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TO CLEAN OR NOT TO CLEAN: MANAGEMENT OPTIONS FOR BIOFOULING ON SHIP HULLS

Minimizing biosecurity risks and vessel emissions to air, as well as pollution from antifoulants.

Marine growth on ship hulls (hull biofouling) represents, along with ballast water, a vector for introduction and spread of **non-native invasive species (NIS)** by shipping [1]. Also, hull biofouling results in considerable propulsion penalties [2], and thus **increased emissions to the atmosphere.** However, fouling prevention methods relying on release of antifouling biocides (AF) from hull coatings may lead to **chemical pollution** [3]. The current work thus aims at providing guidance on **options for management of hull biofouling**, focusing on the relation between in-water hull cleaning and the use of different types of hull coating. Hull cleaning may be performed **reactively**, once a relatively high level of fouling is detected, or **proactively**, at early fouling stage.

METHODS

Two main parts were involved in the present work:

1. Effects of **minimized in-water cleaning forces** on ship hull coating **performance, damage and wear,** by adhesion testing with immersed waterjet, **Fig. 1**.
2. Effects of **maintenance practices** on monitored **propulsive performance** for a worldwide-trade tanker and North-Sea trade Roll-on/Roll-off vessels, to gain insight into effects of maintenance on energy consumption penalties and air emissions.

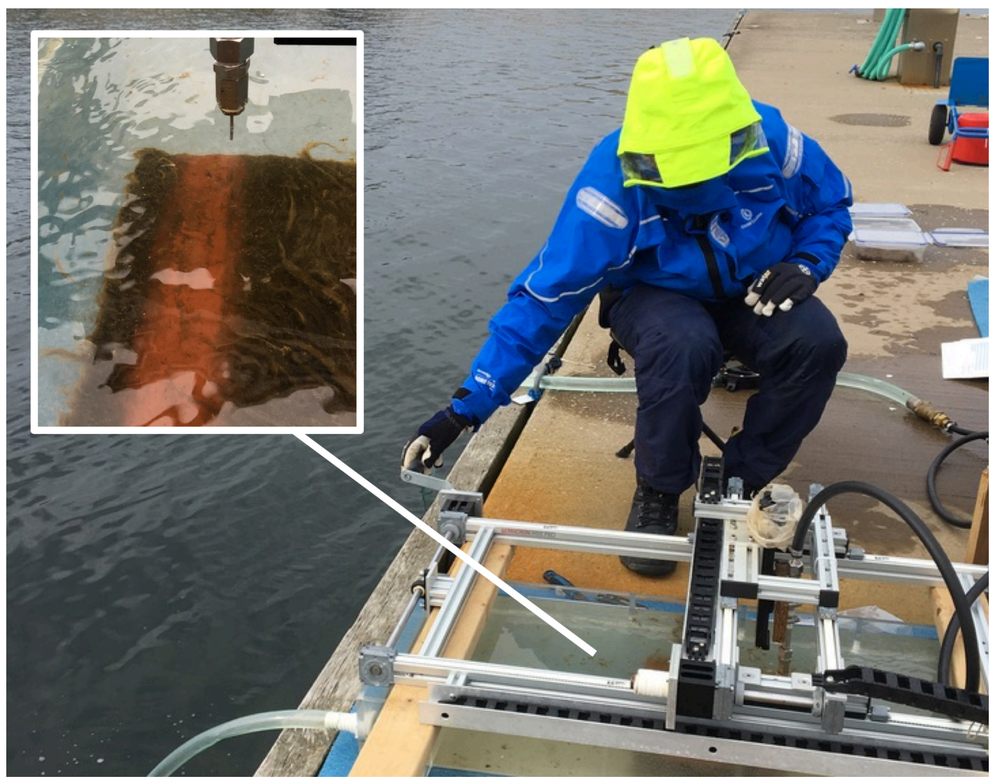

Fig. 1 *– Immersed waterjet adhesion-strength testing.*

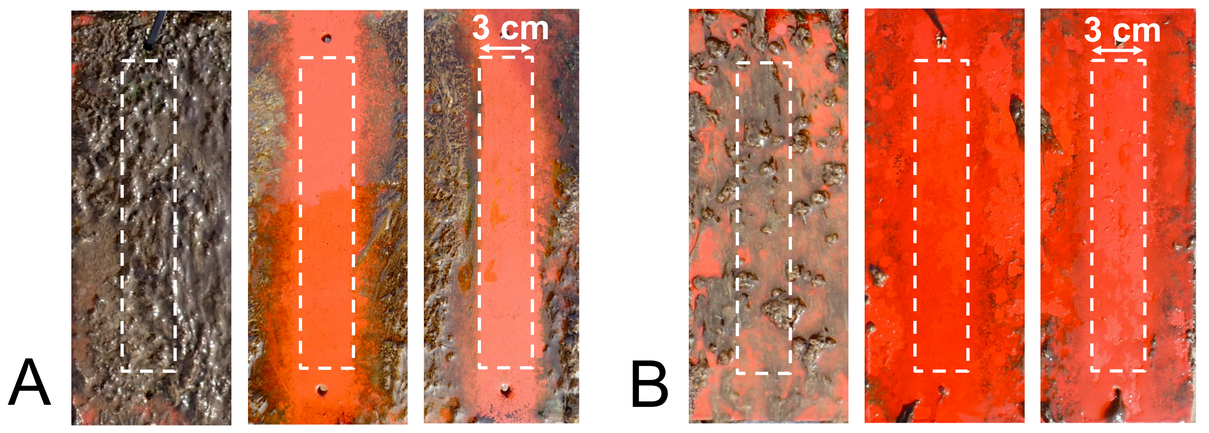

Fig. 2 *– One year of marine fouling (Gothenburg, Sweden) on **A) biocidal coating** (AF coating) and **B) non-biocidal foul-release coating** (FR coating), under no cleaning, bi-monthly or monthly cleaning (left, middle and right, respectively).*

RESULTS AND DISCUSSION

Minimized cleaning forces enabled to keep fouling to a minimum, i.e. a clean to lightly-slimed surface, **Fig. 2**. Such forces did not cause any significant wear/damage to a self-polishing AF coating, with no statistical difference among cleaning frequencies in terms of average biocide release (~13 µg Cu /cm^2/day, polishing rate mass-balance method).

Further, investigation of **ship propulsion performance** revealed that **reactive in-water hull cleaning** may lead to depletion of AF coatings and considerable variation in propulsion power due to fouling, **Fig. 3A**, and thus high risk of spread of non-native invasive species. Currently studied Roll-on/Roll-off vessels had considerably lower penalties, **Fig. 3B**, and these vessels might be eligible for non-biocidal coatings, combined with **proactive cleaning**.

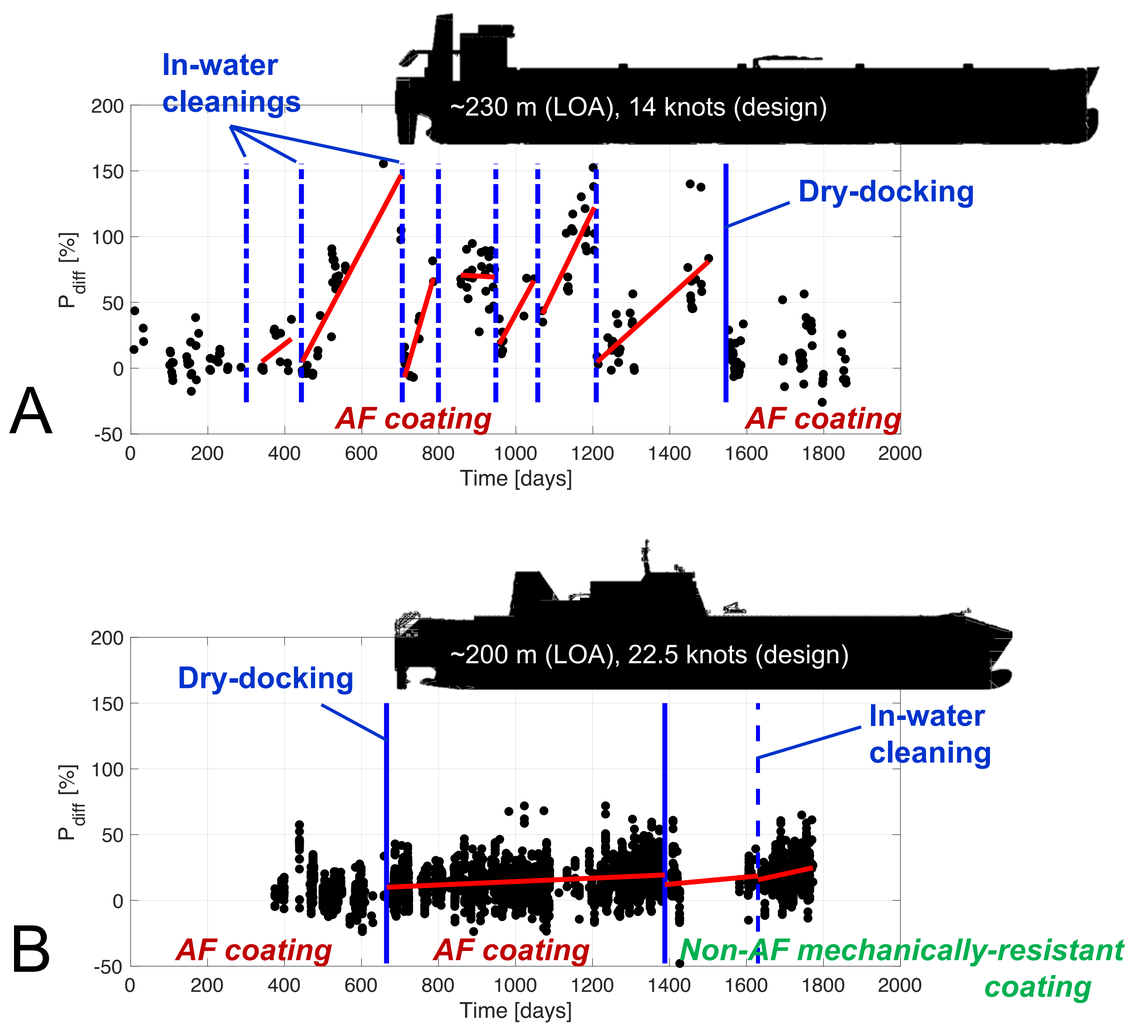

Fig. 3 *– Percentage increase in propulsion power due to hull and propeller roughness: **A)** tanker, **B)** Roll-on/Roll-off vessel. LOA = length overall.*

FUNDING

COMPLETE project [4], co-financed by [#R069]:

Interreg Baltic Sea Region
EUROPEAN REGIONAL DEVELOPMENT FUND
EUROPEAN UNION

REFERENCES

[1] Davidson et al. (2016). *Biofouling*, 32, 411–428.
[2] Schultz (2007). *Biofouling*, 23, 331–341.
[3] Dafforn et al. (2011). *Marine Pollution Bulletin*, 62, 453–465.
[4] COMPLETE Project: www.balticcomplete.com

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