The Impact of 'Fouling Idling' on Ship Performance and Carbon Intensity Indicator (CII)

Markus Hoffmann, I-Tech AB, Gothenburg/Sweden**,** markus.hoffmann@i-tech.se

Abstract

On January 1, 2023, the International Maritime Organization (IMO) will introduce the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) measures for every ship above 5,000gt in size as a means to reduce carbon emissions from international shipping. In particular, the CII, as an operational index, will be impacted by biofouling load on the underwater hull surface. This is due to accumulated biofouling creating additional hydrodynamic drag that necessitates a ship to burn more fuel when sailing through water to maintain a set speed. This paper explores the connection between biofouling and ship CII ratings and offers insight and strategies for improving hull performance associated with the use of antifouling coatings. It also highlights the key findings of I-Tech's recent, extensive research into global fleet idling and why ship operators are concerned about the impact of biofouling in terms of both ship performance, profitability, and commercial reputation.

1. Introduction

Biofouling has been a perennial headache for the shipping industry for centuries. Accumulating biological matter on the hull is not a new problem for merchant ships. However, it is a problem that is set to get far worse, particularly for vessels idling in warmer waters. With ocean temperatures rising on a global scale, biofouling hotspots are increasing in size and severity, leaving more ships at risk of the negative impacts of biofouling on ship efficiency. Since fouling species flourish in warmer waters, the risk of them making a home on ship hulls is significantly increasing year-on-year.

In addition to the far-reaching impact of the COVID-19 pandemic on global trade, geopolitical events have continued to render vessels idle in coastal areas. New regulations that seek to reduce the environmental impact of shipping also mean that ship operators will be harder pressed to keep their ships operating efficiently and polluting less than they have done previously.

Biofouling has a threefold effect on ships; slowing them down, increasing fuel use and reducing cargo capacity therefore, its role in decreasing ship efficiency and lessening the impact of fuel saving measures should not be underestimated.

The negative impacts of biofouling are well-documented and increasing attention is being given to the issue by national and international authorities. Port cities are also becoming increasingly sensitive to air pollution and biosecurity risk created by visiting ships.

2. Uncertainty ahead

As the world entered the first few months of 2022, a great deal of uncertainty existed. Differing fiscal policies around the globe, continuing concerns around the COVID-19 virus, and geopolitical risks and growing tensions have made it difficult to foresee the main trends for the year ahead. Anticipations about the escalating situation in the Ukraine sadly came to fruition in 2022 and events in Asia around China, Hong Kong and Taiwan remain to be concerning.

The winter of 2021 also brought soaring energy prices on a global scale putting huge pressures on human populations and industries alike. Inflation is running at levels not seen for 20-40 years in Europe and the US, creating strains on green initiatives at local, national, and regional levels.

In its 2021 Global Trade Outlook report, UNCTAD warned that the forecast for 2022 was uncertain in spite of positive trends for international trade in 2021. Subsiding pandemic restrictions, economic stimulus packages, and increases in commodity prices added to the international shipping industry moving towards returning to business as usual, albeit in a new "normal" world.

Among the factors contributing to industry uncertainty in 2022, UNCTAD cites China's "below expectations" growth in the third quarter of 2021. "Lower-than-expected economic growth rates are generally reflected in more downcast global trade trends," it says, while pointing to "inflationary pressures" that may also negatively impact national economies and international trade flows. UNCTAD's 2021 report also noted that "many economies, including those in the European Union", continue to face COVID-19-related disruptions that could affect consumer demand this year. That is a view that appears both confirmed and contradicted by extended delays for container ships at numerous ports around the world. Queues continue to grow because of labour and capacity issues but consumer demand remains strong even if disrupted by shortages of goods leaving factories.

Fuel costs have also shot up and represent a significant part of the total ship operating costs. As crude prices nudged the US$90 per barrel mark in early 2022, bunker costs were also rising in line. Some analysts believe that 2022 could see crude oil touch the US$150 price point making eyewatering increases in bunker costs inevitable.

3. Incoming environmental regulations

In an attempt to bring the world fleet in line with its greenhouse gas (GHG) reduction programmes, the IMO has initiated two new measures that will be implemented at the beginning of 2023.

The EEXI is a means of applying a similar regime to the Energy Efficiency Design Index (EEDI) for newbuildings to vessels that existed before the EEDI rules became effective in 2011. EEXI is a technical measure and attempts to limit the carbon emissions based upon the equipment and technology installed on the ship. Both the EEDI and EEXI are laudable and effectively make shipping the only industry that has been obliged to reduce emissions on a global scale.

However, both are imperfect because they cannot effectively allow for measures where the impact on emissions is not constant. Battery hybrid ships, dual fuel engines and antifouling coatings are not adequately covered in these rules because they are dependent upon the way the ship is operated.

The CII coming into effect in 2023 will see further pressure on ships to become more efficient. From a coatings point of view, the CII is a regulatory requirement that will be influenced by hull performance, as opposed to the EEXI which is not.

The CII measures how efficiently a ship transports goods or passengers and is given in grams of CO_2 emitted per cargo-carrying capacity and nautical mile. The ship is then given an annual rating ranging from A to E. The rating thresholds will become increasingly stringent towards 2030. If a ship is rated E or D for three consecutive years, the owner will have to submit a corrective action plan to bring the vessel back into compliance. Some analysts believe that more than half of the world fleet will score a D or E rating and will need to take corrective action.

At the same time, other regional environmental regulations present a significant challenge. The EU's ETS scheme will introduce carbon pricing for ship fuel for the first time. There are disputes over who should cover this. Currently it looks as though charterers will be presented with a bill for carbon emissions, almost certainly ensuring they will then pressure shipowners to make ships more efficient.

Biofouling regulation remains to be a national matter, despite IMO guidelines. However, this is evolving. A newly signed initiative is set to provide pilot projects to demonstrate technical solutions for biofouling management in developing countries, address the transfer of invasive aquatic species (IAS) and help reduce GHG emissions from ships.
As new requirements for managing biofouling on international vessels arriving in Australia will begin on 15 June 2022, more countries around the world have already established similar regulations to address the effects of biofouling.

In New Zealand, the Craft Risk Management Standard (CRMS) came into force on 18 May 2018. This mandatory ‘clean hull’ requirement applies to vessels entering NZ territorial waters and non-compliance can lead to expulsion.

In California, the California State Lands Commission (SLC) Marine Invasive Species Program (MISP) applies to vessels 300 GT and above. These biofouling regulations require the development and maintenance of; a Biofouling Management Plan, a Biofouling Record Book, the mandatory biofouling management of the vessel’s wetted surfaces, and mandatory biofouling management for vessels that undergo an extended stay in the same location (45 or more days). An Annual Vessel Reporting Form (AVRF) must also be submitted once per calendar year and at least 24 hours prior to a vessel’s first arrival at a California port through a web-based platform.

Also, at the 76th MEPC session, held in June 2021, IMO adopted amendments to the International Convention on the Control of Harmful Anti-fouling Systems in Ships (AFS Convention) regarding controls on cybutryne and the form of the International Anti-fouling System Certificate. The amendments will enter into force on 1 January 2023. From this date, the application or re-application of an AFS containing cybutryne will not be permitted.

4. The biofouling problem

Marine fouling is the biological process of single celled organisms, algae, and hard-shelled organisms, attaching to submerged surfaces and colonising at a rapid rate.There are approximately 5,000 different fouling species that are found in the world’s oceans. These can be classified into “Micro fouling” which comprises slime fouling, and “Macro fouling” which comprises weed fouling and animal fouling (hard, with a shell and soft, without a shell).

Any organisms anchored on the hull create increased drag (commonly referred to as added resistance) which significantly decreases hull performance. Hard (with a shell) animal fouling (calcareous fouling in Table 1) which includes molluscs, bryozoans, tubeworms, and barnacles cause the greatest penalty in terms of hydrodynamic drag when attached to a ship’s hull. A biofouled vessel must burn more fuel to attain the same speed through water when in active service, resulting in higher fuel costs for the ship operator. Therefore, the increase in fuel consumption due to the adverse effect of hard biofouling on hydrodynamic performance is one of the most significant financial penalties for the shipping industry to endure, as detailed in Table I.

Table I: Roughness and Fouling Penalties - Adapted from *Schultz (2007)*

Hull condition	Additional shaft power to sustain speed (%)
Freshly applied coating	0
Deteriorated coating or thin slime	9
Heavy slime	19
Small calcareous fouling or macroalgae	33
Medium calcareous fouling	52
Heavy calcareous fouling	84

In 2019, research commissioned by I-Tech AB quantified the true extent of the barnacle fouling problem across the global shipping fleet. I-Tech contracted independent marine coating consultants, Safinah Group to analyse underwater hull fouling condition on a sample of 249 ships which drydocked over a four-year period between 2015-2019. The sample included all major ship types covering a range of trading activity.

Barnacle (hard) fouling can only occur when a vessel is static for a few weeks in coastal waters. It was found that nearly every vessel surveyed had some degree of underwater hull hard fouling. On 44% of vessels surveyed, over 10% of the underwater hull surface was covered with hard fouling. Anything more than 10% coverage is deemed to cause an 'unacceptable' impact on vessel performance.

On many of the vessels surveyed, fouling levels were even worse; approximately 15% of vessels had between 10-20% of hard fouling coverage on the hull, 10% of vessels had 20-30% of hard fouling coverage and the remaining 10% of vessels had between 40-80% of hard fouling coverage.

Extrapolating from published data taken from *Schultz et al. (2011)*, this level of hard fouling could be responsible for at least 110 million tonnes of excess carbon emissions, and an additional US $6 billion spent on fuel per year for the global commercial fleet. The true figure is likely to be higher, as this is a conservative calculation based on relatively low fuel prices in 2019 and only assumes a 10% coverage of hard fouling.

Therefore, the significant extent of hard fouling found across this sample of vessels demonstrates the magnitude of unnecessary demand being placed on engines because of hard fouling, increasing fuel consumption and emissions, and exacerbating speed losses due to increased hydrodynamic drag. According to the study observations, the frequency of hard fouling was relatively higher on vessels with lower activity rates – confirming the link between idling and barnacle fouling risk. 45% of lower activity vessels surveyed suffered from hard fouling coverage of >10% compared to just 27% of higher activity vessels.

This data analysis was carried out before the COVID-19 pandemic therefore, I-Tech anticipates that since this study was conducted, the extent of barnacle fouling coverage across the global fleet will have increased significantly, particularly for the huge proportion of vessels that have laid idle.

Hard fouling on the hull is also extremely impactful on maintenance costs. Costs associated with hull cleaning services are factored into a ship operator's operating expenditures (OPEX) but as global biofouling risk increases, hull cleaning is likely to be required more frequently, in-creasing maintenance costs. Repeated cleaning of the hull can also remove layers of the antifouling coating, reducing its service life. Abrasive methods to remove hard fouling species, such as barnacles, are particularly damaging to the coating.

5. Quantifying the true extent of idling in the global fleet

An extensive, independent study undertaken by I-Tech and Marine Benchmark of global fleet data up to, and including, the year 2020 explored the issue of idling and resultant biofouling. The results gave novel insight into differences between sectors of the industry confirmed a large increase in vessel idling over the past decade.

Remarkably, no in-depth study has been previously conducted that quantifies the true level of idling in the global fleet or in specific vessel type segments of the global fleet. Many shipowners hold extensive statistics and knowledge on their own fleet's activity, with statistics on vessel performance and operating parameters such as average speed, fuel use, etc. Also, studies that examine idle capacity of different market segments used as an indicator for available capacity and future price developments can be found. But no current studies include the quantification of idling period length against water temperature and fouling pressure.

The Marine Benchmark web platform used for this study has capability for a full bottom-up AIS based fuel consumption calculation, globally and by countries EEZ (Exclusive Economic Zones). The database uses an online feed from IHS Markit including a feed from their AIS antennas and IMO vessel register. Its algorithms are run live 24/7 on its 18 servers performing global calculations of distance, speed, fuel consumption, cargo onboard, transport work and Energy Efficiency Operational Indicator (EEOI).

6. Defining "fouling idling"

Disputes often arise between the shipowner and coatings supplier since there remains to be no clear industry definition of idling, which is surprising as idling guarantees are based on this.

To complicate matters further, different coating suppliers may offer their own definition of idling and there is no clear industry standard on how idling is defined. The narrowest definition is a vessel on a defined spot without any movement. But what happens with very short trips or manoeuvring. If an idling guarantee stipulates a maximum period, some shipowners may make a short trip prior to the maximum period being exceeded with the intention to limit the idling time and thereby keeping the guarantee active.

For this idling study, the focus by I-Tech was to look at vessels where idling resulted in high fouling risk in particular. We refer to this as "fouling idling" as a distinct from "commercial idling".

Where the purpose of commercial idling is to measure the commercial activities and inactivity of vessels, the purpose of "fouling idling" is to define idling as a risk for operations due to the resultant biofouling.

For this definition, we link idling to water temperature and how long the vessel is "fouling idling" in an unbroken sequence. As such, "Fouling idling" is defined as any vessel that is idling for 14 days or more in waters of 15^{o}C or more.

Though all vessels are included in the database it is well known that some ship types, in general, have a trading pattern which can be regarded as idling, these types of vessels include tugboats, fishing boats, bunkering vessels and some type of ferries. These vessels are taken out of the analyses to give a more accurate result. Stationary times at yards were also not counted as fouling idling because the vessels are usually dry-docked and, in most cases, a long stay implies that the vessel will be re-coated with new antifouling coating. However, a vessel waiting to discharge of cargo or sitting stationary due to use as a floating storage may be commercially employed and active but is also idling when it comes to fouling exposure.

The following steps were used to filter the AIS data:

1. Vessels were divided into three segments depending on activity:
- **a.** Stationary - below 1 knot (at yard and outside yards)
- **b.** Manoeuvring - 1 to 6 knots
- **c.** Steaming - above 6 knots

3. To be defined as "fouling idling", the following intermediate activities are allowed:
- **a.** Up to 12 hours manoeuvring is allowed between 2 stationary activities
- **b.** Up to 6 hours steaming are allowed between 2 stationary activities

4. Exclude all yard calls since these vessels are going into drydock.

5. The distance between first and last AIS observation for each fouling idling period is calculated and a maximum distance of 100 nautical miles are allowed.

6. Sea water surface temperatures were divided into three groups: below 15°C (cold), 15°C to 25°C (medium) and above 25°C (warm).

7. The data was divided in number of vessels staying in fouling idling periods: above 14 days, above 30 days and above 45 days.

7. Key study findings

In-depth analysis of the global fleet patterns based on AIS data for all IMO-registered vessels of the global fleet, revealed a substantial increase in the numbers of idling vessels over the past decade.

- The total number of vessels idling has roughly doubled over the last decade.
- A high percentage of idling is occurring in water temperatures above 15°C.
- Many bulker vessels are idling even outside of peaks. The level of idling for this vessel type is regularly above 1000 vessels monthly.
- The number of idling tanker vessels has constantly increased since 2009, peaking at 1421 vessels in 2020.
- During the idling peak in 2020, nearly all idling container vessels were laid up in warm waters and almost half of all container vessels had long idling periods of more than 30 days.
- Cruise vessels at anchor for more than 14 days in 2020 increased from an average of 3% to between 20-30%.
- Depending on season, between 50% - 85% of idling is occurring in water temperatures of above 15^{o}C.
- During 2020, compared to previous years (2018-2019), the number of vessels idling for more than 14 days increased for most segments within the global fleet.

I-Tech found that ‘Fouling Idling’, as defined in the study, has increased constantly since 2009, with a starting point of 25.4% to a peak of 35.0% in May 2020. Given the growth of the fleet, this means that the absolute number of vessels idling in the global fleet has doubled between 2009-2020.

Significantly, the study also found that vessels are increasingly idling in so-called biofouling ´hotspots´, where water temperatures above 25°C. Vessels spending the majority of their time sailing in these regions are at acute risk of excessive hard fouling accumulation.

There was a clear peak in June 2020 with 99 container fleet vessels sitting idle in warm temperature waters, 96 vessels idling in medium temperature waters and 2 vessels idling in cold temperature waters giving a total number of 197 vessels being idle. Comparing this to June 2019 when there were only 22 vessels idling in warm temperature waters, 13 in medium temperature waters and 1 in cold temperature waters giving a total number of 36. This represents an increase of over 447% year-on-year.

The effects of the COVID-19 pandemic had an impact within the bulker fleet. There was an increase from 1,100 vessels being idle in the beginning of 2020 to over 1,500 in April 2020. The majority of vessels were idling in water warmer than 25^{o}C.

For the tanker fleet, idling was at its highest level in May 2020 since 2009, with 15.4% vessels sitting idle. A notable 84.2% of the idling activity happened in medium to warm waters with high risk of fouling. At the peak in May 2020, 1421 tanker vessels were idle for more than 14 days.

The cruise fleet results show an extreme picture. Comparing the time before the Covid break out with after, vessels at anchor for more than 14 days increased from an average of 3% to between 20-30%. In numbers, idling went from less than 10 vessels with long idling periods monthly, to over 60 vessels being laid up.

When looking at the proportion of the global fleet idling for 30 days or more the results were very interesting. For example, looking at the peak in 2015, 5,5% of all container vessels (10000 to 13499 TEU) were idling for more than 30 days, and at the 2020 peak, the number was close to 3%.

For Suezmax tanker vessels (130,000 to 199,900 DWT) idling was peaking to above 4% on regular occasions and during the peak in 2020, 8,5% of vessels were idling for over 30 days.
Capesize bulkers (120,000 to 349,900 dwt), are also part of this trend with several idling peaks between 2009-2020 where 2-4% of all vessels in this segment had idling periods of longer than 30 days.

8. What's the solution to increasing fouling idling and preparing for CII?

Selecting an antifouling technology mix that is suitable for the vessel type, activity, and trading patterns but that also offers an insurance of extended static protection against barnacle fouling during unexpected long idle periods is the best strategy for any ship owner. In combination with a vessel-optimal antifouling coating, ship operators would benefit from planning potential idling periods to take place away from the biofouling high-risk zones.

With unpredictable operations resulting in long periods of idling, it is also more important than ever to examine the idle period guarantees provided by coating manufacturers and identify what components can provide protection during extended idling periods. Apart from ship owners investigating idling guarantees, it has also become clear that there is a need for an industry definition of idling to clarify the meaning of guarantees and make it easier to choose the most suitable antifouling system for a vessel´s operation.

For most antifouling coatings, protection guarantees range between 14 and 21 idle days, with the majority of premium antifouling coatings offering up to 30 days idle guarantee. Some premium antifouling coatings offer idle guarantees over 30 days. However, under tough market conditions such as those encountered during the COVID-19 pandemic, the I-Tech/Marine Benchmark study has proven that it is not uncommon for a vessel to be idling for more than 30 days, and in some cases even longer than 45 days. It is therefore clear that owners and operators need to take into consideration that only the best idling protection guarantees are sufficient.

9. The importance of Selektope® post-2022

Taking future-proofing approach to antifouling coating selection, without any certainty of future trade, is exerting great pressure on the coating suppliers, prospering great innovation and new approaches with fouling prevention technology

For many antifouling coatings on the market, longer idling guarantees are made possible by the inclusion of the biocide, Selektope®. There is increasing demand for antifouling coatings that contain Selektope® from ship owners and operators reflecting the growing issue of increased idling and barnacle fouling.

Selektope® is a biocide that is currently used in Self-Polishing Copolymers coatings. It is not used in Foul Release coating types, yet. Selektope® binds to pigment and other particles in the paint system and is therefore continuously released in the same way as other active substances and components. This contributes to long-term performance as long as the paint remains on the hull. The compatibility between

Selektope® and the paint matrix in the marine coatings industry, ensures as slow and steady release secures the antifouling effect over time.

Selektope® has highly favourable antifouling properties at low concentrations (nano Molar). To obtain full protection against barnacle fouling, 0.1 - 0.3% w/w of Selektope® should be used in a wet paint formulation. Just 2 grams Selektope® is used per litre of paint, comparable to 500-700 grams of copper oxide used per litre of paint for barnacle prevention.

Selektope®'s mode of action is completely unique. Barnacles attach to surfaces when in their cyprid larva stage but if a larva comes into contact with a coating containing Selektope, the active agent interacts with the larva's neurological system temporarily stimulating a receptor (the Octopamine receptor), causing a hyperactive swimming behaviour. This makes it impossible for the larvae to attach to the surface. Once out of contact with the Selektope® being leached from the coating, the effect ceases, and the larvae can swim away unharmed to settle elsewhere.

10. Conclusion

Cutting carbon emissions will be an unavoidable necessity post 2023, and ship operators are likely to use various fouling control solutions in their efforts to achieve greater efficiencies.

Most importantly, when it comes to biofouling management, they must ensure that, should any idling take place, the vessel hull remains to be in good condition to perform optimally with no increased emissions. Familiarisation with the individual vessel's risks of biofouling based on its operating footprint is an essential starting point.

When looking at the future trading potential, ship operators need to ensure that their ship is protected, whether it is in constant active service, idle for long periods of time, or at risk of fluctuating between the two. Selektope® takes the role of providing an insurance policy when contained within marine coatings that enables this flexibility due to its ability to prohibit barnacle fouling, even during extended static periods in warm waters.

References

SCHULTZ, M.P. (2007), *Effects of coating roughness and biofouling on ship resistance and powering*, Biofouling 23(5), pp.331-341

SCHULTZ, M.P.; BENDICK, J.A.; HOLM, E.R.; HERTEL, W.M. (2011), *Economic impact of biofouling on a naval surface ship*, Biofouling 27(1), pp.87-98