How much could barnacle biofouling limit shipping´s decarbonisation?

A WHITE PAPER BY I-TECH AB, DEVELOPERS OF SELEKTOPE®
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Introduction

I-Tech commissioned independent marine coatings advisors, the Safinah Group to gain insights into the condition of ship hulls upon arrival in dry-dock following time in service.

The extensive research study included the analysis of data from 685 vessel hull inspections conducted by Safinah between 2015 and late-2024.

The sample group comprised most vessel types, with a range of trading activity levels. While vessels within the group spanned from a few years old to 35 years old, most vessels in the group were under ten years of age The data analysis conducted also included ships with Selektope antifouling coatings.

The goal of this research study was to gain knowledge about coating performance and challenges, specifically regarding barnacle fouling.

This study updates a 2020 study published by I-Tech wherein data from 249 vessel inspections were independently analysed by Safinah Group to quantify the scale of barnacle fouling on the global shipping fleet.

Click here to download the 2020 study.

Hull condition data from the inspection of 685 ships was independently analysed.

For the majority of vessel types in the global fleet

Most vessels inspected were >10 years of age.

The majority of vessels had biocidal coatings, and the minority had biocide-free coatings.

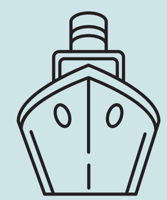
Key findings

Nearly every vessel inspected had some degree of barnacle biofouling present on the underwater hull.

>1/5 of ships inspected had >20% barnacle biofouling coverage on their hull.

>1/3 of ships inspected had >10% barnacle biofouling coverage on their hull.

>110million tonnes of excess carbon emissions can result from just 10% hard biofouling coverage on a ship hull.



90%

Almost 90% of tankers inspected had barnacle biofouling.

Only 140 vessels had less than 0.1% barnacle biofouling coverage on their hull.

INTRODUCTION

What is biofouling?

Ships spend their working lives sailing through, or sitting in, a watery soup of aquatic micro and macro-organisms. The composition of the watery soup varies from area to area, determined by several varying factors including light levels, water temperature and pH.

Biofouling: a quick introduction

Soon after a vessel enters the water, a natural process occurs whereby micro-organisms in the water form a biofilm. After around one week, spores and protozoa, and larvae of macrofouling species attach to the hull. Over the course of a few weeks, larger macrofouling species anchor to the surface and grow. This process is called biofouling.

In the 2023 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) , the International Maritime Organization (IMO) defines biofouling as:

"the accumulation of aquatic organisms such as microorganisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment."

They also state that "Biofouling can include pathogens."

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).

In the 2023 Biofouling Guidelines, the IMO defines microfouling as:

"…biofouling caused by bacteria, fungi, microalgae, protozoans and other microscopic organisms that creates a biofilm also called a slime layer."

..and macrofouling as:

"…biofouling caused by the attachment and subsequent growth of visible plants and animals on structures and ships exposed to water. Macrofouling is large, distinct multicellular individual or colonial organisms visible to the human eye such as barnacles, tubeworms, mussels, fronds/filaments of algae, bryozoans, sea squirts and other large attached, encrusting or mobile organisms."

Any organisms anchored on a ship's hull create increased hydrodynamic drag (added frictional resistance) which significantly decreases vessel performance.

Hard animal fouling, for example calcareous biofouling organisms such as barnacles, molluscs, bryozoans and tubeworms cause the greatest added resistance penalty in terms of hydrodynamic drag.

Rapid biofilm formation

The initial stage of biofouling, biofilm formation, can occur within minutes of a surface being submerged.

Biofouling process

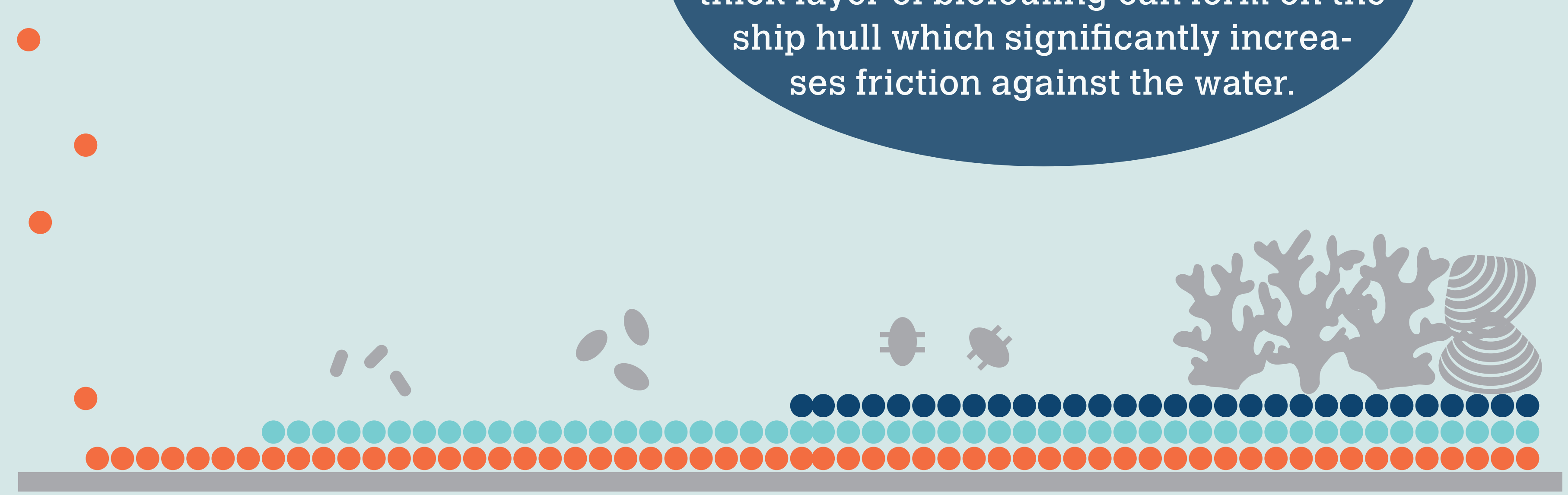
The biofilm alters the surface texture and chemistry, making it more hospitable for larger organisms like barnacles and mussels to colonise

Barnacle adhesion

Barnacles produce a cement-like substance that hardens upon contact with water, forming a durable bond with the ship hull.

Biofouling can occur at any time. Barnacle fouling in particular becomes much more of a problem when vessels spend long periods either idling or sailing at lower speeds. Ships exposed to longer periods at anchor waiting for cargo or access to port face a larger risk of biofouling. The scale and extent of marine fouling depends on the temperature of the water and the availability of light and nutrition. Biofouling takes place significantly faster in warm, tropical waters.

Marine biofouling is a biological process which immediately affects every surface submerged in sea water. Over time, a thick layer of biofouling can form on the ship hull which significantly increases friction against the water.



BACKGROUND

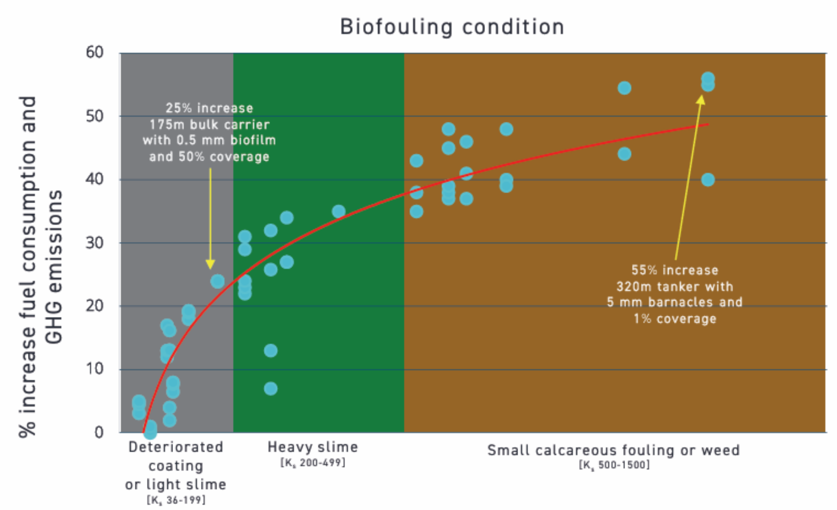
How do barnacles impact decarbonisation progress?

Marine biofouling is not good news for ship operators navigating strict global rules around GHG emissions reduction. The 2023 IMO GHG Strategy, enforced by the UN Body responsible for regulating the maritime industry, the International Maritime Organization (IMO), requires ship operators meet a CO_2-per transport work reduction target of 40% by 2030, and a net zero GHG target by, or around, 2050. Tighter restrictions are also coming into force around biofouling management and biosafety.

The impact of biofouling on ship fuel consumption

In the *'Analyzing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures'* report published by the IMO Initiative, GloFouling in 2022, a statement in the opening introduction to the report reads:

"One of the most significant factors impacting the efficiency of all ships in service is associated with the resistance generated by the friction of water on the ship's hull. Resistance increases when the hull is fouled. Therefore, maintaining a smooth and clean hull free from biofouling is of paramount importance to optimise the energy efficiency of ships."



Impact of ship hull fouling on GHG emissions.

Source: GEF-UNDP-IMO GloFouling Partnerships Project and GIA for Marine Biosafety, 2022, Analysing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures. (2022)

36%

A vessel with 10% barnacle coverage would need a 36% shaft power increase to maintain the same speed.

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

*Roughness and fouling penalties for a navy vessel - adapted from Schultz for specific conditions in this paper (2007) ***

198 million tons-

of CO_2 could be saved each year if the entire global fleet was sailing with smooth, biofouling free hulls.*

A 2022 study conducted by Geoffrey Swain and multiple other experts in the field of marine biofouling calculated that if the underwater portion of all the world shipping fleet could be maintained in a smooth and fouling free condition, then the reduction in CO_2 and other exhaust gasses would be significant. In this study, the estimated hull condition from Munk et al., 2009 was used to quantify the reduction in CO_2 emissions if all vessels were maintained in a smooth and fouling free condition:

"1,056 million tons/year (an IMO estimate for CO_2e emissions from ships from the 4th Greenhouse Gas study) × 0.7 friction resistance (assuming the average contribution of power from frictional resistance to move a ship is 70%) × [(33% ships with a 10% penalty) + (50% ships with 30% penalty) + (17% ships with 50% penalty)]
= 198 million tons of CO_2e or 19% per year reduction of ship emissions."

19%

reduction in ship emissions could be acheived per year if all vessels sailed biofouling-free.*

A hull suffering from heavy biofouling is also extremely impactful on maintenance costs. Costs associated with hull cleaning services must be factored into a ship operator's operating expenditure (OPEX). Repeated cleaning of the hull can also remove layers of the antifouling coating thickness, reducing its service life.

In addition, growing regulatory focus on the transportation of invasive aquatic species by the international shipping fleet can also impact a ship commercially. Some regional regulations are already in force that allow ports to refuse entry of heavily bio-fouled ships, resulting in greater financial costs for the operator.

As the maritime industry moves towards using cleaner, greener, less carbon intensive fuel options, the cost of fuel per metric ton will only increase. Therefore, increased fuel consumption resulting from biofouling accumulation will incur a more expensive cost penalty than today in a not-so-distant future.

**Munk, T., Kane, D., and Yebra, D. M. (2009). "The effects of corrosion and fouling on the performance of ocean-going vessels," in Advances in Marine Antifouling Coatings and Technologies.*
***Schultz, M. P. (2007). Effects of coating roughness and biofouling on ship resistance and powering. Biofouling 23, 331–341.*

BACKGROUND

The nature of barnacle fouling

The biofouling success of barnacles is attributable to their adhesion to the hull surface. Barnacle larvae release an oily droplet to clear water from surfaces before sticking down using a phosphoprotein adhesive. This two-component system ensures that the glue can adhere even in the challenging conditions of the ocean, where dissolved ions, varying pH levels, and constant wetness would typically hinder adhesion.

Barnacles attach using a super-glue

The strength of this glue-like substance is such that mechanical forces are required to dislodge attached barnacles. In the first week after settling, barnacles constantly release "barnacle" glue to bond to the surface. At this stage, the barnacles can be removed by hull cleaning without damaging the coating. However, the older and larger a barnacle becomes, the more difficult it will be to remove from the hull without damaging the coating.

Once one barnacle larva attaches to the hull and progresses from cyprid larvae, to juvenile and into its adult life stage, it does not take long for a whole colony of barnacles to follow.

When colonised on the hull surface, hard macro-organisms create the greatest added frictional resistance. This type of biofouling, and the glue they use to stick themselves to surfaces, also introduces complexities for hull grooming practices. For example, even when cleaning methods that can remove hard fouling are used, the base plates of barnacles and their colonies can remain on the hull.

However, avoiding barnacles isn't an easy task.

As a rule of thumb, barnacle larvae attach to a ship hull when it is stationary. Since most barnacle species prefer shallow or tidal zones, with 75% of them residing at depths of less than 100 metres, ships sailing in the open ocean or seas are at a lower risk. This means that barnacle fouling risk increases significantly within coastal areas, and if a ship is spending time at anchor, or at very low speeds, typically below 6 knots.

20,000

Adult barnacle can release anywhere from 10,000 to 20,000 nauplius larvae. During their planktonic, swimming phase, barnacle nauplii and cyprid larvae can survive for several weeks in the water column.

50%-85%

of vessel idling occurs in water temperatures of above 15°C.

1 week

Within only one week of sitting idle, or moving at low speeds under 6kts, a ship hull will be colonised by spores, protozoa and larvae of macrofouling organisms such as barnacles.

Idling ships are at highest risk from barnacles

A study published by I-Tech and Marine Benchmark in 2022 presented the results from an examination of idling and barnacle biofouling using in-depth analysis of the global fleet patterns from AIS data for all IMO-registered vessels in the global fleet.

This research revealed that the total number of vessels idling has roughly doubled over the decade 2010-2020 and that depending on season, between 50%-85% of vessel idling is occurring in water temperatures of above 15°C.

I-Tech found that 'Fouling Idling', as defined in the study as 'any vessel that is idling for 14 days or more in waters of 15°C or more', had increased constantly since 2009, with a starting point of 25.4% to a peak of 35.0% in May 2020 in the global fleet.

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

The conclusion of this study was that antifouling coating products that can offer extended static protection from both soft (slimes) and hard (barnacles) fouling are essential for the adequate protection of the global shipping fleet from biofouling.

Click here to download the 'Managing Biofouling in Shipping - The Idling Challenge' study.

RESEARCH DATA

Just how big of a problem is barnacle biofouling?

In January 2025, I-Tech contracted marine coatings consultants, the Safinah Group to independently analyse a dataset comprising hull condition data from 685 vessel inspections they had undertaken over a nine year period between 2015-2024.

Before we get into the data

There are certain limitations related to the data analysis that should be taken into account when interpreting the results and conclusions of this study:

- Certain ship types are better represented in the data, for example, tankers.
- In-water cleaning frequency is not taken into account in this research study,
- The age of the ships comprising the sample is relatively low. That may have an impact on the choices regarding surface preparation and coating selection.
- Commercial product names or any identifiers linked to the inspected ships have not been disclosed.However, it can be assumed at the majority of vessels inspected had biocidal anitfouling coatings on the underwater hull. This is reflective of the current market status wherein the majority of vessels in the global fleet use biocidal self-polishing coatings and foul release coatings with biocides, versus a minority using non-biocidal coatings.

In this research study, observations of animal fouling are used as a method to quantify barnacle fouling coverage. Safinah confirms that while the term 'animal fouling' is used for the purposes of this study, animal fouling presence on vessel hulls is pre-dominantly barnacle related.

Furthermore, the dry dock reports with inspection data used in the analysis do not provide details as to a vessel's activity and/or static periods. Extended static periods are known to be particularly challenging for any antifouling coating type.

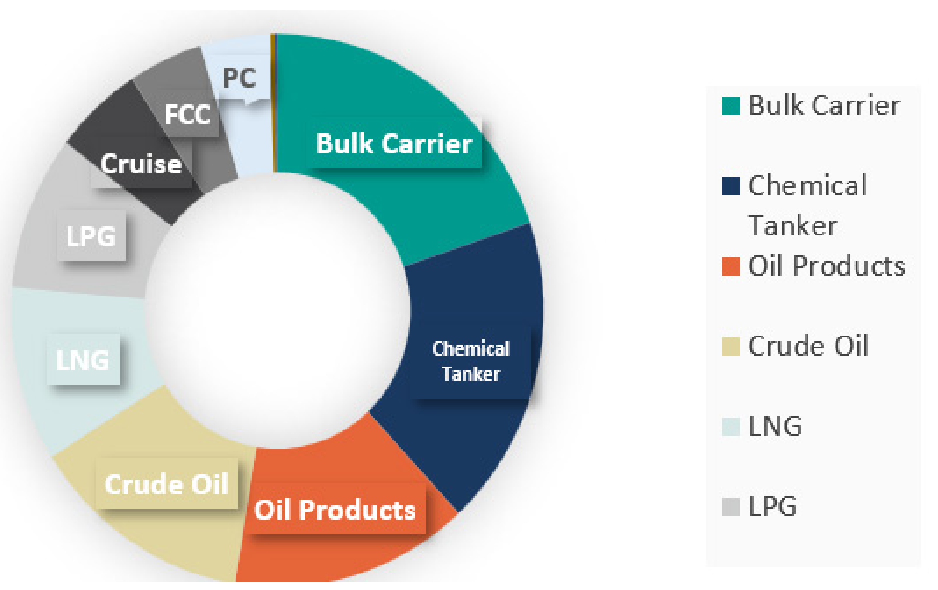
This research study updates the orginal research study published in 2020 by I-Tech wherein data from 249 vessel inspections were independently analysed by Safinah to quantify the scale of barnacle fouling on the global shipping fleet.

Click here to download the 2020 study

The data source

The data used in the research is based on historical drydock attendance reports / inspections conducted by Safinah during the period 2015 – 2024. This dataset comprised data from 685 individual vessel inspections undertaken from 836 hull-related drydock projects managed and conducted by Safinah in that time period.

Types of vessels inspected and the age profile

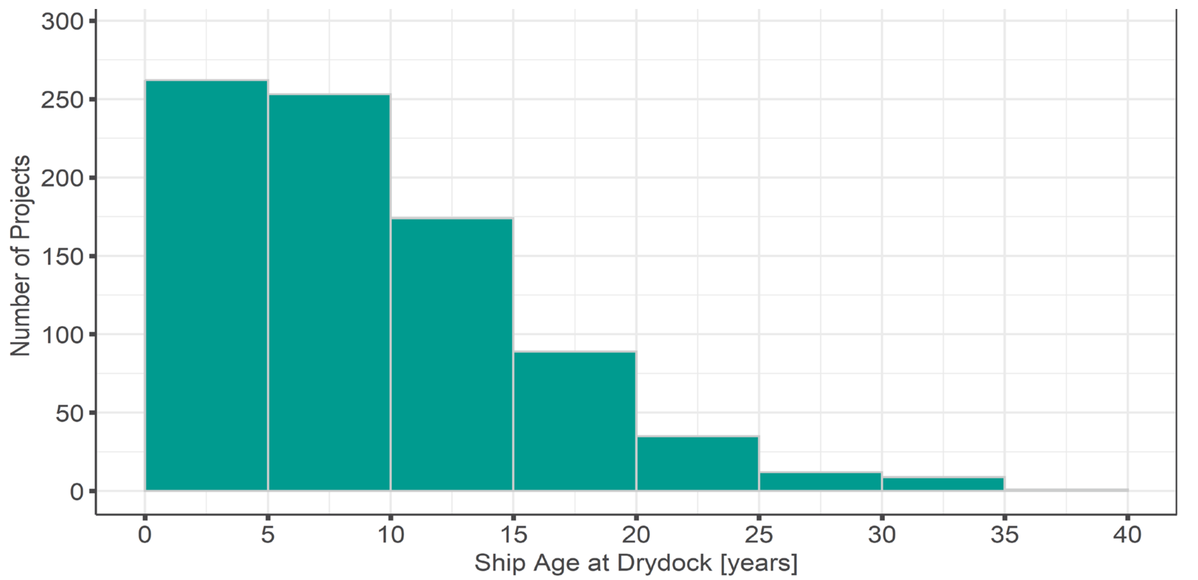


Vessel types inspected in dry dock by Safinah Group between 2015 - 2024.

Of the 836 hull-related drydock projects completed by Safinah during which vessel condition inspections were undertaken, the majority of vessels were younger than 10 years old.

- 260 drydock projects were conducted for vessels that were 0–5-years-old
- 250 drydock projects were conducted for vessels that were 5–10-years-old.
- <100 drydock projects were conducted for vessels that were over 15 years old.
- <50 drydock projects were conducted for vessels that were aged 20 years and over.

The young age of the sample group, and the fact that the owners of these vessels have invested in independent coatings consultancy services to inspect hull condition may indicate that investments in coating selection and other energy efficiency improvements were greater for this sample group.

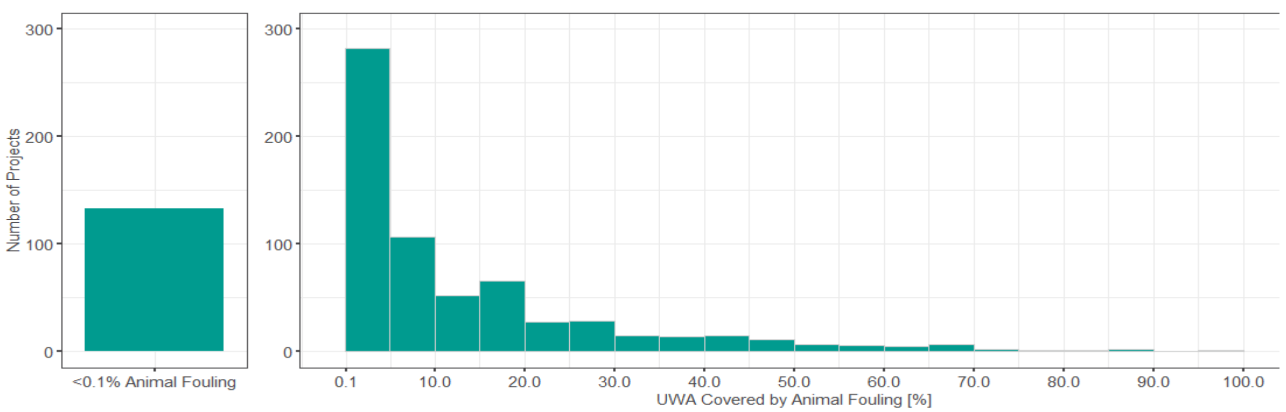


Vessel age when inspected in dry dock by Safinah Group between 2015 - 2024.

What were the key findings for barnacle biofouling presence on ship hulls?

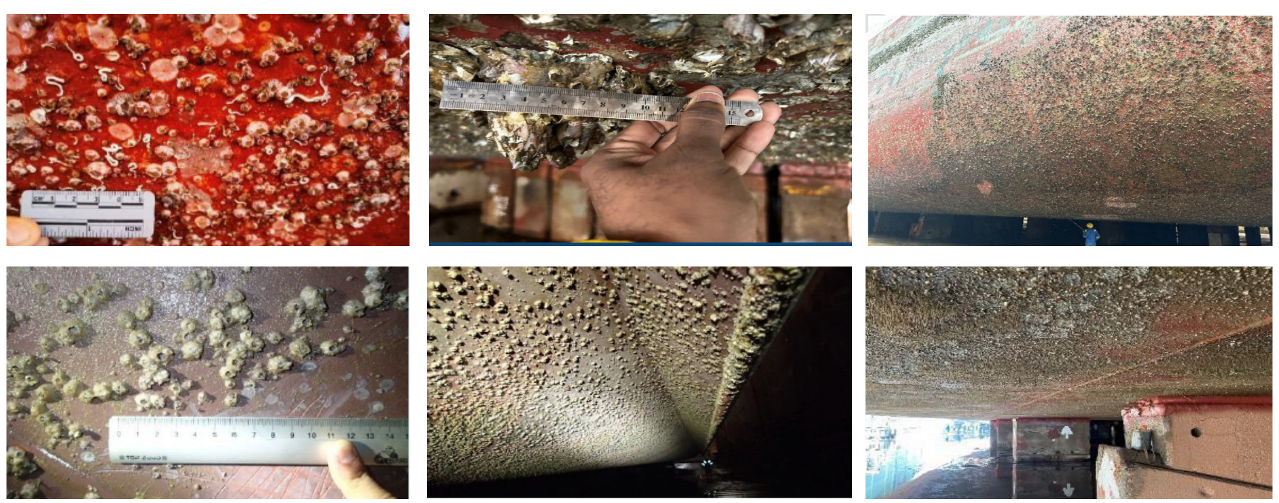
The analysis of hull condition data for 685 vessels inspected in dry dock confirmed that over one third of vessels sailed into dry dock with barnacles covering more than 10% of their hull surface. More alarmingly, more than one fifth of vessels inspected were found to have over 20% barnacle coverage on the underwater hull. In comparison, just 140 vessels in the 685-vessel group arrived into dry dock with less than 0.1% barnacle biofouling coverage.

The sample group comprised most vessel types, with a range of trading activity levels. Although barnacle fouling was found on all vessel types, it was more prevalent on tankers and less prevalent on certain other ship types. For example, nearly 90% of tankers inspected had barnacle fouling present on their underwater hull with varying intensity, compared to around 70% of pure car carriers and container ships inspected. From the data analysed, it was also clear that lower activity vessels are at greater risk from barnacle fouling and that barnacle fouling was more common on the flat bottom area of the hull.

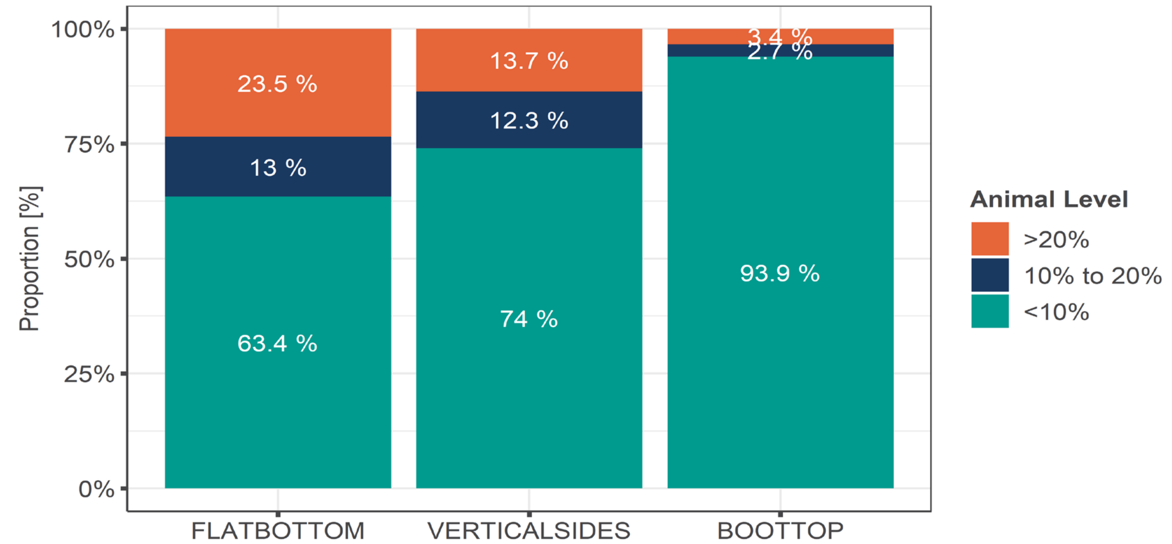


Percentage animal fouling coverage on the underwater hull (predominantly barnacle) of vessels inspected

What did the barnacle biofouling look like?

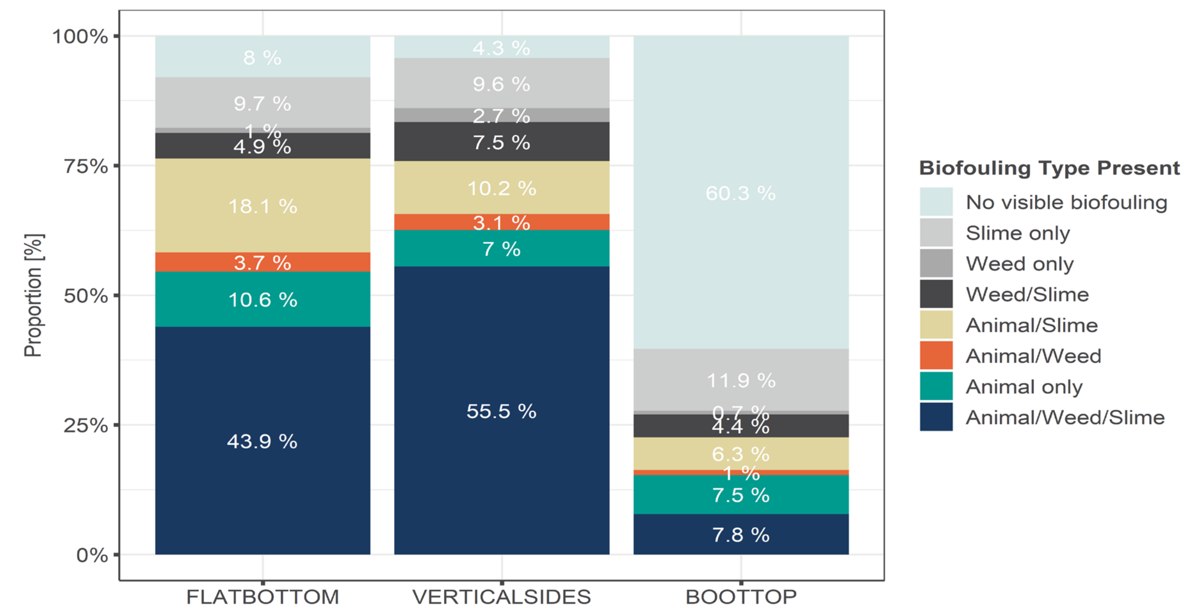


Are there particular areas of the ship hull where barnacle biofouling was greater?



Animal fouling levels by main hull area

What were the common biofouling combinations by hull area?



Biofouling type combinations by main underwater hull area

This graph shows that animal/weed and slime were the most encountered fouling condition on the flat bottom and vertical sides logged for the 685 vessels inspected. Whilst animal fouling, with or without other fouling types, is present on the majority of vessels inspected for vertical sides and flat bottom, animal fouling is more prevalent on the flat bottom hull area.

**animal fouling*

RESEARCH FINDINGS

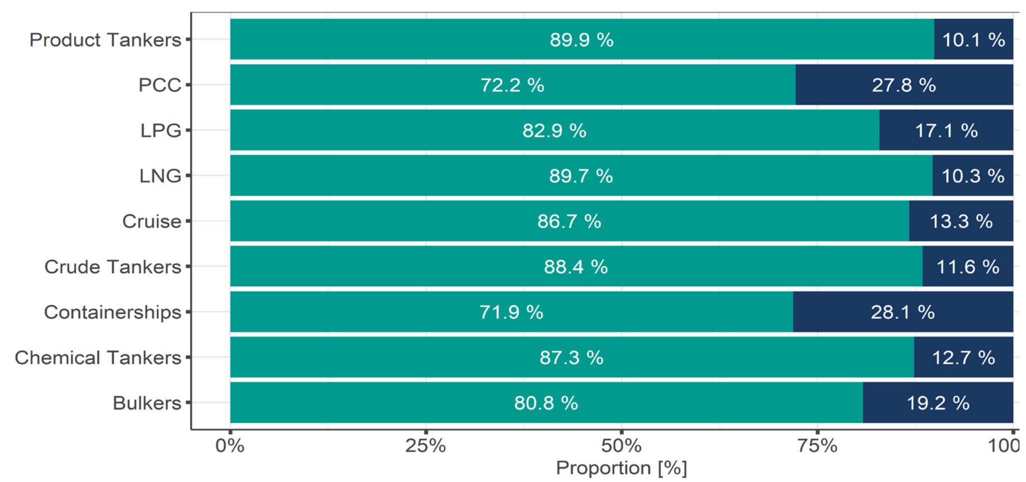
Are certain ship types more at risk from barnacle biofouling than others?

To understand the barnacle biofouling challenge better, the research study took a deep dive into the occurance of animal fouling (mainly barnacles) on different vessel types. The aim was to identify the vessel types which suffer most or least/are at the highest or lowest risk from barnacle fouling.

The analysed inspection data showed that all vessel types had some level of animal fouling presence on the hull when inspected. However, there were certain vessel types that had more animal fouling than others.

- The vessel type with the highest proportion of animal fouling was tankers (product, chemical, crude, LNG, and LPG).
- The vessel types with the lowest proportion of animal fouling were containerships, closely followed by Pure Car Carriers (PCC).

Large variations in animal fouling between vessel types can be attributable to a certain degree to different root causes, different paint systems, speed, activity and where the vessels sail (geographically).

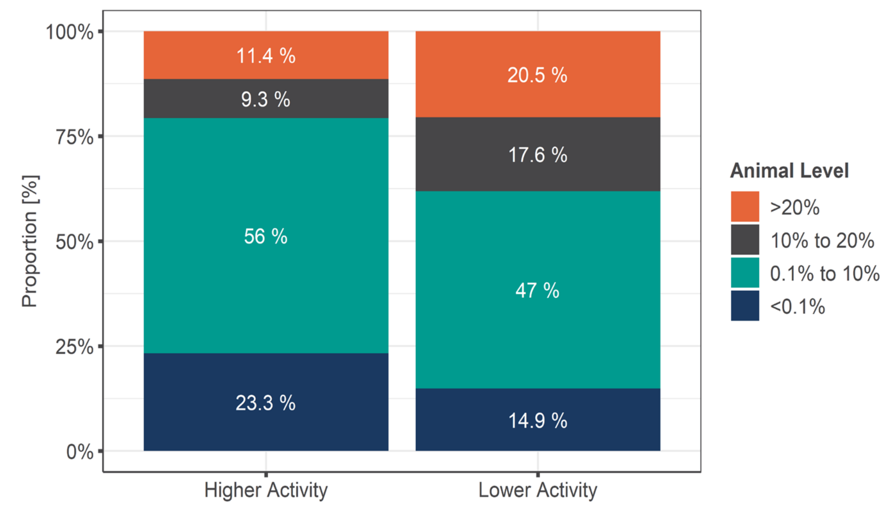


Animal fouling presence by ship type

Does vessel activity level influence barnacle biofouling risk?

A further split of the data was made to assess barnacle fouling by relative activity of the vessel types. The split of vessel types by higher activity level and low activity level is shown below. While the actual activities of the vessels in the dataset were unknown, the vessels were grouped by relative vessel activity based on typical industry assumptions in this table.

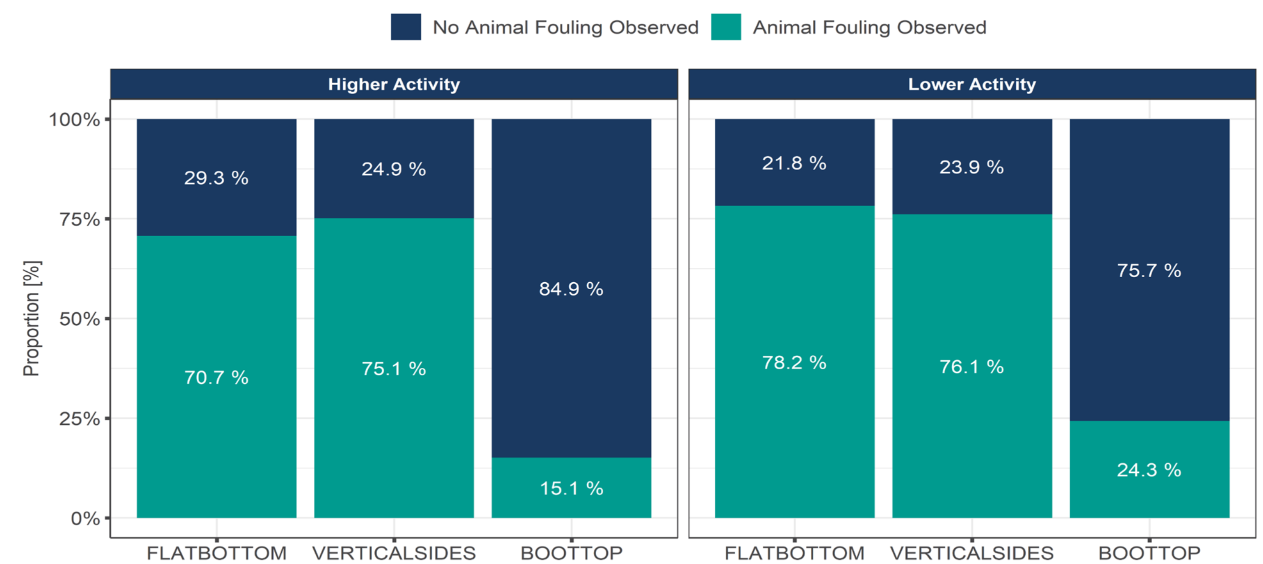
Relatively lower activity vessels	Relatively higher activity vessels
Chemical / Product Tanker	Car Carrier
Crude Oil Tanker (up to 80k DWT)	Crude Oil Tanker (up to >80k DWT)
LPG	Container
Oil Products Tanker	Cruise Ship
	Ferry
	LNG



Animal fouling proportion (%) – higher activity vessels versus lower activity vessels

This data shows us that higher levels of animal fouling are more prevalent on lower activity vessels (20.5% on lower activity vessels versus 11.4% on higher activity vessels). Also, we can conclude from the data that larger proportions of the relatively lower activity vessels arrive in drydock with more than 10% of the hull area covered in animal fouling.

Which areas of the hull have most barnacle biofouling on higher versus lower activity vessels?



Animal fouling presence by undewater hull area type, higher activity vessels versus lower activity vessels.

The inspection data shows that animal fouling coverage is significantly greater across the flat bottom of both higher and lower activity vessels compared to the boottop. In lower activity vessels, animal fouling is more prevalent on the flat bottom than on higher activity vessels. However, animal fouling on the vertical sides of both lower activity and higher activity vessels is relatively similar.

BACKGROUND

The important role of antifouling coatings

Antifouling coatings act as the first line of defence against micro and macro biofouling organisms. They prolong the life of marine vessels and reduce GHG emissions by keeping the hull surface smooth and with minimal frictional resistance. Careful selection of an antifouling coating product for a ship is essential to ensure it meets the requirements of the ship in terms of its trade routes, activity levels and potential biofouling risk encountered during the coating's service lifetime, which could be up to 60 months.

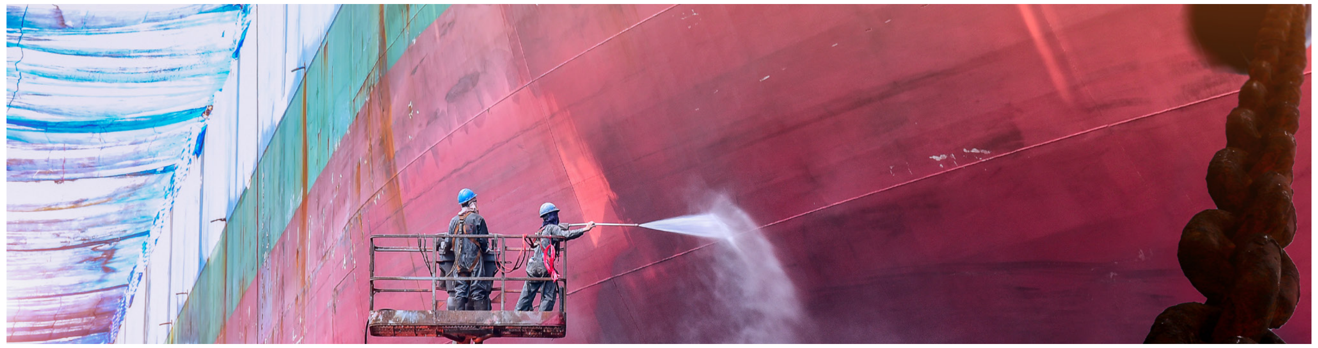
Choosing the right coating

There are essentially two main types of fouling control technology for commercial vessels, foul release coatings (with or without biocides) and biocidal antifouling coatings.

A traditional, self-polishing antifouling coating comprises a soluble, or partially soluble, resin system that contains a mixture of biocide(s) effective against a broad range of fouling organisms. They are the most widely used technology for fouling control and account for approximately 90% of the fouling control technology market. These types of antifouling coatings primarily differ by the resin system used, also referred to as 'delivery mechanism', and the level and type of biocides used. The two main types of biocidal antifouling resins are: Controlled Depletion Polymers (CDPs) and Self-Polishing Copolymers (SPCs).

Foul release coatings typically comprise low surface energy silicone polymers. The speed of the vessel produces the hydrodynamic shear needed for the loosely attached fouling to fall off. Some foul release antifouling coating products are biocide-free and some contain biocides.

There are also 'hard coatings' that are based on epoxy technology and are biocide free. These coatings are mainly used for ice-going vessels. They accumulate biofouling quickly but are designed to withstand regular in-water cleaning without damaging the integrity of the coating.



90% of the marine coatings market is so-called traditional antifouling products that use biocides in various combinations.

80% of the marine paint market demand is met by 6 of the largest suppliers in the world.

100m litres of antifouling coating products are used globally.

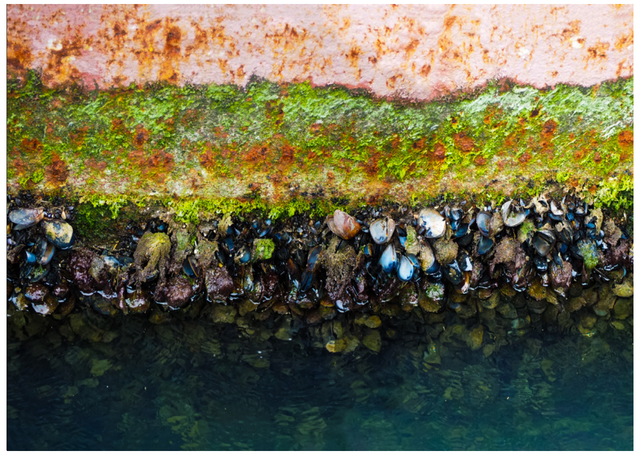
The need for antifouling biocides

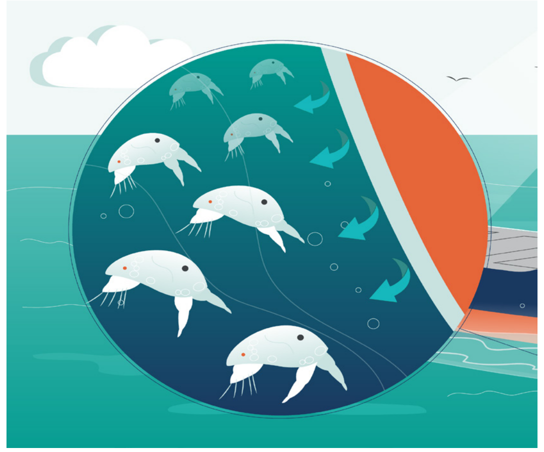
For centuries, materials or compounds that have an antifouling effect have been used for biofouling prevention on surfaces submerged in water.

Throughout this vast experience in using biocidal compounds, no other solutions have been proven as viable alternatives to meet increasingly tough requirements from the industry on i) application procedures, ii) long-term in-service life (up to 60 months) and iii) coating renewal processes, for the entirety of the global shipping fleet.

Biocidal products have been proven to be the one of the best solutions to meet the environmental and performance requirements for marine vessels operating in a highly competitive commercial environment where vessels sail in waters with varying biofouling risk.

To be effective across the entire range of biofouling micro- and microorganisms, a combination of biocides are generally used within an antifouling coating, referred to as co-biocides.





Today, there are a limited number of biocides that have passed evaluation and are approved for global use in marine coatings. Biocides are approved by the most stringent regulatory schemes in many global regions such as EU, UK, Turkey, Malaysia, South Korea, Japan, China, Australia, New Zealand, Canada, and the USA. The regulatory landscape for new biocidal substances is complex and this is certainly the case for biocidal substances intended for use in marine antifouling coatings. Biocides in use today have been tested, evaluated, and used for more than twenty years.

However, the biological complexity and the high industrial requirements for hull coatings present an increasingly complex challenge for this small, but highly impactful collection of certified biocides. According to data presented by Alistair Finnie at the 2023 International Antifouling Conference, in the listed antifouling coating products in the Lloyd's Register Antifouling Coating Type Approvals database as of August 2023, 10 biocides were used but with 45 different listed combinations.

AVOIDING BARNACLE FOULING

Selektope® and it's role in barnacle biofouling prevention

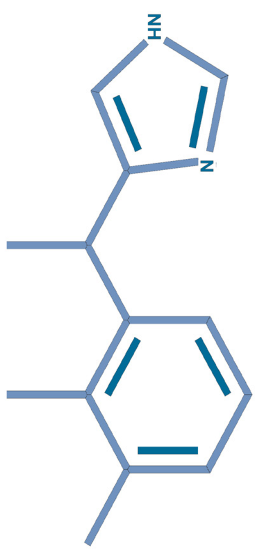
Improving static performance against barnacle fouling has been a focus for the sector given the severe impact that barnacle fouling has on increasing added resistance and GHG emissions.

The introduction of the biocide, Selektope to the market in 2015 has offered antifouling coatings manufacturers the ability to increase static performance guarantees for coating products.

As an organic, non-metal active agent, Selektope is relatively unique compared to traditional marine biocides. When exposed to Selektope, the swimming behaviour of a barnacle cyprid larva is activated through receptor stimulation, this disables their ability to settle on a surface. The effect of Selektope is temporary and has reversible effects. Any larvae that come into contact with Selektope can still metamorphose into juvenile barnacles with no apparent ill effect. When used in antifouling paints, Selektope can protect all ship types when they are idle or operating at low speeds for extended periods of time, even in extreme barnacle fouling risk areas.

Today, approximately 3,000 ships are sailing with coatings that contain Selektope. SPC antifouling coatings products that contain Selektope are sold by multiple coatings manufacturers.

In SPC biocidal coatings, Selektope binds to pigment and other particles and is continuously released in the same way as other biocides present. The compatibility between Selektope and the paint matrix in the marine coatings industry ensures slow and steady release to deliver the antifouling effect for the entire service life.

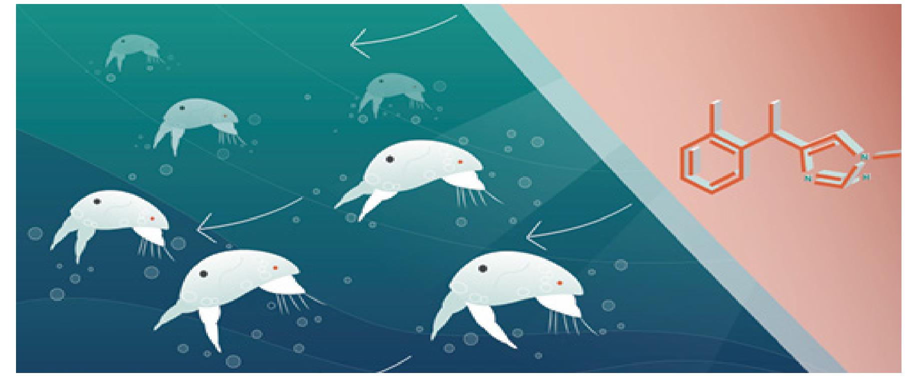


Selektope is a biocide that has highly favourable antifouling properties at low concentrations (nano Molar). To obtain full protection against barnacle fouling, 0.1 - 0.3% w/w of Selektope should be used in a wet paint formulation. That equates around 2 grams of Selektope per litre of paint when 0.1% w/w is used, comparable to 500-700 grams of cuprous oxide used per litre of paint.

Extensive R&D efforts are being undertaken by scientists at I-Tech to incorporate Selektope into foul release coatings (e.g. via attaching Selektope to a polymer chain) with successes achieve to-date.

With extended static exposure in combination with increasing water temperatures due to global warming, the task of keeping hulls clean during extended idling periods is more challenging than ever.

Hull cleaning activities are costly and impacts the coating lifetime negatively, particulary if cleaning methods are used for hard fouling removal. Selektope-containing products are offered by several leading paint manufacturers to raise extended static performance to the next level.



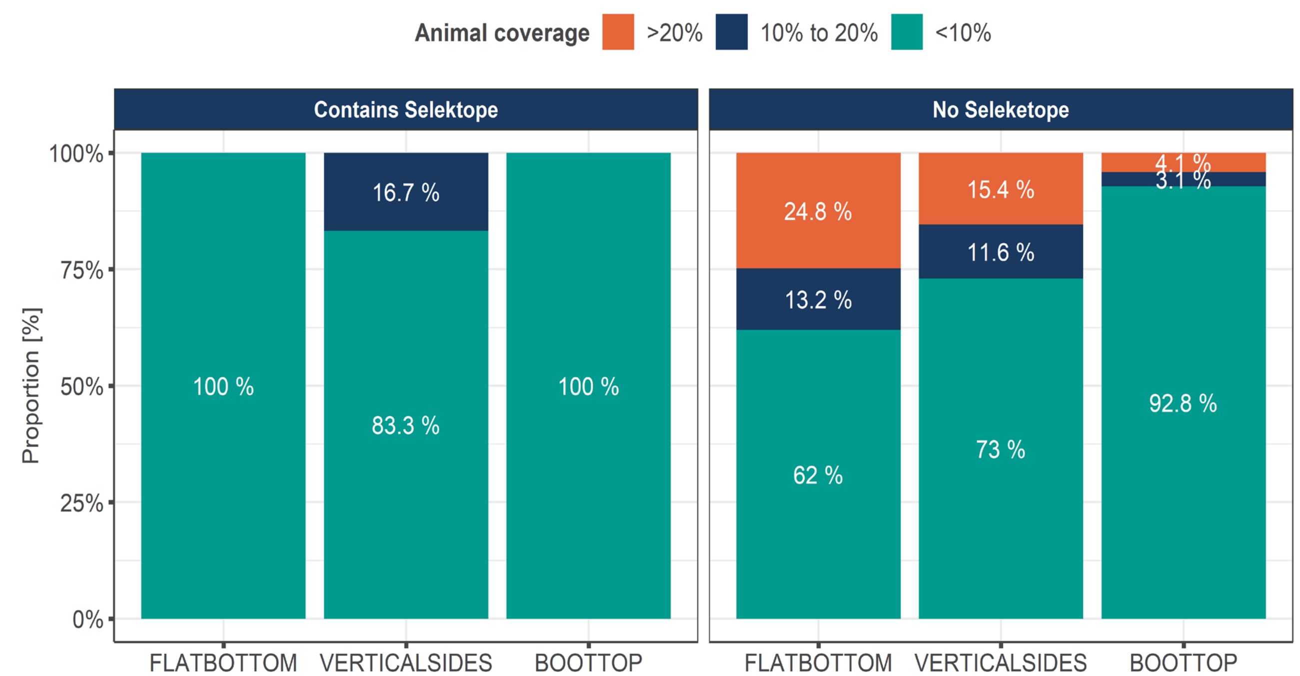
Selektope is an ingredient technology with a unique receptor-stimulating effect on the target organism, barnacle larvae. With Selektope inside the coating, it creates a temporary swimming behaviour in the barnacle larva without affecting it otherwise. Selektope´s precision in antifouling systems provides extended protection in ultra-low concentrations, even during static conditions in water with high biofouling pressure.

Selektope-containing coatings and their impact on preventing barnacle fouling

As part of the study, Safinah conducted an independent analysis of hull inspections carried out on a small sample of vessels with a Selektope-containing antifouling coating on the underwater hull.

A total of 12 ships were inspected. 11 ships had their full underwater hull coated with a Selektope-containing antifouling coating product, whereas 1 ship had only the vertical sides of their hull coated with a Selektope-containing antifouling coating. It should be noted that this is a small sample size and data on in-water cleaning events were not available. Therefore, the impact of in-water cleaning events is not factored into the analysis.

This data analysis confirmed that ships with coatings containing Selektope arrived in drydock with <10% animal fouling coverage on their hull in most cases (10 out of 12 ships inspected).



Animal fouling presence on vessels with Selektope-containing cotaings, versus vessels inspected with non-Selektope containing coatings.

CONCLUSION

This research study confirms that barnacle biofouling is a big burden for the shipping industry, with all vessel types at risk.

Barnacle fouling was found more on product tankers more than any other vessel type.

1/5 of inspections found >20% barnacle biofouling coverage on the underwater hull surface.

Barnacle fouling was found during most inspections ranging from <0.1% up to 90% coverage of the hull.

Barnacle fouling was found on container ships less than any other vessel type.

1/3 of inspections found >10% barnacle biofouling coverage on the undewater hull surface.

Lower activity vessels are at higher risk from barnacle biofouling.

CONCLUSION

From this study, the reality of barnacle biofouling burden on the global shipping fleet has been determined. The findings from the extensive, independent hull condition analysis across a large group of ships, of varying type and age, confirm that barnacle biofouling is an extremely common occurrence.

While this sample group is relatively small in comparison to the 55,000 merchant ships trading internationally, the high prevalence of barnacle biofouling found on this sample group of vessels gives indicative insight that should be of great concern to the industry considering the immense negative impact barnacle biofouling has on increasing vessel emissions.

Variations in barnacle biofouling between vessel types can be attributable to a certain degree to different root causes; different paint systems, speed, activity and route. However, the presence of more than 10% barnacle biofouling coverage can result in significant added resistance, with 36% more shaft power required to maintain the same speed through water. This has a significant negative impact on a vessel's fuel use and subsequent emissions to air.

Extrapolating from published data taken from a 2011 study by Michael P. Schultz1, this level of hard biofouling could be responsible for at least 110 million tonnes of excess carbon emissions per year, and an additional US $15 billion spend for the global commercial fleet. The true figure is likely to be higher, as this is a conservative calculation based on today's low sulphur fuel oil prices and only assumes a 10% coverage of hard biofouling.

Therefore, the significant extent of hard fouling found across this sample of group of 685 vessels in the research study demonstrates the magnitude of unnecessary demand being placed on engines because of barnacle biofouling, increasing fuel consumption and emissions, and exacerbating speed losses due to increased hydrodynamic drag.

From the conclusions drawn in this research study, I-Tech's advice for ship owners and/or operators includes using careful consideration of hard biofouling protection components during antifouling coating selection process. Ensuring adequate hard biofouling protection, for all vessels, but particularly those at risk of longer idling periods while in-service, is essential for the adequate protection of the global shipping fleet from barnacle biofouling.

Dr Markus Hoffmann, Technical Director of I-Tech concludes:

"The findings that more than one fifth of vessels in this study had more than 20% barnacle fouling coverage on the hull is concerning. This reinforces that antifouling coating systems with extended static performance, boosted by the presence of biocides that target hard fouling, even under super static conditions, are an absolute necessity if barnacle fouling is to be reduced to much lower levels on a global shipping fleet scale."