Arab Academy
for Science , Technology and Maritime Transport

MARLOG 13 2024

The International Maritime Transport and Logistics Conference

"MARLOG 13"

Towards Smart Green Blue Infrastructure

3-5 March 2024 - Alexandria, Egypt

ASSESSMENT OF SHIP FOULING: FORMATION, PREVENTION AND ENVIROMENTAL IMPACTS

By

Capt. Fawzy Dekinesh and Dr Mona Kaamoush

Do the current antifouling mechanisms meet the standard of sustainable antifouling systems?

Main Objective

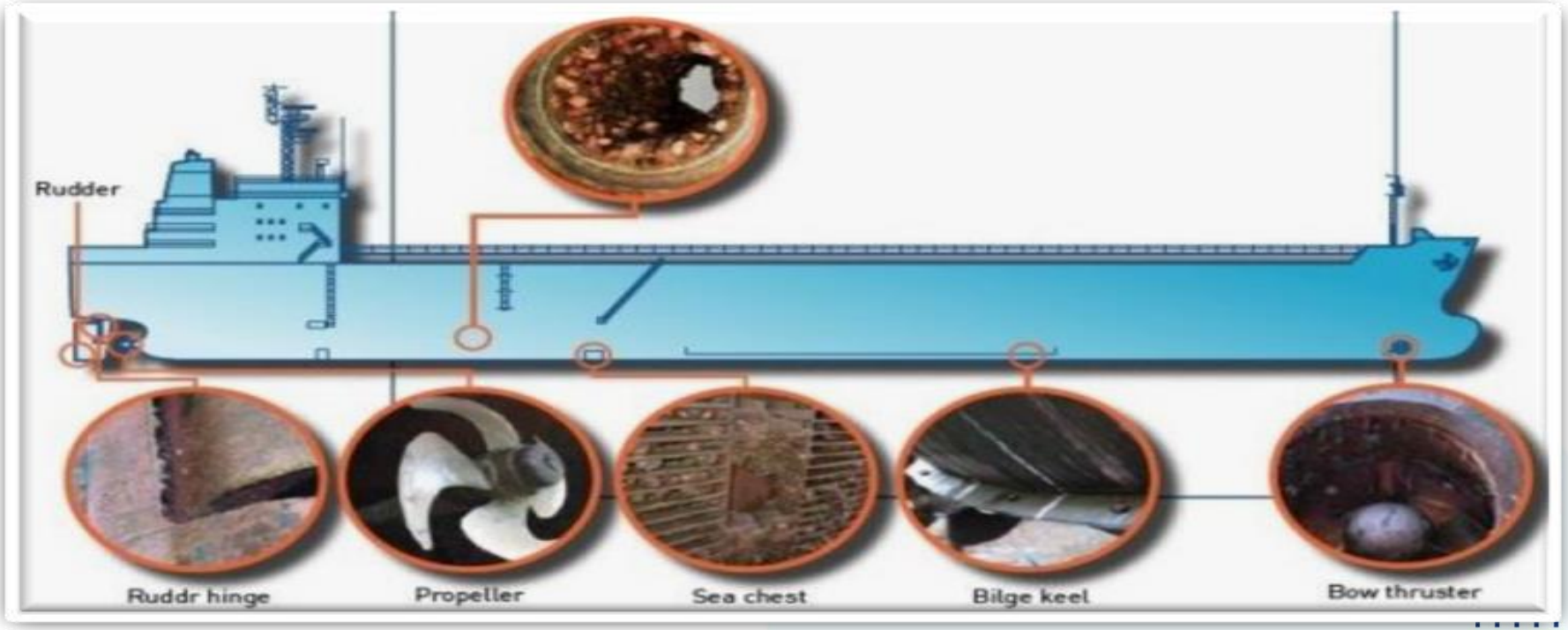
Help shipping companies to choose the most effective anti-fouling system among several options.

Introduction

Biofouling is the accumulation of aquatic micro and macro sticky organisms and plants on the immersed surfaces of the niche areas resulting in a non protected damaged coating system.

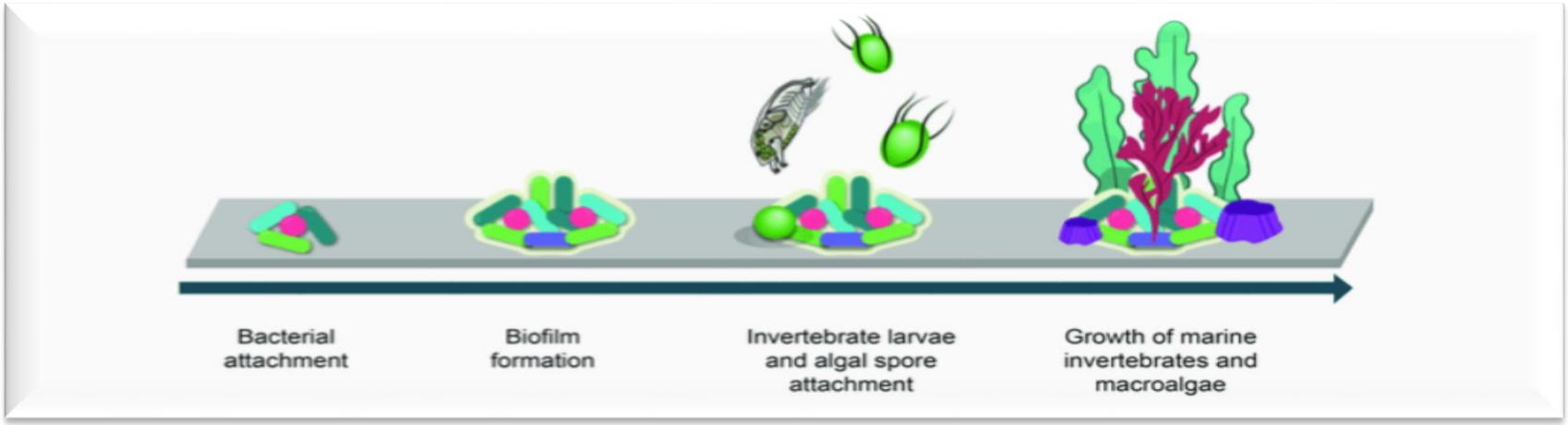
Niche areas are areas on a ship that are more susceptible to biofouling due to the different hydrodynamic forces e.g., sea chests, bow thrusters, propeller shafts, inlet gratings, dry-dock support strips, etc.

- Barnacles on under water surface



- Niche Areas

Biofouling Process:



1- Settlement

- To find and attach a suitable surface.

2- Attachment

- Attachment permits the **biofilm** formation and more **macro-organisms** to **settle down.**
- **More rough** hydrophobic surfaces drive to **more durable** attachment

3- EPS (extra polymeric substance) deposition

- *EPS* is **a slimy, highly hydrated** matrix **mostly** composed of **polysaccharides** associated with a mixture of glycoproteins, proteins, nucleic acids, humic substances, Phospholipids and glycolipids.

Introduction

The evolution of anti-fouling system

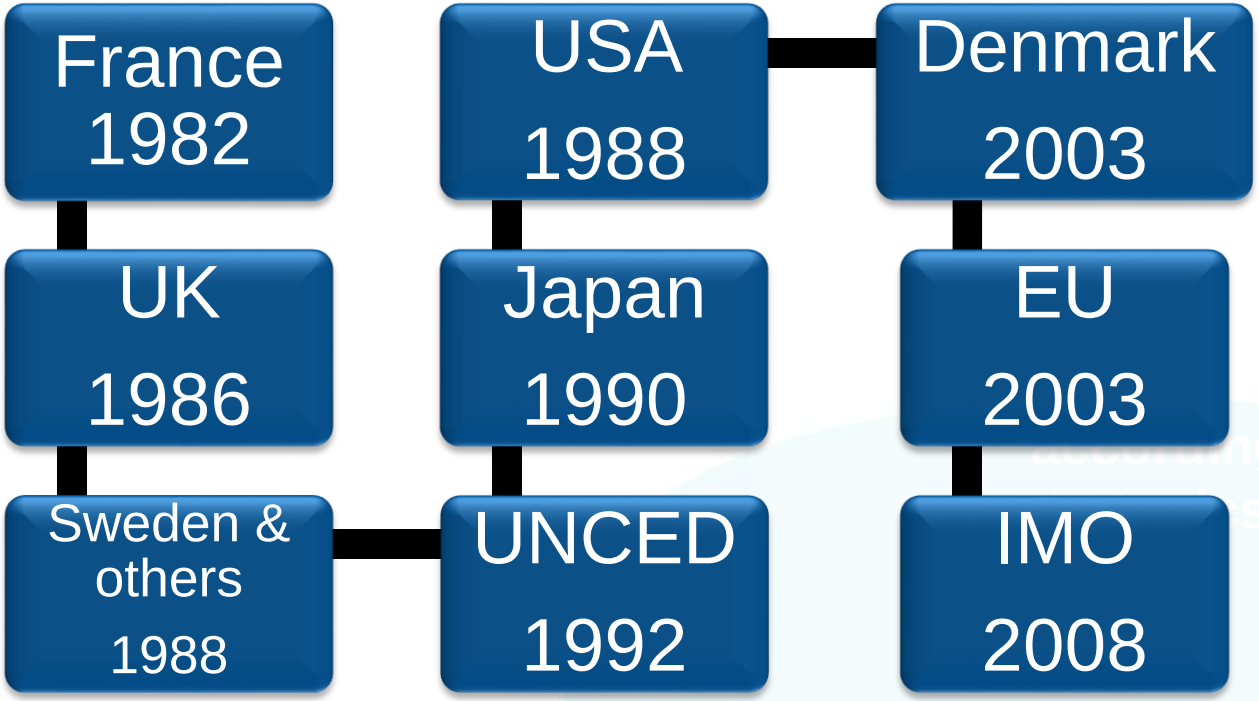
The result from reviewing the era before the AFS convention shows the early record of fouling control and several substances used as an anti-fouling system such as **lead sheets, lime, arsenal, and oil mixed with Sulphur and copper.**

anti-fouling system included:

- Paints with biocidal anti-fouling properties,
- Free association paint
- Ablative or Copolymer depletion paint (CDP)
- Tributyltin self-polishing copolymer (TBT-SPC paints)
- TBT-free copolymer-based technologies /first anti-fouling system free of TBT

Introduction

National, international agreements and treats governing the antifouling system.



Methodology

- A SWOT analysis was used **to better understand** the strengths, weaknesses, opportunities and threats for the collected **data** by **literature review** and **questionnaire** regarding anti-fouling systems and hull cleaning mechanisms.
- Qualitative analysis has been **applied** through **a SWOT** analysis **for assessing** the **current anti-fouling systems in use.** The collected **data was coded by** the author **under the following categories**:

1. **Biocidal paint** (Antifouling biocides, Soluble matrix paints, Contact leaching paints, Ablative paints, and Self-polishing copolymer paints)
2. **Non-toxic coatings** (Fouling release coatings, Deterrent surfaces, Biomimetic coating, Hull Bug (grooming device), and Cleaning device (boat washer))

SWOT

Anti-fouling category	Strengths	Weaknesses	Opportunities	Threats
Biocide dependent anti-fouling	Effective anti-fouling agents	Has environmental impact as biocide based	Based on Copper compound therefore is less hazard than TBT	Regulation for limiting the use of biocides
Paints with soluble matrix	Mixed with matrix/binder/resin	-Leaching overtime -Valid for 18-24 months	Produced from natural wood rosin	Regulation for limiting the use of biocides
Paints that leach	-Insoluble matrix - Hard racing - Low cost	- biocide release - effective time not exceeding 18 months - Negative environmental impact- Creating hazard health- Releases very much quantity of biocides during hull cleaning	Minor hazard biocides	-Regulation for limiting the use of biocides -Significant improvement in other biocides release systems like (CDP, SPC) -New solution evolved not biocides dependent
Ablative paint Or (CDP)	-Soluble matrix/control depletion polymer- affordable- Currently in use	-Dissolution and hydration mechanisms- Contain strong biocides than SPC- Negative environmental impact -Releases biocides during hull cleaning- The leaching mechanism led to hull roughness - Get oxidized when contact with air	-Valid for 36 months-the cost factor dominating the anti-fouling selection	-Regulation for limiting the use of biocides -New solution evolved not biocides dependent

Findings

The antifouling mechanism

- implements heavy metals; biocides, as active chemicals to eliminate organisms
- reduce the fouling thickness rather than completely removing the biofouling on the ship's hull
- regulation for limiting the use of biocides

The fouling release mechanism

- a more environmentally friendly technique, relies on the non-stick mechanism and does not release any heavy metals or biocides.
- reduce the fouling thickness rather than completely removing the biofouling on the ship's hull
- performs inadequately in the idle ship and slow steaming modes.

Conclusion

1. Based on the SWOT analysis, it is noted that the currently applied methods and solutions of anti-fouling systems do not meet the requirements for high performance and environmental impact.

2. Shipping companies are facing difficulties identifying which anti-fouling solution is most appropriate for their fleet to maximize their financial gains.

3. It is essential to have a decision-making framework that helps shipping companies choose the best antifouling solution to maximize energy efficiency.

4. There are numerous key factors guiding the shipping companies while selecting the anti-fouling systems such as the type, size of the ship and seagoing areas.

Conclusion

5. The Shipping companies must adopt and carry out an anti-fouling management strategy.

6. The requirement for new technology development to achieve a balance between economic interests and impact on the environment.

7. The need for developing a model to determine and quantify how much fuel oil is consumed as a result of biofouling.

8. Future anti-fouling technologies could improve ship energy efficiency and contribute to decrease biofouling.

Recommendations

1. Provide a comprehensive reference on antifouling systems that are currently in use for shipping companies, this will help decision-makers choose the best system for their fleet.

2. Addressing the need for new anti-fouling technology to meet the future demand.

3. Develop a strategy to fill the gap between the current anti-fouling systems and the requirements for new technologies to develop a new anti-fouling system.

4. The large paint producers' research and development departments should search for new/innovative technology.

Recommendations

5. Create a model that uses historical data from tankers, containers, and RoPax ships to calculate the possible power savings when examining a new anti-fouling solution.

6. Design a framework for making decisions while choosing the best anti-fouling technique to maximize energy efficiency.

7. Shipping companies are required to adopt cost and benefit analysis for selecting the optimum anti-fouling system, compatible with the ship's profile.

References

Abbasi, A. R., Shackley, S. E.& King, P. E. (1995) Effects of copper on the ultra-structure ofbrain cells of Atlantic herring, Clupea harengus L. Pakistan J Zool 27(3):203–206

Allison, D.G. (2003) Molecular architecture of the Biofilm Matrix, Biofouling, 19:2, 139- 150, Lens P. editor, IWA Publishing, London DOI: 10.1080/0892701031000072190.

Amann, R. I., Ludwig, W., & Schleifer, K. H. (1995). Phylogenetic identification and in situ detection of individual microbial cells without cultivation. Microbiological reviews, 59(1), 143-169. Retrieved from https://mmbr.asm.org/content/59/1/143.short

Antunes, L. C., Ferreira, R. B., Buckner, M.M. & Finlay, B.B. (2010). Quorum sensing in bacterial virulence. Microbiology, Vol 156, 2271–2282. DOI:10.1099/mic.0.038794-0

Callow, J. A., & Callow, M. E. (2011). Trends in the development of environmentally friendly fouling-resistant marine coatings. In *Nature Communications* (Vol. 2, Issue 1). https://doi.org/10.1038/ncomms1251

Callow, M. (1990). Ship fouling: problems and solutions. Chemistry and Industry (London), (5), 123-127.Retrieved from https://www.researchgate.net/publication/279903448_Ship_fouling_Problems and solutions

Champ, M.A. & Pugh, W.L. (1987) Tributyltin antifouling paints: introduction and overview. In: Oceans 87 Proceedings. International Organotin Symposium, Institute of Electrical and Electronic Engineers, New York. 14, 1296-1308. Retrieved from https://zenodo.org/record/1278098/files/article.pdf

Clare, A.S. (1995) Natural ways to banish barnacles. New Scientist. 145, No. 1965, 38-41.

Cooksey BW-C, K.E. (1995). Adhesion of bacteria and diatoms to surfaces in the sea: a review. Aquatic Microbial Ecology, Vol 9,87-96. Retrieved from https://www.int- res.com/articles/ame/9/a009p087.pdf

Daims, H. and Wagner, M. (2007). Quantification of uncultured microorganisms by fluorescence microscopy and digital image analysis. Appl Microbiol Biotechnol, Vol 75,237-248. DOI:10.1007/s00253-007-0886-z

Costerton, J.W.; Cheng, K.J.; Geesey, G.G.; Ladd, T.I.; Nickel, J.C.; Dasgupta, M. and Marrie, T.J. (1987). Bacterial biofilms in nature and disease. Annu Rev Microbiol 41:435–464

Arab Academy
for Science , Technology and Maritime Transport

13 Marlog 2024

The International Maritime Transport
and Logistics Conference

"MARLOG 13"

Thank You