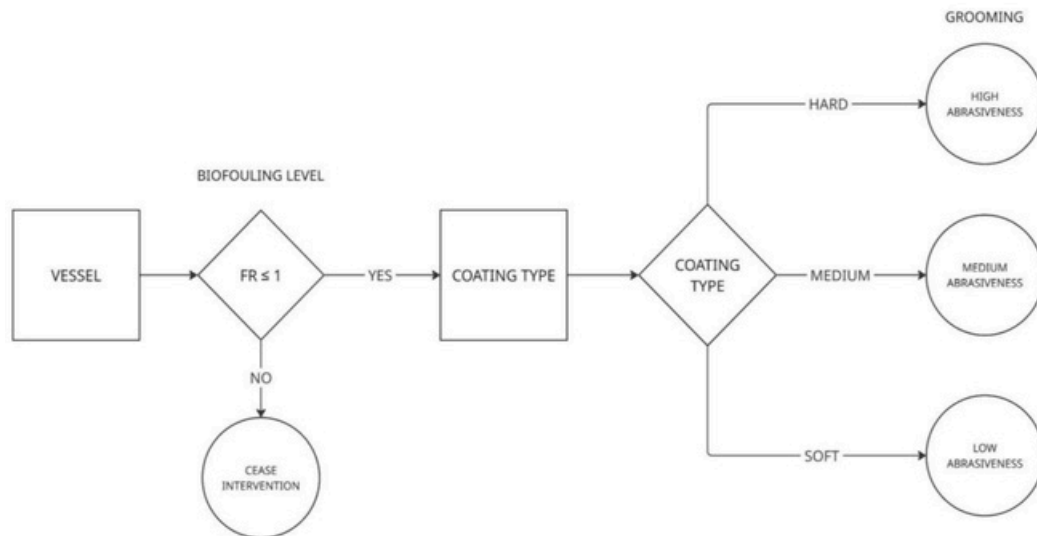


Fig.7: Grooming Abrasiveness Decision Matrix

5. Policy implications: Outcome focussed, not prescriptive

Proactive grooming data from over three years of fleet operations, independent submerged panel testing, and the water quality test together show that adjustable, controllable grooming is a successful way of cleaning across coating categories. The outcome that matters is a clean hull without coating damage or a measurable increase in harmful substances released to the water. This is achievable across coating categories because grooming can be adjusted to keep fouling from ever reaching a level that needs anything more than gentle, non-abrasive cleaning. A framework built around this outcome could accommodate a wide range of successful and environmentally friendly fouling prevention and intervention approaches, across coating categories and future cleaning technologies. A framework prescribing what can be cleaned and how, by contrast, would need constant revision to keep pace with new technology.

Acknowledgement

Thank you to the Defence Science and Technology Group (DSTG), Australia, for project partnership and scientific support, and SGS Marine Services for professional water quality testing.