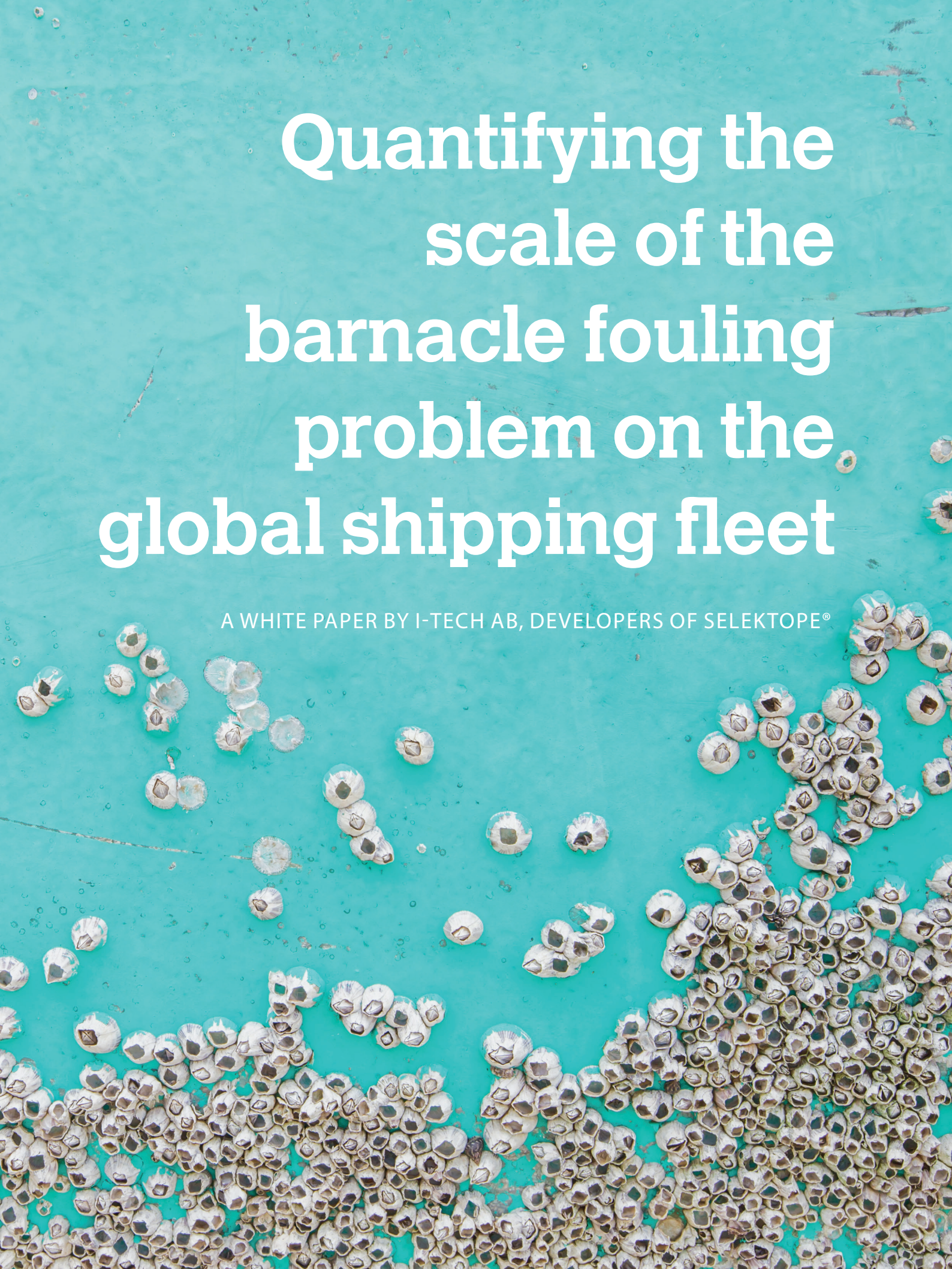
Quantifying the scale of the barnacle fouling problem on the global shipping fleet

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



This is I-Tech

The Technology: Selektope®

Selektope® is an organic, metal-free active agent added to marine antifouling paints to prevent barnacles from settling on coated surfaces by temporarily activating their swimming behaviour. This bio-repellent effect makes Selektope® the only type of technology of its kind available to marine paint manufacturers.

Barnacle fouling is very detrimental to ship fuel consumption, emissions and invasive aquatic species transfer. The use of antifouling paints containing Selektope® significantly reduces fuel consumption, which contributes to reducing harmful emissions. They also enable ship operators to unlock financial savings associated with hull cleaning costs.

Depending on the formulation, Selektope® can also help to reduce emissions to water by reducing biocide release by more than 90 percent compared to other antifouling paints, without negatively impacting the performance of the paint.

The Company: I-Tech AB

I-Tech is a global biotechnology company based on the west coast of Sweden.

Since 2006, I-Tech has successfully transformed the scientific invention of Selektope® into a commercially ready and available antifouling active agent which is supplied to marine coatings manufacturers for inclusion in antifouling products.

I-Tech is uniquely the first company to apply principles from biotechnology research in the paint industry to keep ship hulls free from marine fouling.

i-tech

selektope®

Key takeaways from this whitepaper

"Nearly every vessel surveyed had some degree of underwater hull hard fouling."

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.

44%

On 44% of vessels surveyed, over 10% of the underwater hull surface was significantly covered with hard fouling.

36%

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

Powered by selektope®

500

million USD

The market for Selektope® is valued at 500 MUSD.

3.0

billion USD

Turnover of the global antifouling paint industry.

>100

million tonnes CO_2

The savings potential corresponding to 0.3% of the global CO_2 emissions.

20

million USD

The fuel-savings potential connected to fouling on the hull.

INTRODUCTION

What is biofouling?

For as long as humans have traversed the world's oceans, ships' hulls have acted as magnets for marine life. The accumulation of marine organisms on submerged surfaces is called biofouling. Biofouling is a highly dynamic process and specific organisms that develop in a fouling community depend on the substratum, geographical location, the season and factors such as competition and predation. Therefore, where a ship sails, or sits idle, when, and for how long, all influence which type of biofouling will accumulate and how fast.

36%

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

20k

Each barnacle parent can release anywhere from 10,000 to 20,000 larvae, and they survive for several weeks in the water column.

Barnacle cyprid larva

Biofouling: a quick introduction

Biofouling is a complex process that often begins with the production of a biofilm. Within minutes of immersing any clean surface in water, organic and inorganic substances adhere to form what is known as a conditioning layer.

Micro-organisms such as bacteria and unicellular algae then colonise the surface to form the primary biofilm, commonly known as the 'slime' layer. If the growth of the slime layer progresses far enough, it can provide the foundation for the growth of 'macro-biofouling' organisms including seaweed, barnacles, and other hard-shelled organisms which use the biofilm like an incubator.

Macrofouling is commonly divided into two types: 'soft fouling' and 'hard fouling';

- Soft fouling comprises algae and invertebrates, such as soft corals, sponges, anemones, tunicates and hydroids.
- Hard fouling comprises hard-shelled invertebrates, most commonly barnacles, but also mussels and tubeworms. This type of biofouling is often referred to as 'animal fouling'.

While ship design has evolved over time, the issue of biofouling remains to be a significant problem for the maritime sector. Natural selection amongst fouling creatures has adapted them to thrive while adhered to wet surfaces.

Spotlight on barnacle fouling

Take barnacles, for example. Like other stationary marine invertebrates, barnacles begin their lives as highly mobile larvae. Each barnacle parent can release anywhere from 10,000 to 20,000 larvae, and they survive for several weeks in the water column.

In order to complete the transition to adult life, the 'cyprid' form of barnacle larvae must attach to a hard substrate. Therefore, these tiny, shell-less swimmers are on a mission to find their ideal habitat. The perfect, submerged, static surfaces presented by ship hulls are very attractive real estate.

The cyprid barnacle larvae explore the hull surface, walking around using a pair of attachment organs called 'antennules'. Once they find a suitable place to call their forever home, they attach themselves head-first by releasing a glue-like substance (called proteinaceous cement); only then can they develop into the sturdy, calcareous-shelled adult barnacles we all recognise.

The strength of this glue-like substance is such that mechanical forces are required

to remove barnacle fouling from ship hulls. Its strength is so admired that it has been subject to much scientific assessment and analysis. For barnacles, it means that once they are attached, only mechanical force can remove them, much to the detriment of the paint on the hull.

For barnacles, attracting more barnacles to mate with is important. Therefore, while exploring a surface, they leave behind blobs of temporary adhesive 'footprints'. The temporary adhesive operates as a signaling molecule to induce the settlement of additional barnacle larvae. Therefore, once a ship hull has some barnacle fouling, the problem will only get worse.

Why is barnacle fouling so bad?

For the barnacle glued to the hull, life is great; it now has its home established in a place where the constant flow of water will bring food directly to its door and it can start to consider starting a family. However, for the ship operator barnacle fouling presents a significant financial and operational burden.

Hard fouling significantly increases the amount of frictional resistance (hydrodynamic drag) across a ship's hull when it moves through the water. In fact, increased frictional resistance requires the ship to burn more fuel to maintain a set speed through the water. Alternatively, if a ship is required to conduct a voyage on fixed shaft power, or a fixed fuel consumption volume, speed losses will result.

A 2007-published study by Michael. P. Schultz proclaims that a vessel with 10% barnacle coverage would need a 36% shaft power increase to maintain the same speed. Although this particular study was based on a naval frigate, the statistics are relatable to cargo ships alike. Therefore, barnacles are creatures that you do not want to colonise the hull of your ship when profit margins are tight.

Barnacle coverage (%)	Additional shaft power to sustain speed at 15 kts (%)	Additional shaft power to sustain speed at 30 kts (%)
10	36	23
17	44	27
39	54	33
48	57	35
57	54	33
63	55	34
70	53	33
79	52	32
Light**	31	20
Medium**	47	30
Heavy**	76	47

*Adapted from Schultz et al (2011) ** values from Schultz et al (2011)

RESEARCH FINDINGS

How big is the global fleet's barnacle fouling problem?

In order to quantify just how significant the barnacle fouling issue is for 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 range of antifouling coating technologies included in the research were ships that were making use of both biocidal antifouling coatings (low, medium and high grade) and foul release coatings (medium grade (first generation) and high grade (latest generation and those that use biocides)).

The sample included all major ship types covering a range of trading activity. The 249 vessels examined were split by type.

"Since anything more than 10% coverage is deemed to be an 'unacceptable' level of coverage by experts, when considering the impact it will have on vessel performance, this is a significant problem for ship operators."

"Nearly every vessel surveyed had some degree of underwater hull hard fouling."

Vessel Type	Number of vessels	Percentage (%) split
Bulk Carrier	28	11
Car Carrier	15	6
Chemical / Product Tanker	78	31
Container	7	3
Crude Oil tanker	38	15
Cruise Ship	21	8
Ferry	1	0.4
LNG	17	7
LPG	33	13
Oil Products Tanker	11	4
Total	**249**	**100**

62%

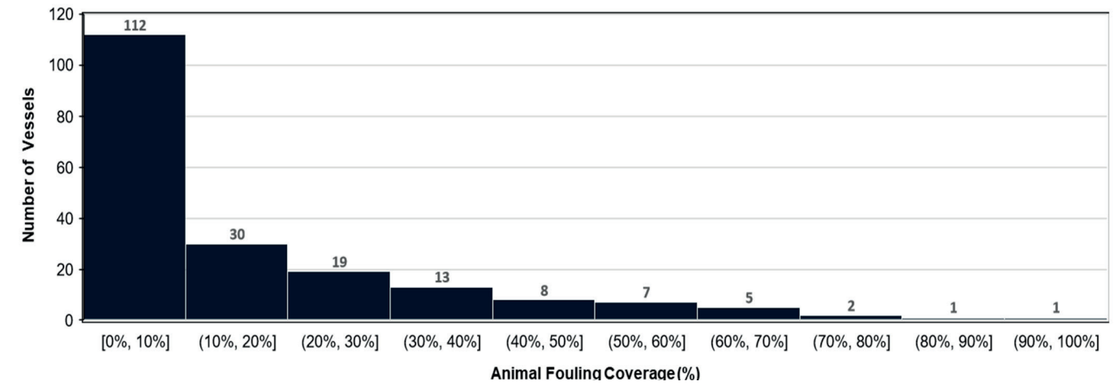
62% of vessels had barnacle fouling coverage on the hull of up to 1000m² on the underwater hull area

44%

On 44% of vessels surveyed, >10% of the underwater hull surface was significantly covered with hard fouling.

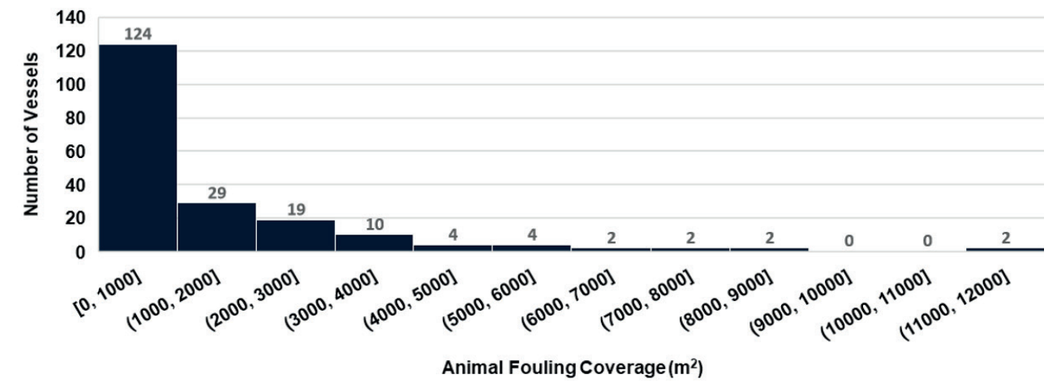
*Out of the 249 vessels inspected during drydock, the fouling condition of 198 could be accurately assessed.

Hard fouling coverage on the underwater hull area (%)



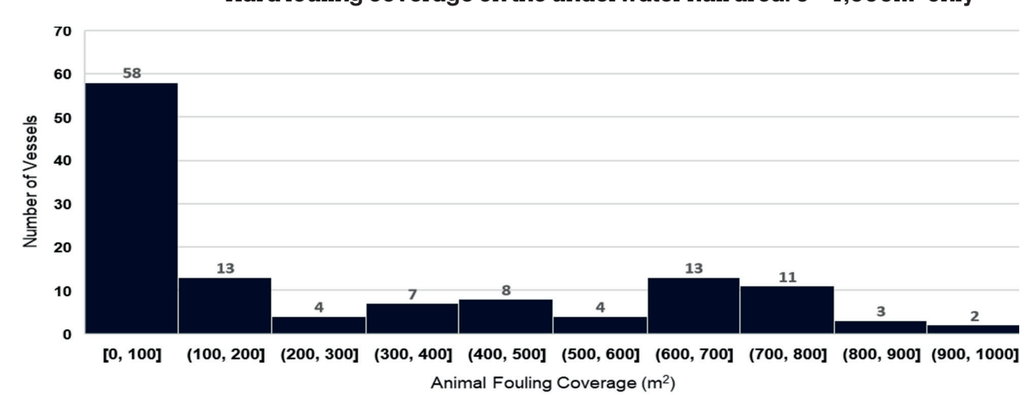
On 44% of vessels surveyed, over 10% of the underwater hull surface was significantly covered with hard fouling. On many vessels, fouling levels were even worse; approximately 15% of vessels had between 10-20% of hard fouling coverage on the hull, 10% of vessels had 20-30% of hard fouling coverage and the remaining 10% of vessels had between 40-80% of coverage. 1% of vessels had hard fouling coverage on the hull of between 80-100%.

Hard fouling coverage on the underwater hull area (m²)



When examining actual hull surface area (per m²) covered by hard fouling it was found that 62% of vessels had hard fouling coverage of up to 1000m². 30% of vessels surveyed had hard fouling coverage up to 4000m². The remaining vessels had hard fouling coverage of between 4,000 – 12,000m².

Hard fouling coverage on the underwater hull area: 0 – 1,000m² only



When taking a closer look at those vessels suffering with 0-1000m² hard fouling coverage, it was found that 53% of those vessels had hard fouling coverage of at least 100m² or more.

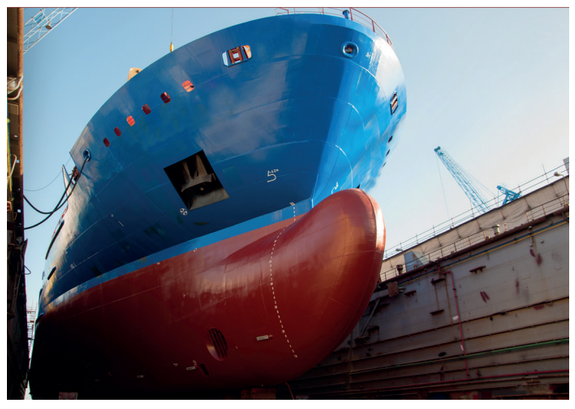
RESEARCH FINDINGS

Where is barnacle fouling most prevalent?

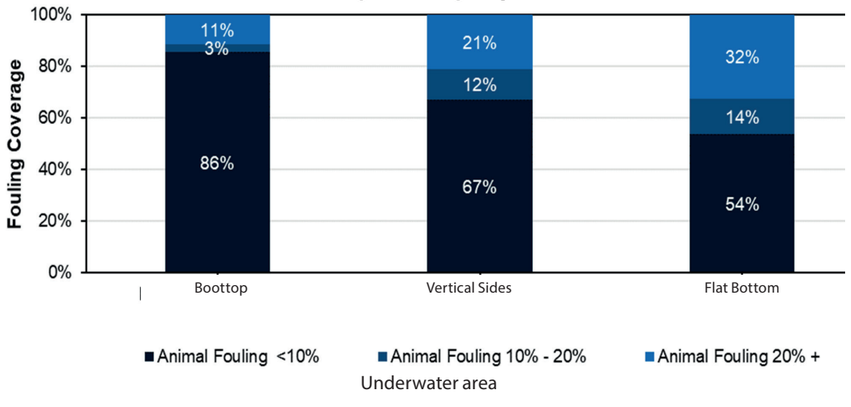
The underwater hull is defined as the area of a ship's hull from the keel to the top of the boottop. The boottop is the part of the hull between the water lines of a ship when fully loaded and when unloaded. The vertical sides are the underwater sides of the hull. The flat bottom is the underwater underside area of the hull.

When comparing the locations boottop, vertical sides and flat bottom, hard fouling was present on the majority of observations for all locations. However, animal fouling was particularly prevalent on the flat bottom

"Hard fouling was present on the majority of observations for all locations, with the flat bottom being most affected area."



Hard fouling coverage by location



Does vessel activity impact barnacle fouling?

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

For the purposes of this research, vessels were grouped by relative vessel activity are typical industry assumptions. Observations across all ship types revealed that the frequency of hard fouling was relatively higher on the lower activity vessels.

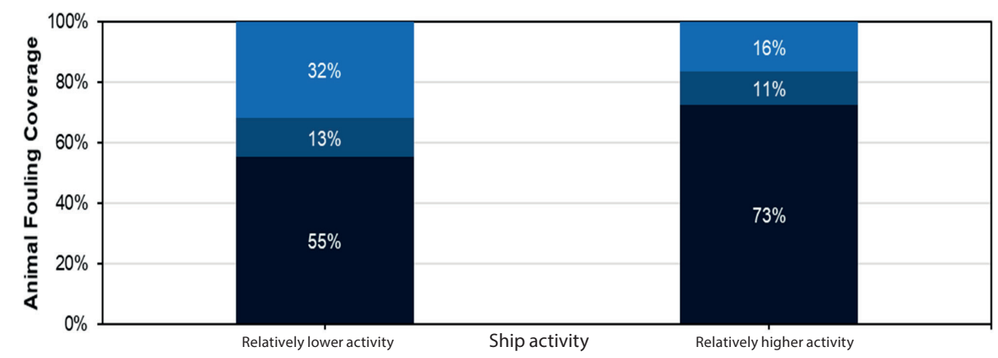
In fact, 45% of lower activity vessels surveyed suffered from hard fouling coverage of > 10% compared to just 27% of higher activity vessels.

45% vs **27%**

of lower activity vessels had hard fouling coverage of > 10%

of higher activity vessels had hard fouling coverage of > 10%

Hard fouling coverage by relative vessel activity



Research summary prepared by Safinah Group

Based on the sample of 249 vessels it has been observed that animal fouling is clearly a problem. Approximately 30% of all vessels with animal fouling have barnacle coverage that is 20% of the total underwater hull area. Heavy animal fouling will impart an increase in vessel drag up to and in excess of 50%, which equates to a significant increase in the fuel consumption and emissions.

Whilst the higher performance fouling control products show improved resistance to barnacle fouling, there is still significant evidence of barnacle fouling on these products. Barnacle fouling as expected is more predominant on the flat bottom and sea chests when compared to the other main underwater area; the vertical sides.

The evidence from the sample data set clearly points to a need for further improvement in either the current fouling control range in resisting animal fouling or the functional specification and selection of coatings based on application and operational requirements. Extended static periods for example are known to be particularly challenging to both biocidal antifouling (BAF) and foul release (FRC) type coatings.

THE SOLUTION

Antifouling coatings to the rescue

When looking at the future trading potential, ship operators need to ensure that their ship is protected whether it be in constant active service, idle for long periods of time, or is at risk of fluctuating between the two. Antifouling coatings that can offer extended static protection from both soft (slimes) and hard (barnacles) fouling are a must for the global shipping fleet.

90%

90 percent of the market is so-called traditional antifouling products that use approved biocides in various combinations.

80%

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

3bn

The global antifouling paint industry has annual sales of approximately USD 3 billion.

The afore-mentioned issues are driving the need for high performance, advanced antifouling technology in the maritime industry. Ship operators are increasingly demanding antifouling paints that are both well-suited to specific ship trading patterns, and varying activity levels in addition to protecting against both soft and hard fouling. When looking at the future trading potential, ship operators need to ensure that their ship is protected whether it be in constant active service, idle for long periods of time, or is at risk of fluctuating between the two.

Also, the dire need for antifouling paint technology that can protect the hull of any ship under any trade has been exacerbated during the COVID-19 pandemic which threw thousands of vessels into idling mode and at high biofouling risk. The majority of antifouling coatings rely on a vessel moving through water to function effectively. So, what happens when that stops? Usually that means biofouling, and especially idle ship-loving barnacles, can accumulate at a rate of knots.

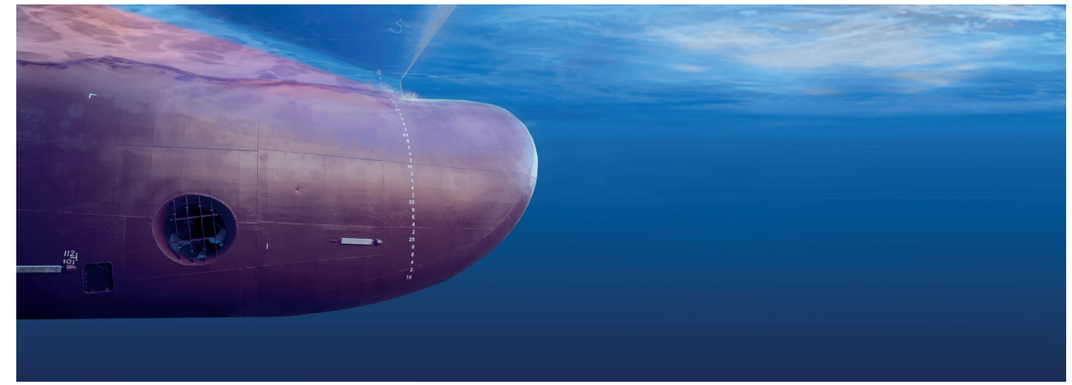
Therefore, antifouling coatings that can offer extended static protection from both soft (slimes) and hard (barnacles) are a must for the global shipping fleet.

However, yesterday's solution will not work for tomorrow's problems. This has catalysed great developments in the marine coating sector to ensure that technologies that can offer superior antifouling protection are incorporated into marine coatings. It is for this reason that our barnacle-repelling ingredient technology Selektope® is being increasingly added to marine coatings by global paint manufacturers to deliver superior protection against hard fouling, allowing them to offer static performance guarantees that are significantly longer than 30 days.

As such, our antifouling coating ingredient technology Selektope® has witnessed significant uptake in the five years since the first commercial Selektope®- containing antifouling coating was launched in 2015.

The science behind Selektope®

Selektope® is an organic, non-metal active agent that is relatively unique compared to traditional biocides currently used in many marine paints. When leached into the water from the antifouling coating, functioning like any other biocide, Selektope® activates the swimming behaviour of barnacle larvae through natural receptor stimulation. This induces the barnacle larvae's swimming behaviour that they use when seeking a hard substrate on which to attach. This constant swimming mode prevents them from being



able to settle, forcing them to find another hard surface on which to glue themselves and build their volcano-shaped shell.

The effect of Selektope® is temporary. The barnacle larvae is only affected while they are in close proximity to the coated surface and exposure to Selektope® ultimately leaves them unharmed. 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. As such, antifouling coatings containing Selektope® can confer relative peace of mind to ship owners and operators that their ship hulls will remain barnacle-free.

Selektope® is currently used in Biocidal Antifouling (BAF) coatings of the self-polishing co-polymer type (SPC). Biocidal antifouling coatings are the most widely used technology for fouling control and account for approximately 90% of the fouling control technology market.

In these coating systems, Selektope® binds to pigment and other particles and is therefore, continuously released in the same way as other biocides and components. This contributes to long-term performance for 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.

Out of the top six marine coatings manufacturers, three have commercialised products containing Selektope® in the past five years: Chugoku Marine Paints, Hempel and Jotun. The technology is also being used in many outfitting coating products in addition to 60-month antifouling systems. To-date, hundreds of ships have benefitted from the anti-barnacle insurance that Selektope® delivers when present in the antifouling coating applied to the hull.

The return of investment for premium antifouling coating technology is favourable given that the fuel penalties from biofouling are so high if a ship is exposed to intense biofouling risk when trading in warmer waters or when at anchor for a few weeks or more. For the industry to weather future shifts in global trade, making informed choices on antifouling paints could mean the difference between profit and loss.

I-Tech's largest customers[2]

CMP CHUGOKU

JOTUN

HEMPEL

Philip Chaabane, CEO, I-Tech AB concludes:

"The insight into the barnacle fouling problem across the global fleet, based on the inspections carried out by the Safinah Group, make for alarming reading.

Based on this sampling, it is extremely likely that a large proportion of vessels are in fact operating with high degrees of hard fouling. Given the increase in idle vessels throughout the first six months of 2020, we can reliably assume that the extent of fouling across the shipping industry will have spiked significantly."

"This entire period needs to serve as a lesson for our industry, coating specifications need to be taking into account the possibility that ships could at any time be forced into extensive idle periods."

"as such, we are encouraging ship owners, operators and managers to consider the technology mix within antifouling coatings to ensure that they protect their vessel from hard fouling during any unanticipated long idling periods."

"A beneficial strategy is to take a proactive approach on prevention of hard fouling. To achieve this, owners need to be looking closely at the antifouling technology mix within their marine coatings and analysing the idle period guarantees their additives have. They will strongly need to consider which antifouling additives enable idle period guarantee that are longer than 30-days, such as Selektope®."

SELEKTOPE

Next generation antifouling

Selektope® is an organic molecule developed and commercialised by I-Tech for use in paint systems. Selektope®'s powerful, repellent effect on barnacles keeps the ship's hull clean—which reduces frictional resistance between the ship hull and water, reducing fuel consumption. After risk evaluation, Selektope® has been approved by the EU as environmentally acceptable.

2g/l

2 grams of Selektope® is used per one litre of paint, comparable to 500–700 grams of copper oxide used per litre of paint for barnacle prevention.

EU-BPR

Along with only seven other substances, Selektope® is approved according to very comprehensive EU biocidal legislation, the EU-BPR.

Today, the global shipping industry accounts for approximately 2.6 percent of the world's total carbon dioxide CO_2 emissions. At the same time, the shipping industry accounts for about 90 percent of global trade transportation. According to the European Environment Agency, the share attributed to shipping could amount to as much as 17 percent of global emissions by 2050.

A unique and effective molecule

Selektope® is a pioneering and innovative solution that offers marine paint companies numerous possibilities to formulate high-performance marine antifouling paint systems that deliver reliable and continuous protection against barnacles and marine fouling. I-Tech's customers, the global paint manufacturers, can combine Selektope® with several other substances and polymers in their paint formulations to create optimal protection. Along with only seven other substances, Selektope® is approved according to very comprehensive EU biocidal legislation, the EU-BPR.

Selektope® is unique in its application as a biotechnology in marine paints because it repels barnacle larvae through natural receptor stimulation, activating their swimming mode with temporary effect. It is a technology characterised by its selective action and high efficacy at extremely low concentrations. This creates opportunities, that in some cases, can reduce biocide release from a paint by more than 90 percent whilst still improving hull performance.

The effect of Selektope® on a paint system is almost insignificant, which means that the paint and its application method are identical to conventional methods.

Selektope® gives I-Tech customers greater freedom to formulate different types of antifouling products. For example, it is possible to formulate Selektope® with or without copper oxide (Cu_2O) and functional materials/coatings can also be formulated. Chugoku Marine Paints' copper-free antifouling coating product, SEAFLO NEO CF-PREMIUM, in which all copper oxide is replaced, demonstrates a particularly good ability to also reduce soft/primary fouling. This is a desirable secondary characteristic enabled by Selektope®.

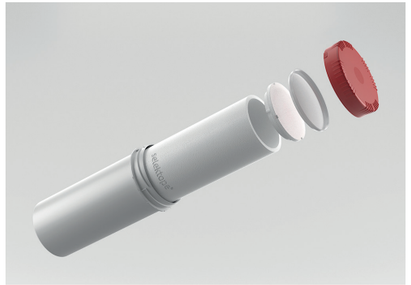
This is how Selektope® works

When Selektope® leaches out from an antifouling paint, barnacle larvae are temporarily affected as they approach the hull surface. The larvae become hyperactive and cannot attach to the surface of the hull, instead they are forced to swim away and find another place to settle.

Selektope® has positive and direct impact on the environment in several stages. Partly by contributing to the reduction of airborne pollutants and also by decreasing the emission of copper oxide into the marine environment. Selektope® can also contribute to an overall lower emission of active substances when the qualities of the product are fully utilised.

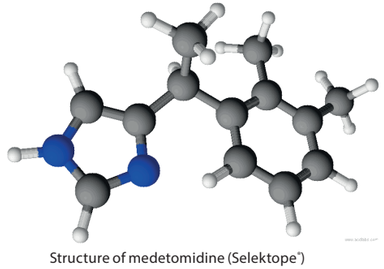
Selektope® in paint

Selektope® binds to pigments and other particles in the paint system. It is, therefore continuously released in the same way as other biocides. This contributes to long-term hull performance so long as the paint remains on the hull. The paint, which mainly comprises binding agents, biocides, pigment and filler material, is applied to the hull using a traditional spraying method. The amount of paint required to coat a hull can vary from a couple of thousand litres to over 20 or 30 thousand litres depending on the ship size and type. With its own soluble packaging solution, Selektope® can be added directly into the antifouling paint production system and is dissolved immediately. This innovative approach minimises the risk of exposure at the paint manufacturing facilities which contributes to a better work environment.



Selektope® is unique as it is effective against marine fouling at extremely low concentrations and has a repellent, but not deadly, effect on barnacles.

Selektope® is based on a molecular structure comprising phenyl and imidazole groups. When a barnacle larvae comes into contact with Selektope®, they becomes hyperactive and performs about 100 kicks per minute. The effect is reversible, and the larvae quickly return to their normal state when not exposed to Selektope®. In this way, the larvae simply cannot attach to a surface painted with Selektope® and, at the same time, the larvae are not damaged in any way.



Structure of medetomidine (Selektope®)

Ship test patch

This Image from Chugoku Marine Paints depicts a paint test patch with antifouling paint containing Selektope® on a coastal ship in Japan. The ship had a low level of activity, i.e. long periods at anchor in the area in and around Tokyo Bay, which is considered to be an area of intense marine fouling. The ship has been in operation for 12 months and the test area (marked) is to be contrasted with the hull in general which uses an antifouling paint with traditional technology, albeit adapted for the current operating conditions. The increased resistance through the water is estimated to be 60% or more due to the fouling.