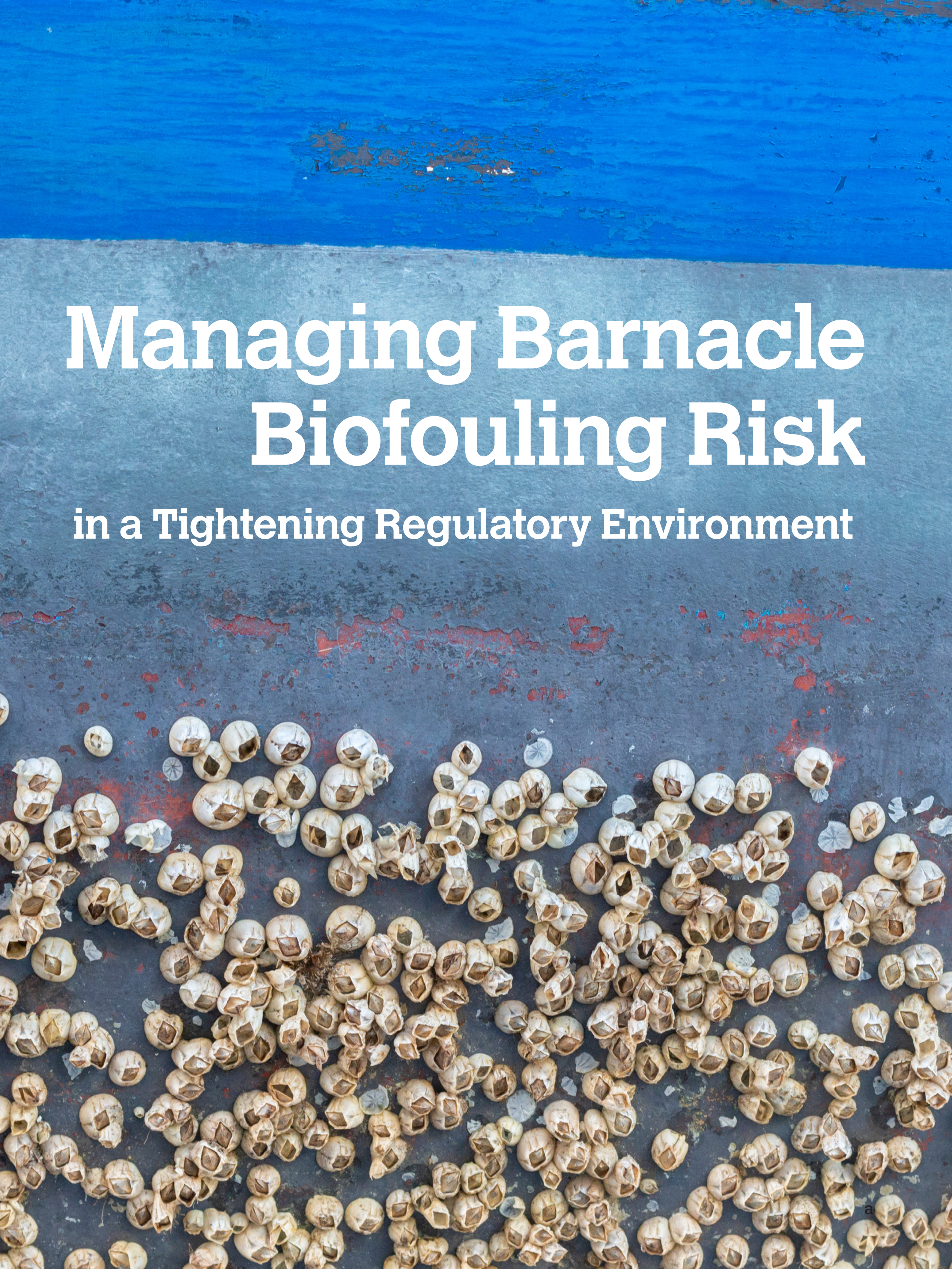
Managing Barnacle Biofouling Risk

in a Tightening Regulatory Environment



Contents

Key findings

~1/5 of ships
of 686 ships inspected had
>20%
barnacle biofouling coverage on their hull.
Page 37

~1/3 of ships
of 686 ships inspected had
>10%
barnacle biofouling coverage on their hull.
Page 37

Idle or low-speed operations (<6kts)
significantly increase barnacle settlement risk.
Page 39

20% of
hull coverage by large barnacles can require up to
~66%
more effective power, depending on barnacle size and ship speed.
Page 18

Medium calcareous fouling has been shown to increase GHG emissions by up to
~90%
under certain conditions (IMO GloFouling study, 2022).
Page 19

For every **1 tonne**
of marine fuel burned,
~ 3 tonnes
of CO_2 are emitted (IMO emission factors).
Page 15

Barnacle fouling
=
Emissions ↑
CII pressure ↑
Compliance risk ↑
Page 17

Barnacle fouling
=
Fuel cost ↑
Hull cleaning ↑
Operating cost ↑
Page 14

Introduction

The operational efficiency of the global shipping fleet is under threat from the negative impacts of biofouling; the accumulation of marine organisms on ship hulls and in niche areas. Barnacle fouling in particular puts ships at great risk of significant excess fuel consumption due to the immense hydrodynamic drag created by the hard, protruding barnacle clusters when water flows across the ship's hull.

Understanding and effectively managing barnacle biofouling is essential for the maintenance of efficient ship operations across the global fleet. However, barnacle fouling risk is not uniform across all vessels. It is highly dependent on a vessel's operational profile, trading routes, and seasonal fluctuations in population density, meaning that a one-size-fits-all approach to barnacle fouling management is not sufficient.

By developing a clear understanding of barnacles, the conditions under which they thrive, conditions needed for them to attach to ship hulls and global hotspots, ship operators can take informed, proactive steps to minimise negative impact. This includes selecting appropriate antifouling coatings that protect a vessel from barnacle fouling under all circumstances, and optimising operational strategies to minimise risk.

This whitepaper provides a comprehensive, data and research- driven overview of barnacle biofouling and why ships are at risk. It also explores current and emerging biofouling management regulatory frameworks, as well as practical mitigation strategies. Together, these insights are intended to support more effective decision-making around barnacle biofouling and help ship operators reduce risk and safeguard ship efficiency and regulatory compliance.

What is a barnacle?

Barnacles are invertebrate crustaceans (Class Cirripedia). Their complex life cycle has multiple stages. Volcano-shaped adult barnacles are easily recognisable, with dense clusters present on anything fully or temporarily submerged in seawater.

Barnacles reproduce through the fertilisation of eggs, which develop inside the adult barnacle, leading to the release of free-swimming nauplii larvae into the water column.

These larvae can survive for several weeks and drift with the currents, feeding on plankton and moulting through several life cycle stages.

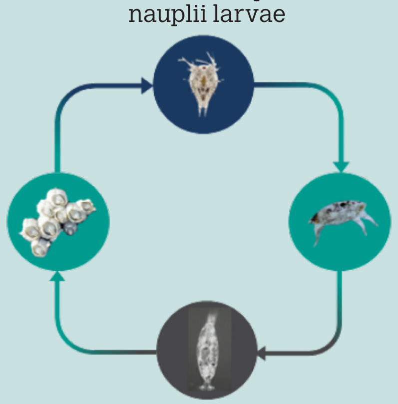
The final free-swimming stage in the barnacle life cycle is the cyprid larva. These larvae are highly mobile. They use sensory structures called antennules to explore a surface, sampling both physical and chemical cues to assess its suitability.

Once a suitable surface is found, the larva cements itself headfirst and builds a hard shell composed of calcium plates - this represents the adult stage of the lifecycle.

The glue that barnacles create to attach their base plates to surfaces is a strong, natural phosphoprotein adhesive that cures underwater. It exhibits remarkable resistance to shear stress, salinity, and temperature variation.

When glued in their permenant place, barnacles feed by extending feathery appendages (called cirri) to filter tiny food particles from the flowing water.

Nauplii larvae
Adult barnacles produce nauplii larvae



Adult barnacle
Once adults grow, they attract other cyprid larvae to that area. Adults reproduce using long appendages

Cyprid larvae
Cyprid larvae search for a place to settle

Settling larvae
The larva glues itself to a surface and metamorphones into an adult

Why do they like ship hulls?

Barnacles don't like ship hulls just because they're ship hulls. They are just taking advantage of a near-perfect artificial habitat. Ship hulls happen to tick almost every box that barnacles need to survive and reproduce.

Every barnacle species needs conditions that balance nutrient access with mechanical stability. A surface must be stable, have the right surface chemistry and biofilm availability, and offer good feeding opportunities.

A ship hull meets all these requirements and presents the perfect living environment for adult barnacles. The surface of a hull is stable, has ample biofilm availability, and the flow of water provides a constant source of food for the adult barnacle.

Ship hulls also present an extensive surface area on which adult barnacle colonies can cluster in large groupings and reproduce effectively in huge numbers.

Hard surfaces are prime real estate

Barnacles need a solid surface to settle on permanently.

In nature: rocks, reefs, shells

Ships provide a: smooth, stable, submerged surface.

A ship hull is basically a floating artificial reef.

Constant water flow = constant food

Barnacles are filter feeders. They eat tiny particles (plankton).

Moving ships create steady water flow over the hull
This delivers a continuous food supply.

More flow = more food = faster growth.

Larvae are programmed to settle on surfaces like hulls

Barnacle larvae actively choose where to settle.

They prefer:
*Dark or shaded surfaces
*Rough or conditioned surfaces (already slimy or fouled)
*Chemical cues from other organisms

A ship hull that's been in the water even briefly, and is sat idle for a few days or more becomes highly attractive.

How do they spread so quickly?

A major aspect of the barnacle life cycle and what makes them so successful at rapidly colonising on a hull surface is that barnacles can release chemical settlement cues into the water.

Chemical cues produced by adult barnacles attract barnacle larvae (cyprids) and encourage them to settle nearby. Over time, this creates tight aggregations where adults are within reproductive reach of one another.

Barnacles typically cross-fertilise with nearby barnacles using an extensible appendage, which allows dense clusters to reproduce very efficiently. If required, they can self-fertilise, as they are hermaphrodites – though this is rare.

A single barnacle can produce thousands to tens of thousands of eggs per brood, and many species reproduce multiple times per year, especially in warm, nutrient-rich waters.

When a free-swimming cyprid barnacle larva finds a suitable spot to settle, it can permanently attach and build its hard, calcareous shell in approximately 24–48 hours.

As a juvenile adult barnacle grows, the contact area with the hull increases, spreading loads and further strengthening the bond to the hull.

The combination of mineralised shell structures and persistent cement secretion promotes long-term stability of the adult barnacle, despite high water flow across the ship hull and vibration from the ship's machinery.

20k

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

Can they be removed successfully?

Yes, barnacles can be removed. BUT the abrasive methods required for removal can be very damaging to a ship's antifouling coating. If barnacles are removed successfully, often their hard base plate remains.

Mechanical cleaning methods such as scraping, brushing, or high-pressure water jets can be used. This is often carried out by divers or during dry docking. Methods for removing soft biofouling species do not remove barnacles.

However, when removing barnacles from a ship's hull, the base plate often remains, leaving a degree of hydrodynamic drag as water flows across the hull surface. If the entire adult barnacle and its base plate are removed, it is very likely that the antifouling coating will also be removed with the base plate, leaving no antifouling protection in that area.

The most effective approach is prevention: using antifouling coatings that stop barnacles from attaching in the first place for the entire drydock cycle.

Barnacle growth cluster.

The adhesive secreted by barnacles, often hailed as nature's strongest glue, is a marvel of biological engineering.

Removing barnacles can be extremely damaging to an antifouling coating.

Where do barnacles like to live?

Barnacles are found worldwide, from polar seas to tropical oceans. They live almost entirely in saltwater environments and do not tolerate freshwater with low salinity for longer periods.

Their primary habitat is coastal and intertidal zones, with 75% of species residing at shallow depths of less than 100 metres. This means that the risk of barnacle fouling increases significantly in shallower, coastal areas.

Environment	Barnacle presence
Rocky coastlines & intertidal zones	Very high (natural habitat)
Harbours, ports	Very high
Open ocean	Moderate (specific species)
Deep sea	Low, specialised species
Freshwater (rivers)	Almost none

Free-swimming barnacle larvae need a ship to be still or moving slowly to attach. This means that ships spending time at anchor or at very low speeds face the highest risk and ships sailing in the open waters are at a lower risk.

However, there are some open-ocean and pelagic barnacle species. For example, goose-neck barnacles that are found to attach to ship hulls, wash up on beaches attached to debris, or be enjoyed as a food delicacy!

Feeding adult barnacles.

saltwater warmer waters ports

sheltered harbours coastal waters

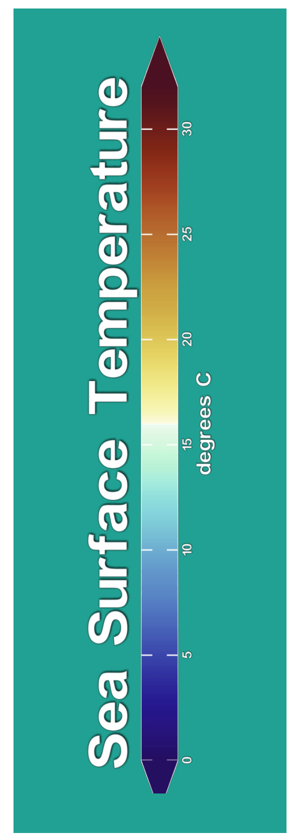
What environmental factors increase fouling risk?

When considering how risky an area is for ship barnacle fouling, we need to understand the factors that significantly increase the number of barnacle larvae per cubic metre of water.

Increased risk of successful barnacle settlement and adhesion to ship hulls are strongly influenced by the following factors:

salinity

water temperature nutrient availability



Typically, cold water can slow growth and reproduction whereas warmer waters speeds up growth and reproduction rates.

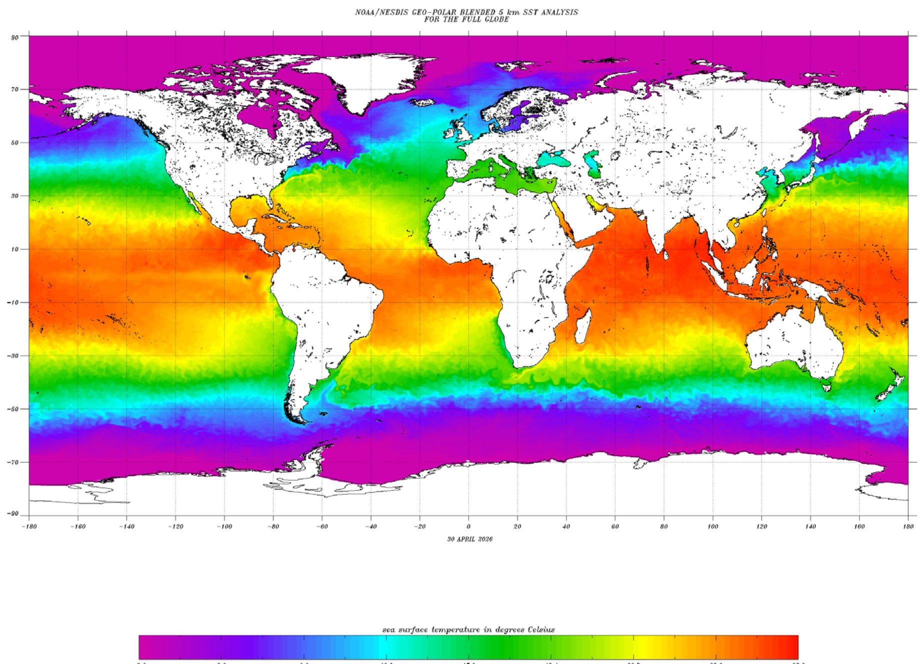
Salinity (the salt concentration of seawater) is a major abiotic factor controlling where barnacles can live, how fast they grow, and whether their larvae survive. There are almost no barnacle species that can survive in freshwater environments.

In some areas, seasonal peaks in water temperature and nutrient levels, boost larval abundance. This can cause rapid fouling during specific months of the year.

WHERE ARE SHIPS AT RISK FROM BARNACLE FOULING?

Where are ships most at risk?

Certain areas can be considered to be "biofouling hotspots" where biofouling risk is significantly elevated due to favourable environmental conditions. For barnacle biofouling, this is typically in areas where water temperatures are warmer (>15°C).



Surface water temperatures. NOAA's Geo-Polar Blended 5 km SST / SST Contour Chart for April 29, 2026.

High-risk barnacle fouling zones worldwide typically share these common features:

- Coastal waters.
- Shallower waters with high light levels.
- Warmer waters.
- Sheltered harbours and anchorages with low water flow.
- Ports located in tropical and subtropical waters.

Geographical areas where barnacle fouling risk is typically increased include:

- Asia Pacific
- The Middle East
- Caribbean
- Persian Gulf
- West Africa
- Brazil
- Northern Australia

When are ships most at risk?

Vessel activity plays a large role in barnacle fouling risk. Free-swimming barnacle larvae can only make initial attachment to a ship that is static in the water, or that is sailing slowly (up to approximately 6 knots).

Ships that are idle or travelling at low speeds are at greater risk of barnacle fouling. Ships that are sailing at speeds of 6 knots or above are at less risk, although the risk is not zero.

High-risk situations include:

- Periods of low speed or prolonged stationary conditions.
- Long port stays.
- Anchorage waiting times.
- Lay-ups and slow steaming.
- Newbuild delivery voyages with low speed.

Containerships in port.

Tankers idling outside of port.

WHERE ARE SHIPS AT RISK FROM BARNACLE FOULING?

Does climate change influence barnacle fouling?

Climate change is turning biofouling into a faster-growing, more variable, and harder-to-manage risk. Rising water temperatures and changing ecosystems will increase distribution, abundance, and fouling pressure, with added variability and unpredictability in all regions.

A growing body of academic research demonstrates a clear link between climate change, particularly rising sea temperatures, and shifts in barnacle distribution, abundance, and fouling pressure.

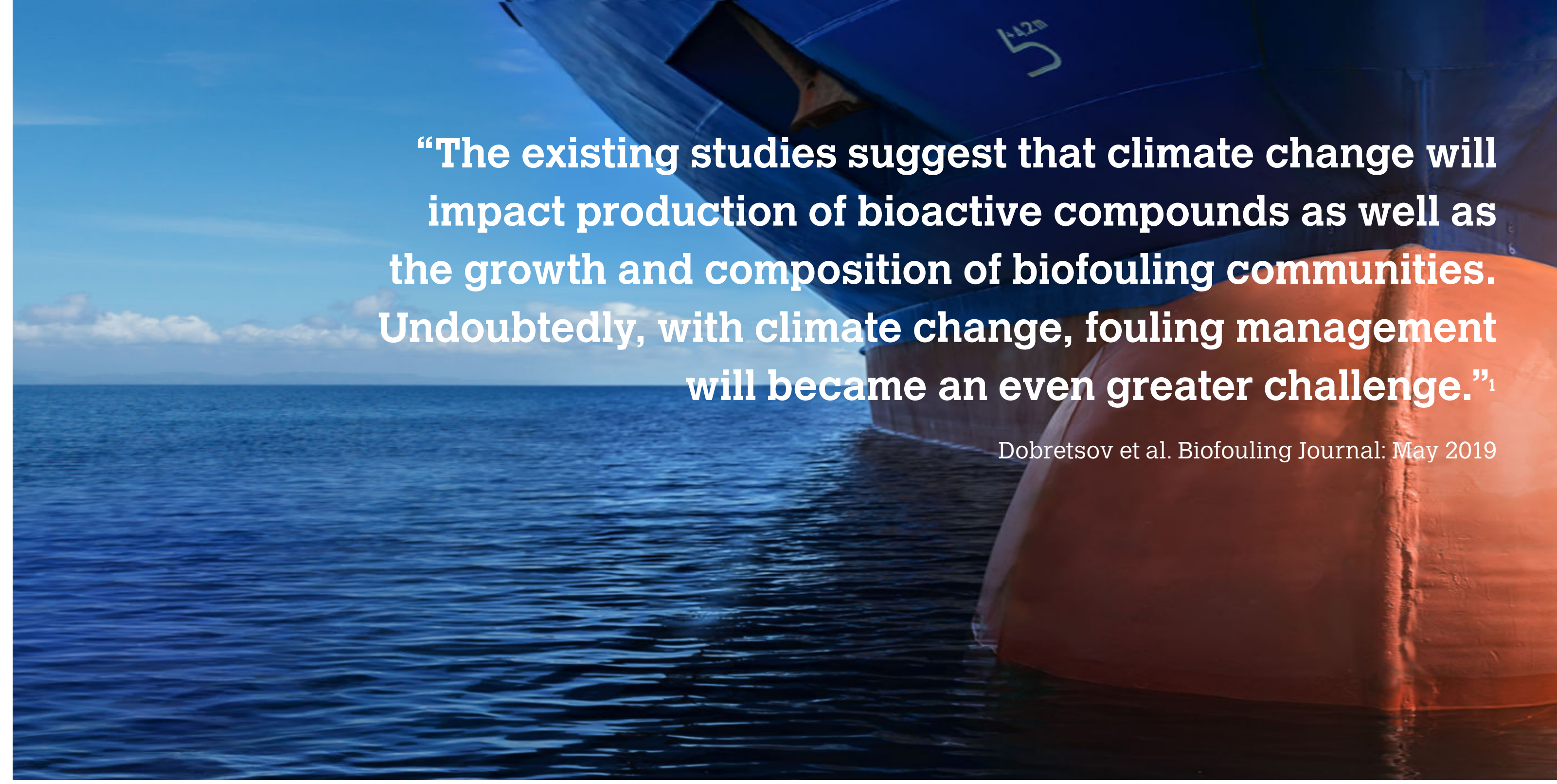
It's not just barnacle species that are affected, climate change is driving modification of the chemical and physical properties of oceans with profound consequences for species and ecosystems. (Dobretsov et al., 2019)[1].

For barnacle species, temperature doesn't just shift where they can live; it directly affects whether they can survive, and reproduce. Higher water temperatures could promote faster reproduction with longer growing seasons in many regions.

Scientists say that climate change will not uniformly increase barnacles everywhere, instead it could both expand population density in some regions and reduce population density in others.

However, the net effect will be greater variability, unpredictability, and in many cases, increased barnacle fouling pressure in warm, high-risk regions.

Long-term observational programmes such as the MarClim project (Hawkins et al.)[2] show consistent poleward expansion of warm-water barnacle species alongside declines in cold-water taxa, driven by changing thermal regimes. Experimental and physiological studies further confirm that temperature directly influences barnacle metabolism, reproduction, and recruitment success, with warmer conditions often



> **"The existing studies suggest that climate change will impact production of bioactive compounds as well as the growth and composition of biofouling communities. Undoubtedly, with climate change, fouling management will became an even greater challenge."[1]**
>
> Dobretsov et al. Biofouling Journal: May 2019

accelerating settlement rates and population growth in suitable regions (e.g., Wethey & Woodin, 2008[3]; Little et al., 2021[4]).

At the same time, climate-driven "tropicalisation" is altering predator–prey dynamics and ecosystem structure, further reshaping barnacle communities (Fenberg et al., 2023[5]).

Collectively, this evidence indicates that ocean warming is not only redistributing barnacle species geographically but also increasing the variability and intensity of fouling risk, particularly in warm-water regions already associated with high settlement pressure. Thereby reinforcing the need for biofouling management strategies to prevent barnacle fouling.

The issue isn't just "more barnacles"in warming waters, it's less certainty and less margin for error for ship operators in their biofouling management choices.

[1] *Dobretsov S, Coutinho R, Rittschof D, Salta M, Ragazzola F, Hellio C. The oceans are changing: impact of ocean warming and acidification on biofouling communities. Biofouling. 2019 May;35(5):585-595. doi: 10.1080/08927014.2019.1624727. Epub 2019 Jul 8. PMID: 31282218*

[2] *Mieszkowska, N., Leaper, R., Moore, P., Kendall, M.A., Burrows, M.T., Lear, D., Poloczanska, E.S., Hiscock, K., Moschella, P.S., Thompson, R.C., Herbert, R.J.H., Laffoley, D., Baxter, J., Southward, A.J. & Hawkins, S.J. (2005). Marine Biodiversity and Climate Change (MarClim): Assessing and predicting the influence of climatic change using intertidal rocky shore biota. Final Report for United Kingdom Funders. Marine Biological Association, Plymouth.*

[3] Wethey, D.S. & Woodin, S.A. (2008).Ecological hindcasting of biogeographic responses to climate change in the European intertidal zone. Hydrobiologia, 606, 139–151.

[4]. Little, C., Trowbridge, C.D., Williams, G.A., Hui, T.Y., Pilling, G.M., Morritt, D. & Stirling, P. (2021).Response of intertidal barnacles to air temperature: Long-term monitoring and in-situ measurements.
Estuarine, Coastal and Shelf Science, 256, 107367.

[5].Fenberg, P.B. et al. (2023).
Predator-induced defences under tropicalisation: A biogeographic approach.Journal of Biogeography, 50, 2148–2159.

WHY ARE BARNACLES SO BAD FOR SHIP OPERATIONS?

1

Extra fuel costs

According to data taken from a 2011-published study by Michael P. Schultz[6], 10% barnacle biofouling coverage on the hull surface can result in a vessel using 36% more shaft power required to maintain the same speed through water.

The associated increase in fuel consumption could be responsible for at least 110 million tonnes of excess carbon emissions per year and an additional US$15 billion in fuel costs for the global commercial fleet. The true figure is likely to be higher, as this is a conservative calculation based on today's bunker fuel prices.

As the maritime industry moves towards cleaner, greener, lower-carbon fuel options, the cost of fuel per metric ton will continue to rise. Therefore, increased fuel consumption resulting from biofouling accumulation will impose a higher penalty than today in a not-so-distant future.

2

Extra maintenance costs

A hull or niche areas suffering from heavy biofouling significantly increase maintenance costs. Costs associated with hard fouling-specific hull cleaning services must be factored into a ship operator's operating expenditure (OPEX) if required.

Repeated cleaning of the hull can also remove layers of the antifouling coating thickness, reducing its service life. This will incur an extra cost if the antifouling coating is expended before its full-service life is complete and the hull needs to be recoated.

Ultimately, if a vessel must be dry-docked to mitigate barnacle fouling on the hull, or in niche areas, the extra maintenance costs could be enormous, particularly when you factor in off-hire days.

3

Extra regulatory costs

Growing regulatory focus on the international shipping fleet's transport of invasive aquatic species can also affect ship operations financially. Some regional regulations are already in force, enabling ports to refuse entry to heavily biofouled ships, resulting in financial costs for operators associated with sailing to an alternative port for hull grooming.

Since fossil-based marine fuels produce around 3 tonnes of CO_2 per tonne of fuel burned, for vessels subject to the EU Emissions Trading System (EU ETS) rules, increased fuel use will entail additional regulatory compliance costs in the form of EU allowances (EUAs) purchases. EUAs must be bought for each tonne of CO_2 emitted, as per the reportable emissions for a ship per year.

Therefore, extra tonnes of fuel burnt due to marine biofouling on the hull would entail a direct cost to the ship operator.

As such, not only would a ship operator incur a higher fuel cost penalty due to higher consumption to compensate for speed losses from barnacle fouling, the resultant increase in emissions would also require purchasing more EU ETS allowances.

Poor hull condition can also worsen CII (Carbon Intensity Indicator) ratings and the commercial attractiveness of vessels. Charterers increasingly prefer efficient ships, and so if barnacle fouling negatively impacts a vessel's CII rating and its efficiency, it makes the ship a less attractive option commercially.

[6] Schultz, M.P. (2011).Effects of coating roughness and biofouling on ship resistance and powering.Biofouling, 23(5–6), 331–341.

WHY ARE BARNACLES SO BAD FOR SHIP OPERATIONS?

How do barnacles increase fuel use & emissions?

Barnacle fouling significantly reduces a ship's hydrodynamic efficiency by creating surface roughness that disrupts boundary-layer flow. Barnacles act like thousands of tiny "speed bumps" on the hull, creating added frictional resistance.

For ship operations, barnacle biofouling is a triple threat to performance, cost, and compliance. Barnacle fouling creates significant hydrodynamic drag by creating surface roughness. The larger the barnacle, the bigger the disruption to the boundary-layer flow of water across the hull resulting in a biggr frictional resistance effect.

This forces ships to burn more fuel to maintain speed through water. Alternativey, a ship will suffer speed losses if operating on fixed shaft power or fuel consumption.

According to IMO Marine Environment Protection Committee (MEPC) guidelines, the standard fuel mass to CO_2 mass conversion factor (CF) for heavy fuel oil (HFO) is 3.114 t CO_2 per tonne of fuel consumed. Consequently, the combustion of 1 tonne of HFO generates approximately 3.114 tonnes of carbon dioxide emissions.*

Hull condition	Required additional shaft power at 15 kts speed (7.7 ms-1)	Required additional shaft power at 30 kts speed (15.4 ms-1)
Hydraulically smooth surface	0	0
Typical as applied AF coating	1	3
Deteriorated coating or light slime	9	7
Heavy slime	18%	12
Small calcareous fouling or weed	31%	20
Medium calcareous fouling	47%	30
Heavy calcareous fouling	76%	47

Figure 1. Predictions of required shaft power (based on change in total resistance) for an Arleigh Burke-class destroyer (DDG-51) with a range of coating and fouling conditions at a speed of 15 knots versus 30 knots. (adapted from Schultz et al, 2011[7])

** Fuel conversion factor values derived from IMO Resolution MEPC.308(73), Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships, and related MEPC carbon accounting guidelines.*

[7] 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), 87–98.

Preventing barnacle fouling on ship hulls and in niche areas can also positively influence several major ship efficiency and decarbonisation regulations at the same time, even though these rules do not explicitly mention biofouling management.

Carbon Intensity Indicator (CII)

The Carbon Intensity Indicator (CII) measures a vessel's annual operational efficiency in grams of CO_2 per deadweight–nautical mile and assigns a performance rating from A to E.

Hull fouling directly degrades CII performance by increasing hydrodynamic resistance and fuel consumption at constant speed.

Maintaining good hull condition can be one of the most influential strategies available for managing CII performance without changes to machinery or fuel.

This is because effective barnacle fouling control supports CII compliance by:

- Reducing fuel consumption per voyage.
- Lowering reported CO_2 emissions.
- Stabilising or improving annual CII ratings.
- Avoiding D or E ratings that trigger mandatory corrective action plans and commercial penalties.

EU Emissions Trading System (ETS)

Under the EU ETS, vessels must surrender emissions allowances corresponding to reported CO_2 emissions on voyages to, from, and within the European Union.

Reducing barnacle fouling supports EU ETS compliance by:

- Lowering voyage level CO_2 reporting.
- Reducing the number of allowances required.
- Improving voyage economics and annual carbon cost exposure.

FuelEU Maritime

FuelEU Maritime regulates the greenhouse gas intensity of energy used on board vessels and introduces penalties for non compliance. Although fuel selection is primarily the focus, total energy demand remains a critical determinant of compliance.

Barnacle fouling prevention reduces costs associated with FuelEU Maritime by:

- Reducing overall energy consumption.
- Improving the effective carbon intensity of operations.

Recent studies on the impact of barnacle fouling

Study 1

Study name: Effect of barnacle fouling on ship resistance and powering.

Published in: The Journal of Bioadhesion and Biofilm Research in 2017.

Predictions of added resistance and the effective power of ships were made for varying barnacle fouling conditions. A series of towing tests were carried out using flat plates covered with artificial barnacles.

Data for the increase in frictional resistance and the necessary power to move a ship through water at a ship speed of 24 knots for a range of barnacle sizes in the study are shown in the tables below.

This study confirms that 10% coverage of larger barnacles causes the same level of added power requirements as 50% coverage of smaller barnacles on the surface of the hull.

Click here to read the full study.

2.5 mm and 1.25 mm size barnacles	frictional resistance	necessary power to move a ship through water
10% coverage	27%	17.5%
20% coverage	42%	27%
40% coverage	66%	42%
50% coverage	69.5%	44.6%

5 mm and 2.5 mm size barnacles	frictional resistance	necessary power to move a ship through water
10% coverage	49%	31%
20% coverage	67%	43%
40% coverage	97%	63%
50% coverage	103%	66%

10 mm and 5 mm size barnacles	frictional resistance	necessary power to move a ship through water
10% coverage	72%	46%
20% coverage	103%	66%

Study 2

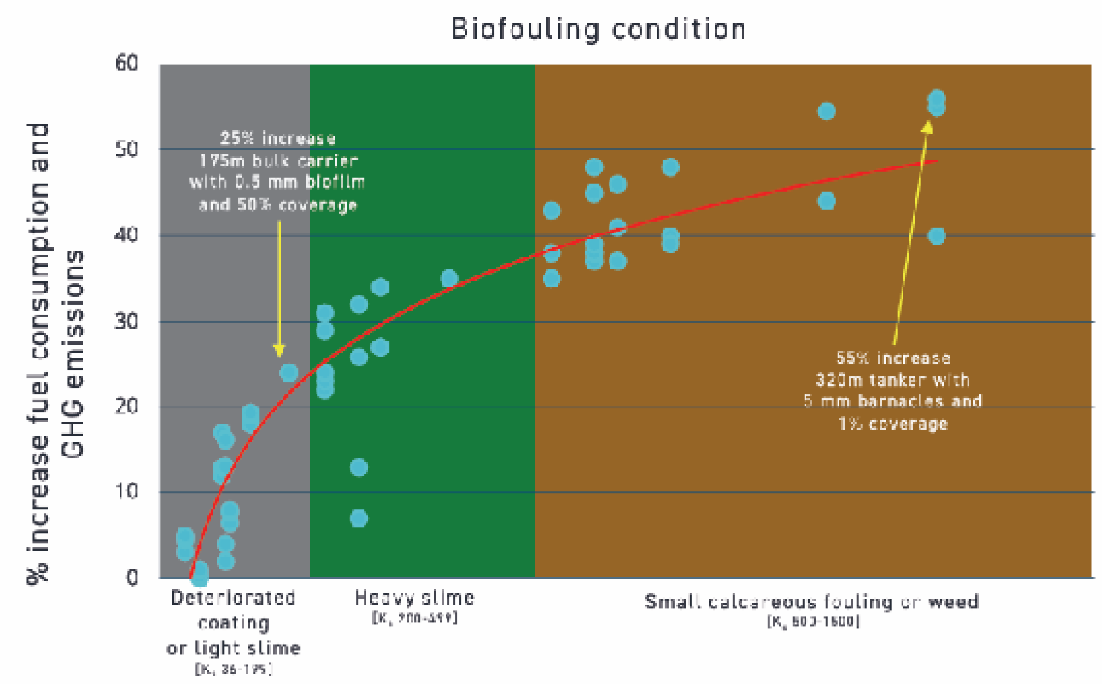


Figure 2. Impact of biofouligng on ship GHG emissions.

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

Study name: Analysing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures.

Published by: The GloFouling Partnerships Project Coordination Unit of the International Maritime Organization (IMO) in 2022.

This report presents data that confirms:

- A layer of slime as thin as 0.5 mm covering up to 50% of a hull surface could trigger an increase of GHG emissions in the range of 25 to 30%, depending on ship characteristics, its speed and other prevailing conditions.
- For more severe biofouling conditions, such as **a light layer of small calcareous growth (barnacles or tubeworms),** an average-length container ship could see **an increase in GHG emissions of up to 60%,** dependent on ship characteristics and speed.
- For the **medium calcareous fouling surfaces,** the increase in **GHG emissions could be as high as 90%.**

Click here to read the full study.

Global Biofouling Guidelines and future legal framework

IMO Biofouling Guidelines

The International Maritime Organization (IMO) Resolution MEPC.207(62) - 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species, was adopted in July 2011.

These non-mandatory Guidelines for the Control and Management of Ships' Biofouling were updated in 2023.

They are intended to provide a globally consistent approach to the management of biofouling, and recommend best practices to avoid biofouling, which include:

- Choosing and installing a type-approved anti-fouling system (AFS).
- Implementing a ship-specific biofouling management plan (BFMP).
- Maintaining a biofouling record book.
- Conducting regular inspections and maintaining contingency action plans.

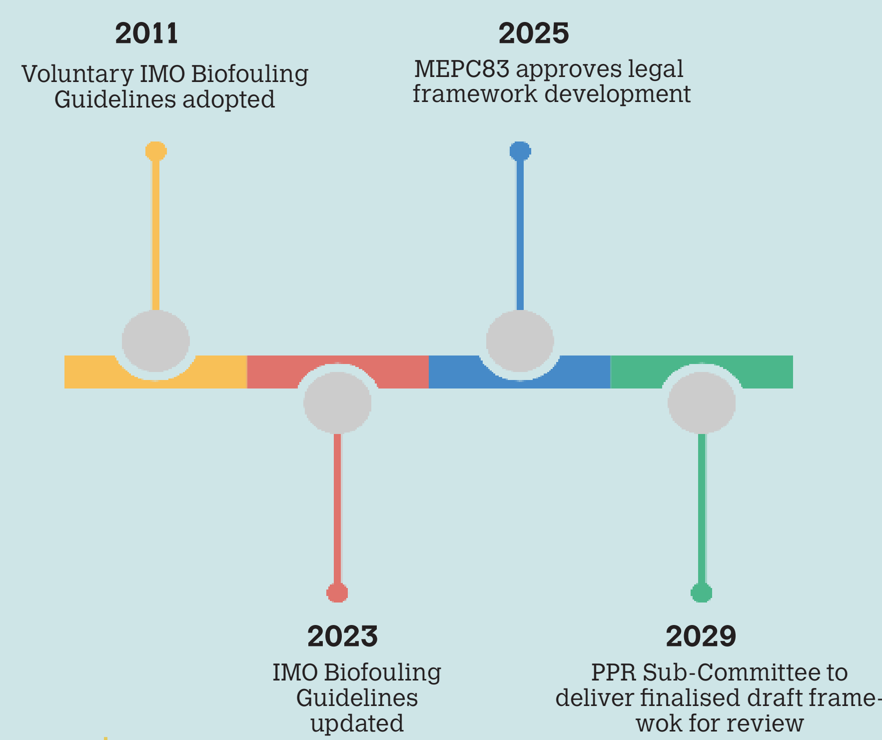
Please note that while the mandatory International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 (AFS Convention) addresses anti-fouling systems on ships, its focus is on the prevention of adverse impacts from the use of antifouling coatings, rather than the prevention of the transfer of invasive aquatic species through hull fouling.

Future legal global framework

In April 2025, the Marine Environment Protection Committee (MEPC) of the IMO approved a new output to develop a legally binding framework for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species.

The development of mandatory requirements will shift biofouling management from voluntary guidelines to enforceable international regulations, providing greater legal certainty in managing biofouling risks.

The new output was assigned to the Sub-Committee on Pollution Prevention and Response (PPR) as the associated organ, with four sessions needed to complete the item; based on this, by the eighty-ninth session of the MEPC (mid-2029) the PPR Sub-Committee are due to provide a finalised draft legal framework and recommendations on the way forward.



Regional and National mandatory regulations

Australia

The Australian biofouling management requirements for commercial vessels (ABF-MR-CV) entered into force in 2022.

Biosecurity risk of vessels is managed through pre-arrival reporting, assessment and inspection of vessels subject to biosecurity control. This information must be reported through the department's Maritime and Aircraft Reporting System (MARS) and provided at least 12 hours, but no earlier than 96 hours, before the vessel is estimated to arrive at its first port in Australian territory.

Vessel operators can demonstrate proactive management of biofouling by implementing one of the three accepted proactive biofouling management options:

- Option 1: Implement an effective biofouling management plan and record book.
- Option 2: Clean all biofouling within 30 days prior to arriving in Australian territory
- Option 3: Alternative biofouling management method approved by the department.

Risk profiling before arrival is based on:

- Time since last dry-dock.
- Trading history.
- Time spent idle.
- Hull and niche area condition.

Click here to read more about these rules.

New Zealand

New Zealand's vessel biofouling rules became legally enforceable on 15 May 2018. The Craft Risk Management Standard (CRMS) requires vessels to meet "clean hull" thresholds before entering territorial waters.

Pre-arrival reporting and evidence of biofouling management are mandatory:

- Vessels must meet a "clean hull" standard on arrival.
- Biofouling levels are assessed.
- Non-compliant vessels may face: mandatory cleaning, delays or denial of entry.

Operators or the person in charge of a vessel must provide evidence for one of the following options to show compliance:

- Continual maintenance using best practice: This includes application of antifouling coatings, operation of marine growth prevention systems and in-water inspections with biofouling removal as required. This measure is suitable for short-stay vessels only.
- Clean before arrival: Inspect and if required, remove all biofouling found from all parts of the hull, including niche areas, less than 30 days before arrival to New Zealand.
- Clean out of water on arrival: Have a booking at a MPI approved haul-out facility to remove biofouling and enter this facility within 24 hours of arrival to New Zealand. Once in the facility, all biofouling from all parts of the hull, including niche areas are removed.
- Treat on arrival: All available approved treatments are listed in Approved Biosecurity Treatments (MPI-STD-ABTRT). This excludes the removal of biofouling in an approved haul-out facility.

Click here to read more about these rules.

Regional and National mandatory regulations

California

On April 20, 2017, requirements of biofouling management in Californian waters were set out in California Code of Regulations (CCR) Article 4.8 - Biofouling Management to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports. These rules have been enforced for new vessels since January 1, 2018, and existing vessels after their first regular scheduled out-of-water maintenance on or after January 1, 2018.

A vessel that is arriving at a California port must submit the “Marine Invasive Species Program Annual Vessel Reporting Form” through the web-based user interface at least 24-hours in advance of the first arrival of each calendar year at a California port of call.

The mandatory biofouling reporting and management regulation require ship operators to demonstrate:

- Biofouling Management Plans
- Record keeping: Hull inspection and cleaning history

Click here to read more about these rules.

Chile

In 2021, Chile introduced new regulations on biofouling management for international vessels entering its ports.

The focus of Chile’s biofouling-related regulations is on controlling cleaning and pollution, with less emphasis on forcing ships to arrive clean. Although clean huls are required in certain zones, especially for aquaculture areas and sensitive ecosystems and inspections and controls are carried out in high-risk regions.

Brazil

In June 2025, Brazil amended its Maritime Authority Standards (NORMAM-401/DPC) to include mandatory biofouling management requirements aligned with the IMO’s 2023 Biofouling Guidelines (MEPC.378(80)) that require vessels over 24 m operating in its waters to carry a BFMP and BFRB and maintain a defined fouling rating.

At the time of writing (March 2026), the enforcement of the penalty phase of the regulation, had been deferred and was scheduled to commence on 10 June 2026.

Vessels entering Brazilian waters must arrive with a ‘clean hull’, the requirements are:

- Implement a vessel-specific Biofouling Management Plan and Biofouling Record Book compliant with the IMO guidelines.
- Maintain a clean hull – where ‘clean’ means no biofouling apart from a slime layer (microfouling) and a very small amount of visible fouling species (macrofouling).
- Schedule a hull cleaning if there is excessive fouling. In-water hull cleaning in port must be requested at least 10 days prior to arrival.

Norway

Norway’s Maritime Authority has drafted a new regulatory framework to address ship hull biofouling and prevent the introduction and spread of invasive species via vessels entering or operating in Norwegian waters. These proposed regulations were under consultation until 10 September 2025. These Regulations are expected to enter into force on 1 July 2028.

The wording is: “Ships and mobile offshore units arriving from outside the Norwegian Economic Zone (NEZ) must not have macrofauna (larger organisms such as barnacles, mussels, and tubeworms) on their hulls when entering Norwegian territorial waters. Only microfouling (thin layers of slime and microscopic organisms) is allowed on arrival.”

Click here to read more about these rules.

Antifouling coating system types

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.

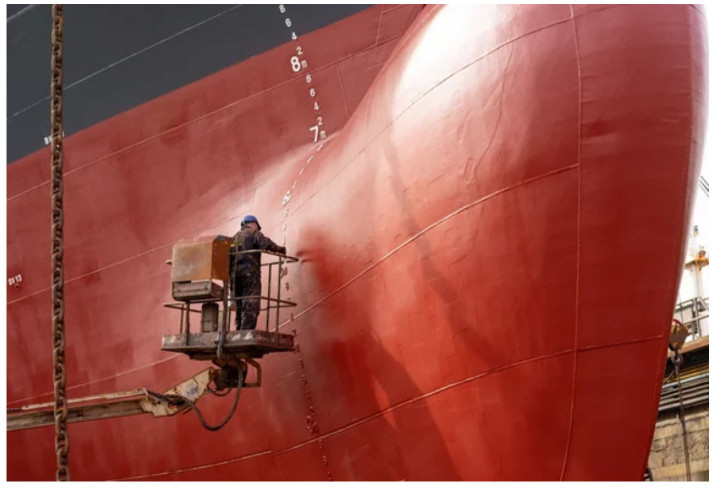
Careful selection of an antifouling coating product for a ship is essential to ensure it meets the requirements of the ship in terms of its trade routes, activity levels and potential biofouling risk encountered during the coating's service lifetime, which could be up to 60 months.

There are essentially two main types of fouling control technology for commercial vessels, biocidal self-polishing coatings (SPC) and foul release coatings (FRC) with products on the market with or without biocides. Alternative coating types are available, including hard coatings. Each coating type works differently and suits different vessel profiles/needs.

To be effective across the entire range of fouling organisms, a combination of biocides is generally used in a coating.

Typical biocide packages usually comprise of a blend of an inorganic biocide (usually cuprous oxide) and one or more 'co-biocides' (organic and/or organometallic) to be effective across a spectrum of target organisms.

However, the biological complexity and the high industrial requirements for hull coatings present an increasingly complex challenge for the current collection of certified biocides.



Self-Polishing 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 fouling control technology use by the global fleet.

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 (FRC)

Foul release coatings typically comprise low surface energy silicone polymers or a hydrogel layer.

The speed of the vessel produces the hydrodynamic shear forces needed for the loosely attached fouling to fall off.

Some foul release antifouling coating products are biocide-free and some contain biocides.

FRC coatings containing biocides use both water flowing over the hull surface to "wash off" organisms and biocidal action to prevent biofouling accumulation.

	Self-Polishing Copolymer (SPC) Coatings	Foul Release (FR/FRC) Coatings
Primary mechanism	When exposed to seawater, the outer layer slowly reacts (hydrolyses) and gradually polishes away, renewing the active surface at the coating-water interface and delivering continuous biocide release. Repelling or having a fatal effect on fouling organisms when close to, or in contact with, the hull surface.	Very low surface energy (usually silicone/fluoropolymer or hydrogel micro layer) prevents strong adhesion. FRCs rely on surface chemistry and hydrodynamics to prevent biofouling on the hull. Water flows over the hull, generating sheer stress, and weakly attached organisms are dislodged from the hull surface.
Typical binder	Hydrolysable polymer binder (commonly silyl-acrylate or similar).	Silicone or fluoropolymer elastomers
Biocide content	Typically, a biocide package of multiple biocides	Products containing biocides, and not containing biocides, are available.
How fouling is controlled	Prevents settlement via biocidal action when biocides are released at the coating surface, when the coating surface is polished by shear force from water flow over the coating surface	Fouling may attach weakly but is easily washed off when the vessel moves through sheer force created from water flow over the coating surface. A hydrogel micro layer prevents fouling organisms from firmly adhering and provides self-cleaning properties.
Surface behaviour	Surface slowly erodes (“self-polishing”)	Surface remains intact. If a hydrogel layer is present, it is constantly renewed.
Performance at low activity / idle	SPC coatings continue to perform when a vessel is stationary or moving slowly. A leach layer may accumulate, potentially impairing biocide release. Certain biocides work well under static conditions and can extend idle performance guarantees. (Selektope)	Needs vessel movement through water to remove fouling organisms if no biocides are present. However, biocide containing FRCs show improved performance when vessels are idle or at low activity.
Typical service life	Long service life, SPC coatings are typically reapplied every 3–5 years between drydockings.	Long service life, FRCs are typically reapplied every 5–7 years Usually, 5 years of service time is aligned with drydock schedules; however, Service life is some-
Suitability by vessel type	All vessel types	Biocide-free FRCs are best suited for use on fast, high-activity ships (e.g., containerships, ferries). FRCs containing biocides are suitable for all vessel types.
Surface damage	Generally robust	More prone to mechanical/abrasion damage
Maintenance / recoating	Maintenance requirements are low. If soft fouling occurs, periodic hull grooming is required. Polish though can occur (coating depletion), which can create a high-risk zone for biofouling grow.Re-coating in dry dock is more straightforward than FRC application.	Requires careful surface preparation; damage repair can be complex

DATA INSIGHTS

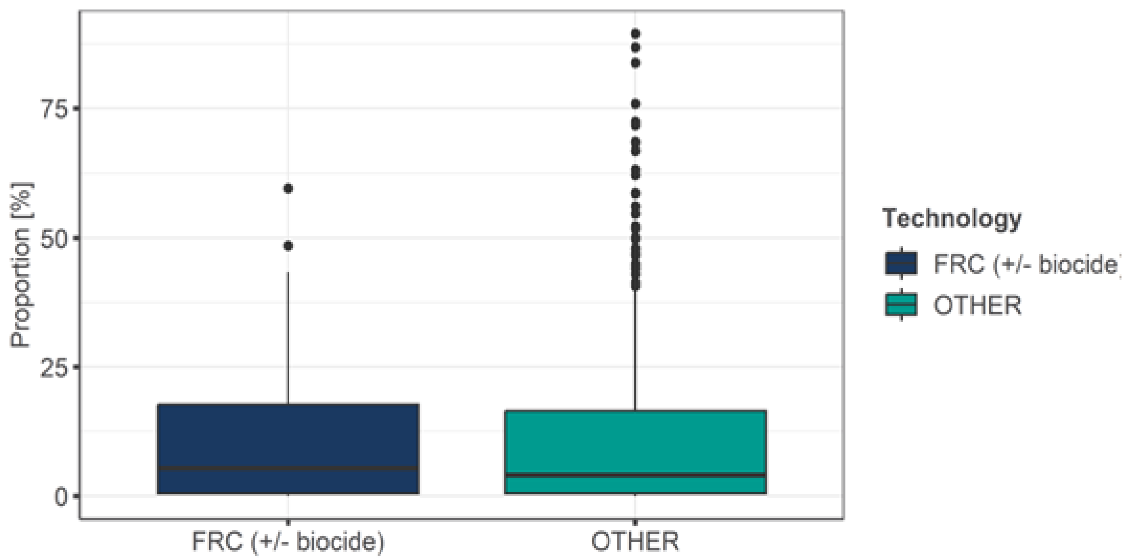
Coating types and barnacle fouling

The dataset analysed in this study comprised 547 historical drydock (DD) attendance reports/hull inspection reports for the period 2015 – 2024, wherein vessel hull conditions were surveyed.

Does coating type influence barnacle biofouling risk?

The answer, according to the dataset analysis, is yes, although in reality a definitive answer to this question is a bit more complicated and wholly dependent on ship type, trading routes and operational profile.

The anti-barnacle performance of SPCs verus FRCs is heavily dependent on vessel type, trade route, idling periods and damage areas. In Figure 3 below, the prevalence of barnacle biofouling (% proportion of biofouling coverage) on two coating types: SPC (biocidal) and FRC (Biocidal + non-biocidal) is compared for the sample group of vessels. In the sample group of vessels, barnacle fouling was found on both vessels with SPC and FRC coatings.



Barnacle fouling presence (% proportion) was marginally higher for vessels with an FRC coating than for vessels with an SPC coating.

The SPC coating vessel dataset had more outlier data, indicating a higher presence of singular high barnacle fouling coverage

Figure 3. Animal fouling by technology. "Other" coatings represent the majority of SPC-coated vessels in the sample group. The single data points represent outliers, i.e., vessels with unusually high fouling prevalence.

Does coating technology grade influence barnacle fouling risk?

The answer is yes. However, this could be related to the suitability of technology grades or coating types for vessels, especially if activity levels or trade routes change during operation between dry dock cycles.

Self-polishing copolymer (SPC) antifouling coatings are often grouped into low, medium, and high (premium) technology grades based on the sophistication of the polymer chemistry, polishing control, biocide system, and expected performance life.

The differences mainly relate to how well the coating controls fouling, maintains a smooth hull surface, and performs over long service periods. The total cost of a coating product is linked to its grade and performance.

In the dataset, foul-release coating products (biocidal / biocide-free) are grouped under the 'FRC' technology. Compared with the different technology grades used for SPC coatings, FRC coatings are typically considered only high-grade 'premium' systems.

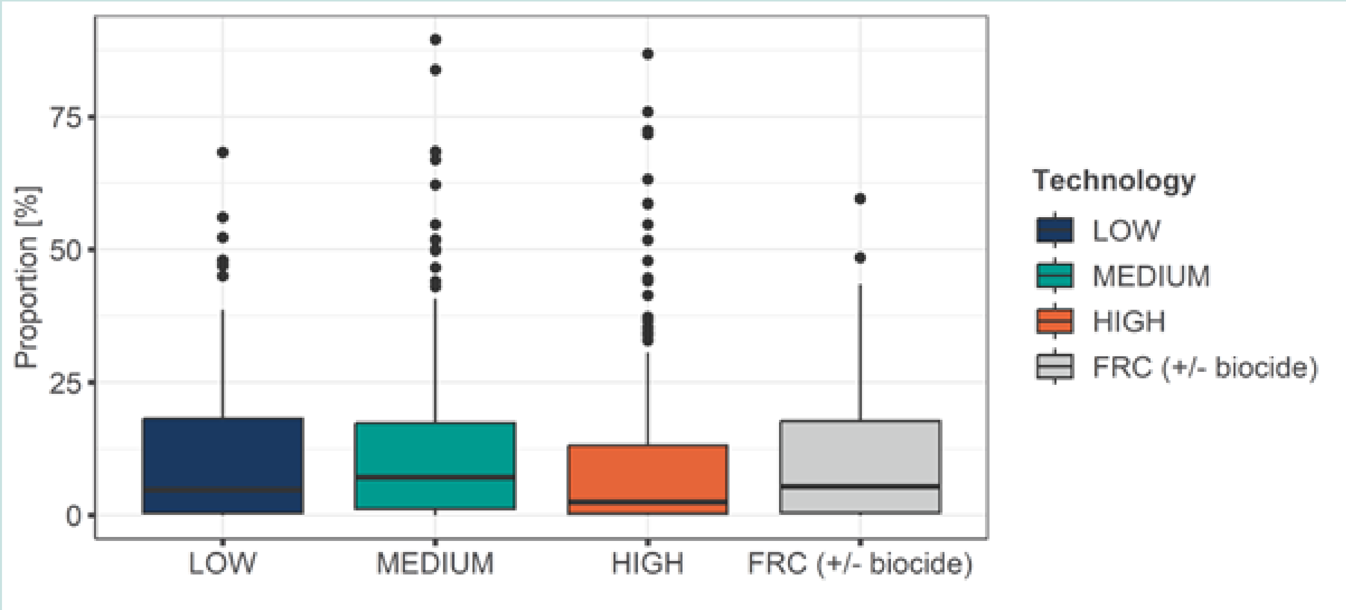


Figure 4. Barnacle fouling prevalence by technology grade: low, medium, high and FRC (inclusive of FRC products with and without biocide)

Foul-release coatings (biocidal and biocide-free) had a greater prevalence of barnacle fouling than high-tier (premium) self-polishing coatings.

Integrating barnacle fouling protection into FRCs

The softness of foul-release coatings (FRCS) makes them vulnerable to scratches, abrasion and mechanical damage (e.g., when the hull comes into contact with fenders during docking). Once the surface is compromised, barnacle settlement becomes far more likely, particularly during extended idle periods.

Foul release coatings reduce the accumulation of marine fouling by forming low-adhesion surfaces that weaken the attachment of biofouling organisms, allowing them to be easily released.

While foul release coatings are often described as being a biocide-free alternative to other commercial biocidal antifouling coatings, many foul release coatings used on ships today are often combined with biocides, such as copper pyrithione (CuPT), to improve protection against primarily soft fouling. Even if no mechanical damage has occurred, if a vessel is idle for long enough, barnacles can form a strong enough attachment. They won't be washed off the coating surface when the vessel sails again.

Vertical sides of the underwater hull area of a LNG carrier with an FRC coating. In service period: Unknown.

Vertical sides of a tanker coated with an FRC. Barnacles attached to mechanical damage areas. In service period: Unknown.

In either scenario, when barnacles can form a strong enough attachment, removing them from a foul-release coating through cleaning practices can cause further damage to the coating.

Although foul release coatings (biocidal, and non-biocidal) are used by a small minority of the global fleet currently, the commercialisation of biocide-containing foul release coatings bring significant benefits to the biofouling management efforts of operators of ship types suited to foul release coating use.

However, while many of today's foul release coatings contain CuPT, as the sole biocide, to mitigate soft fouling, there is generally no additional biocidal protection against hard fouling.

I-Tech's R&D work demonstrates a practical solution: using CuPT as a carrier pigment for Selektope. Key elements of the innovation developed by I-Tech scientists include:

- Selektope is combined with CuPT as a carrier pigment.
- Water penetration gradually dissolves the pigment, enabling a low, stable release of Selektope.
- The system leverages existing CuPT release mechanisms already optimised in modern foul-release coatings.
- The Selektope–CuPT pigment can be introduced as a drop-in solution by partially substituting existing CuPT, without need to redesign a coating formulation.

Schematic illustration of the Selektope release mechanism from the Selektope–CuPT pigment upon exposure to seawater.

R&D INSIGHTS

Test Results: Integrating Selektope into FRCs

To date, no foul-release coatings containing the barnacle-repelling biocide, Selektope, have been commercialised. Now, I-Tech scientists have found a viable pathway for Selektope to be used in foul release coatings.

Extensive R&D activities have confirmed that Selektope can protect against hard fouling during idle periods or in areas of mechanical damage. This breakthrough will offer coating manufacturers a practical pathway to strengthen barnacle protection in their foul-release products, particularly for vessels that encounter extended idle periods or coating damage.

Selektope is a biocide favoured for its highly selective nature and its non-fatal effect on the target organism achieved through a unique mode of action that repels the barnacle larvae from attaching to the hull.

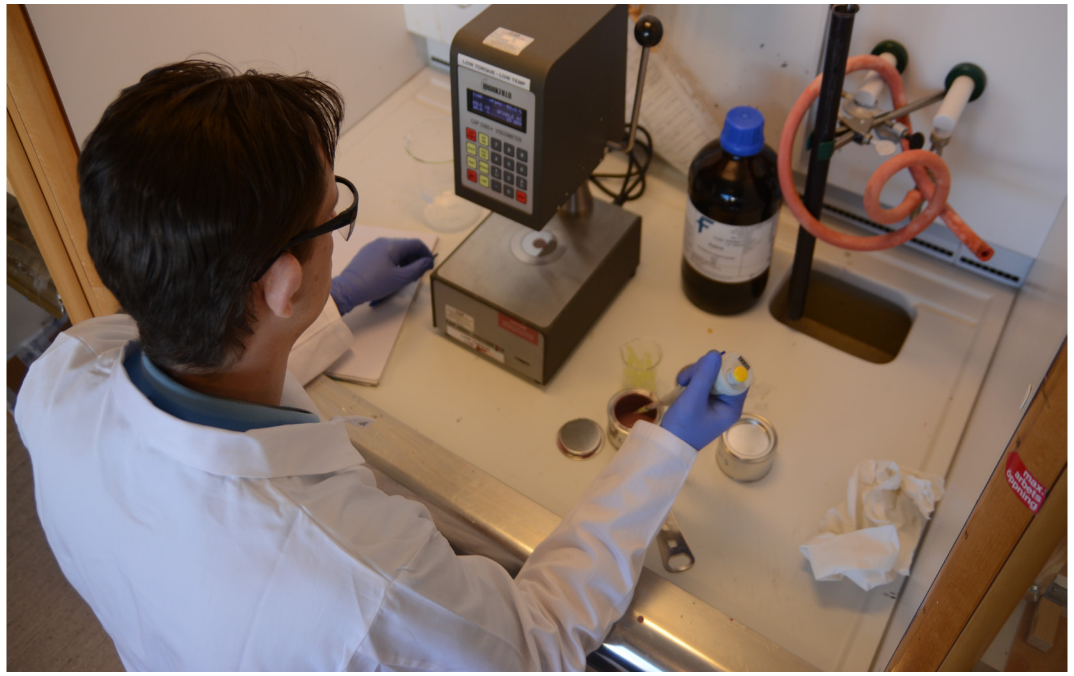


Figure 5 shows three panels painted with a commercial FRC which were submerged for 86 days in the sea outside of the Swedish west coast containing:

- a) no biocides where the surface of the coating was roughened by abrasive paper.
- b) a concentration of 0.1% Selektope in the wet paint where the surface of the coating was roughened by abrasive paper.
- c) the Selektope-CuPT pigment also with a surface roughened by abrasive paper (in total, 0,1% medetomidine and 0,9% CuPT relative to the total weight of the wet paint). These results indicate that controlled Selektope release can effectively protect even mechanically compromised foul-release coating surfaces.

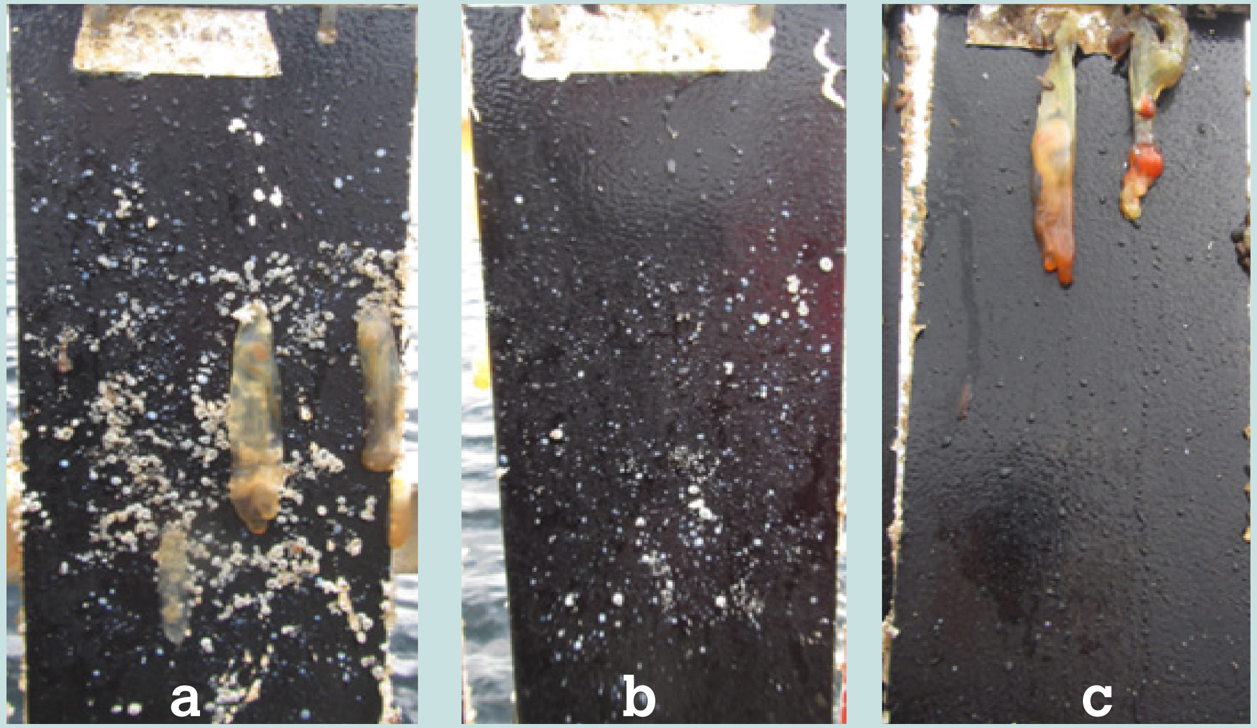


Figure 5. panel test for an FRC containing Selektope with surface roughened versus a FRC not containing Selektope with surface rougheed.

The panel tests in Figure 5 show:

- Damaged surface of a foul-release coatings with heavy barnacle settlement.
- Damaged surface of a foul-release coating containing a Selektope–CuPT system with no barnacle settlement.

These results indicate that controlled Selektope release can effectively protect even mechanically compromised foul-release coating surfaces.

DATA INSIGHTS

Barnacle biofouling: how at risk is my ship?

A dataset comprising 685 individual vessel hull-condition inspections carried out by the Safinah Group was analysed to give an indicator of global fleet barnacle fouling levels.

Two factors not included in the data analysis were vessel activity levels and in-water cleaning events. While the term 'animal fouling' is used for the purposes of this study, animal fouling presence on vessel hulls is pre-dominantly barnacle related.

How common is barnacle fouling?

Very! In a 685-vessel sample, most vessels were not barnacle-free arriving into drydock; most vessels had between 0.1% and 5% of their hull surface covered with barnacle fouling.

The data presented in Figure 6 shows:

- Most vessels had 0.1% to 5% of their hull surface covered with barnacle fouling.
- More than one-third of vessels inspected had >10% of their hull covered with barnacles.
- 18% of vessels inspected had >20% their hull surface covered with barnacles.
- 16% of vessels inspected had "barnacle-free" hulls (<0.1% coverage).

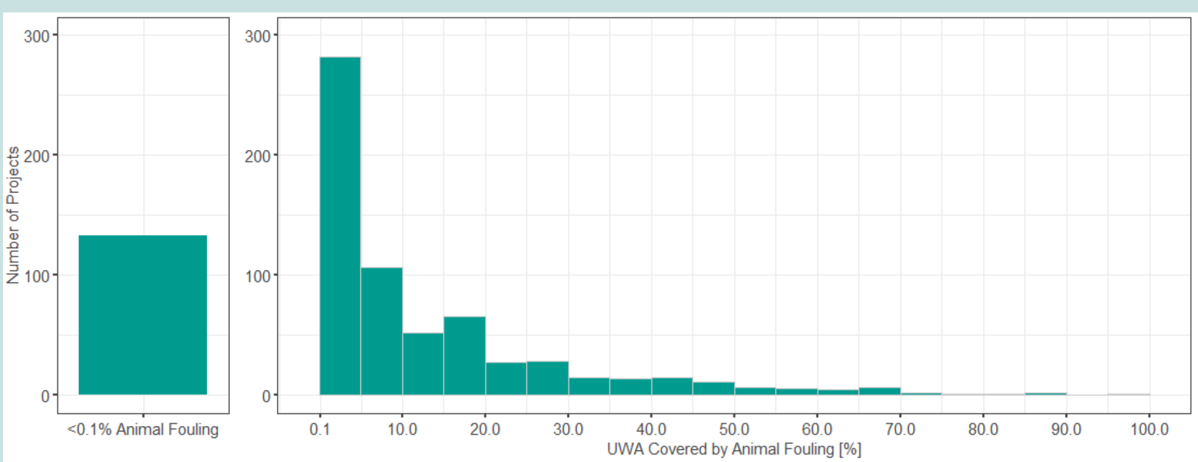


Figure 6. % underwater hull surface covered by barnacle fouling versus number of vessels inspected (number of drydock projects).

Are certain hull areas more at risk from barnacle fouling than others?

The answer is yes; the flat bottom hull area is at a higher risk of barnacle fouling growth.

The data presented in Figure 7 below shows:

More barnacle fouling was present on the flat bottom hull area:

- >20% of vessels had >20% barnacle fouling on the flat bottom.
- >35% of vessels had >10% barnacle fouling on the flat bottom.

Less barnacle fouling was present on the vertical sides:

- >10% of vessels had >20% barnacle fouling on the vertical sides.
- >25% of vessels had >10% barnacle fouling on the vertical sides.

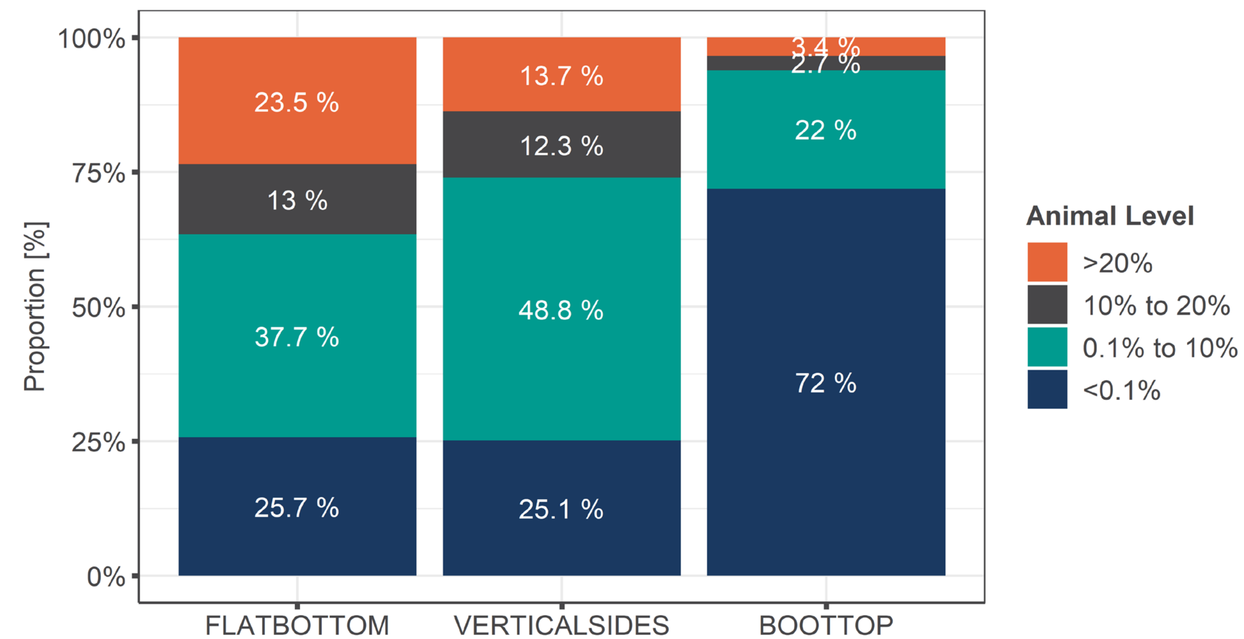


Figure 7. % proportion of barnacle fouling per underwater hull area: Flat bottom versus vertical sides versus boottop)

DATA INSIGHTS

Barnacle biofouling & vessel activity

Barnacle biofouling rates are linked to vessel activity because how often and how fast a ship moves affects how easily barnacle larvae can settle and attach to its hull.

Is barnacle fouling risk linked to vessel activity level?

The answer is yes: lower-activity vessels are at greater risk of barnacle fouling. For the purposes of this study, the following vessel activity assumptions were applied:

- **Relative lower activity vessels:** Chemical/product tanker, crude oil tankers (over 80k DWT), LPG tankers, oil products tankers.
- **Relative higher activity vessels:** Car carriers, crude oil tankers (under 80k DWT), containerships, cruise ships, ferries, LNG carriers.

The data in Figure 8 below shows:

- Barnacle fouling was more prevalent on lower activity vessels.
- Barnacle fouling coverage was more severe on lower activity vessels.
- ~80% of higher activity vessels had <10% barnacle fouling versus ~60% of lower activity vessels had <10% barnacle fouling.

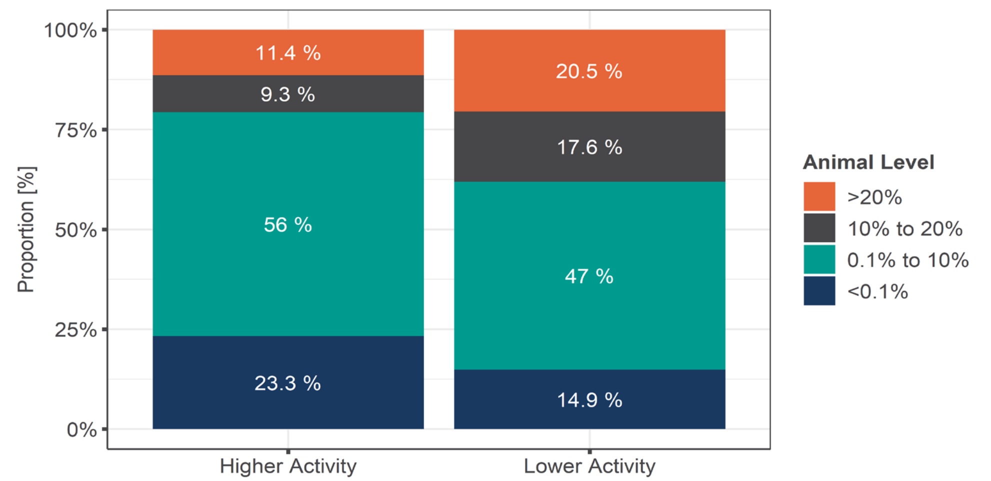


Figure 8. % proportion of barnacle fouling on vessels with a higher activity level versus vessels with a lower activity level.

Does vessel activity level influence where barnacles settle?

Yes: lower-activity vessels have more barnacle fouling on their flat-bottom hulls than higher-activity vessels. However, barnacle fouling on the vertical side hull areas is the same for higher and lower activity vessels.

The data presented in Figure 9 shows:

- A higher proportion of lower activity vessels have barnacle fouling on their flat bottom.
- A similar proportion of lower and higher vessels had barnacle fouling on the vertical sides.

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.

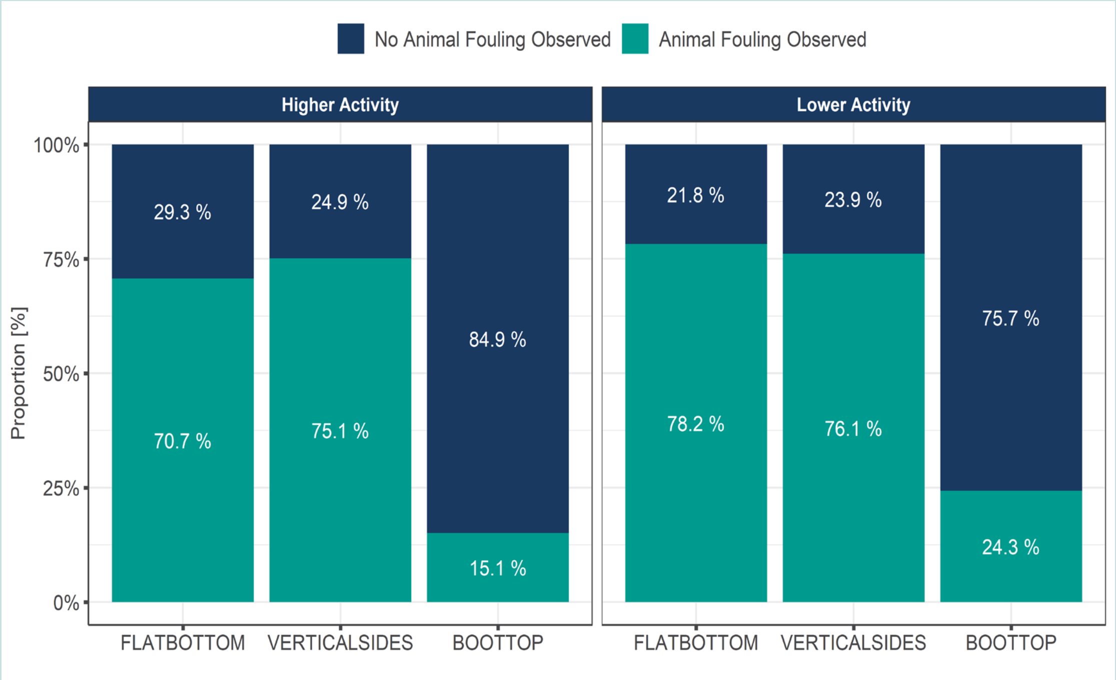


Figure 9: barnacle fouling proportion on different hull areas, for higher activity vessels versus lower activity vessels

DATA INSIGHTS

Barnacle biofouling & vessel type

Barnacle biofouling risk is increased for certain vessel types due to their operating profiles and trade routes. Any vessel that spends more time at low speeds or idle in warmer waters is at a greatest risk.

Are some ship types more at risk from barnacle fouling than others?

The answer is yes; although all vessels are at risk of barnacle fouling, tanker vessels are at greater risk due to their activity patterns and trade routes. However, tankers and bulk carriers were more heavily represented in the datset than other vessel types.

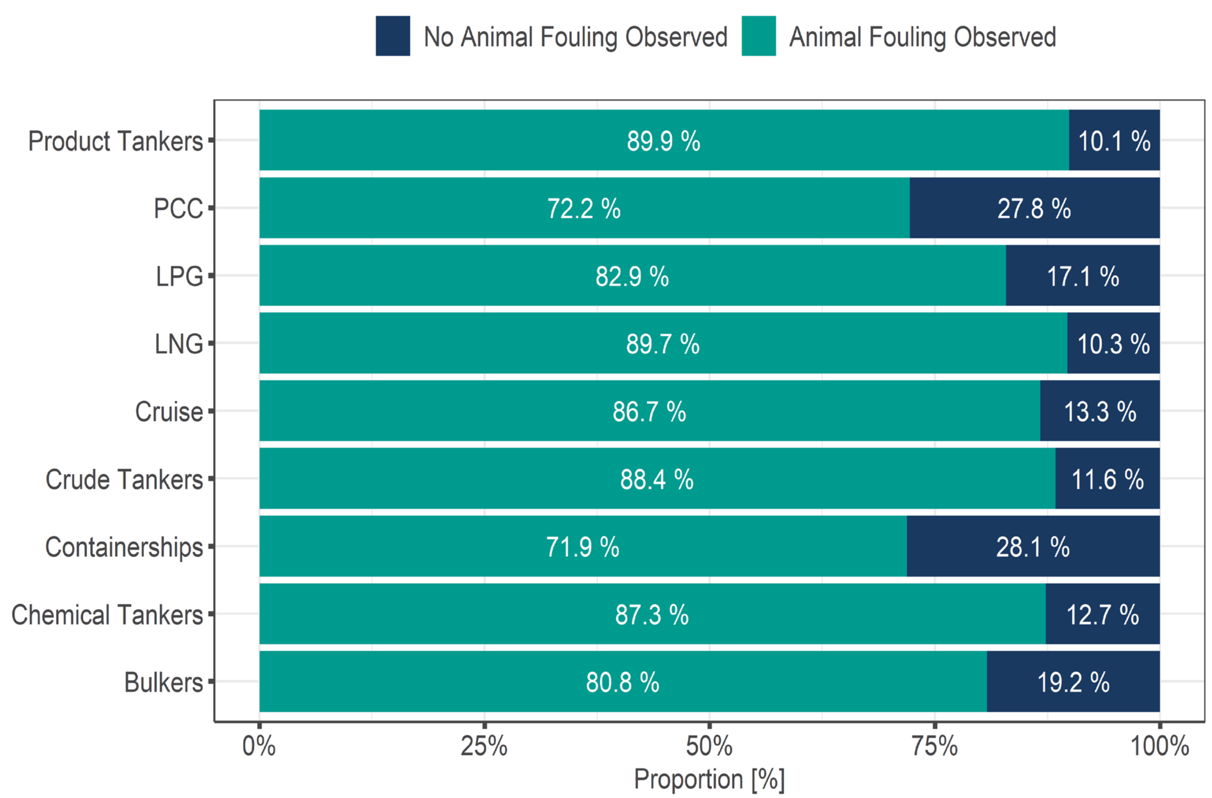


Figure 10. % proportion of barnacle fouling per vessel type

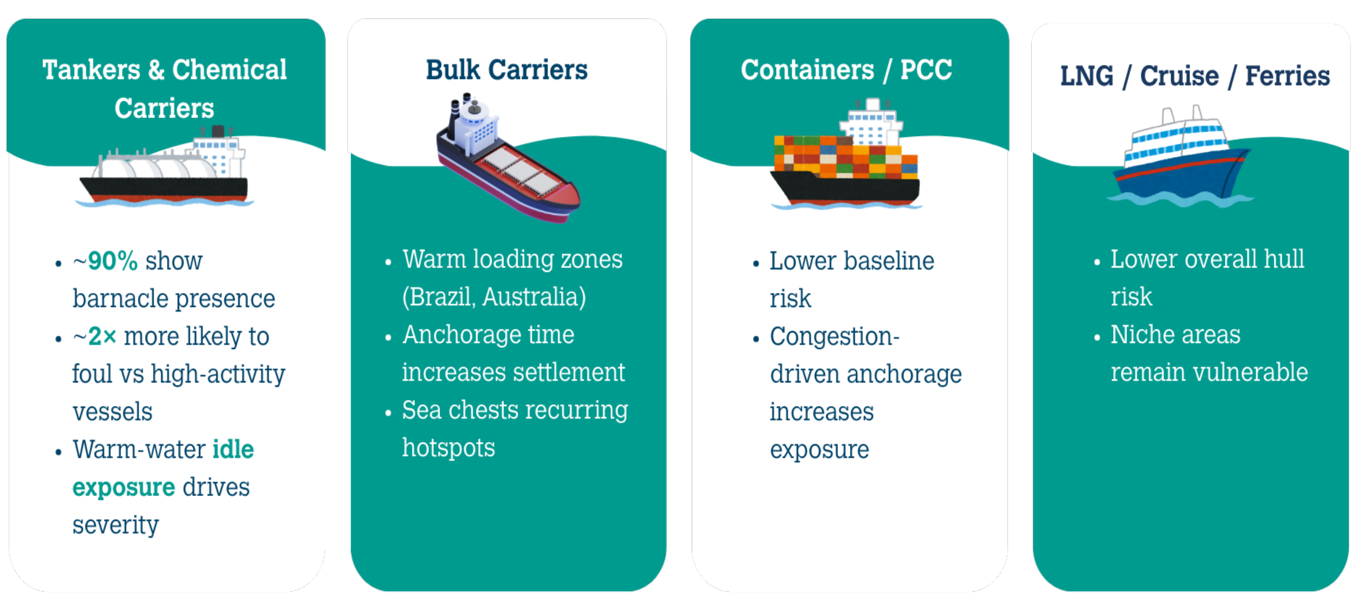
Tankers/chemical carriers are the most affected class; in the 685-ship dataset, ~90% of tankers had barnacle fouling, with frequent idling in warmer waters driving persistent exposure.

Bulk carriers are also at high risk of barnacle fouling, with long waits at warm-water loading and unloading ports (e.g., Brazil, Australia) increasing the risk of barnacle settlement.

Barnacle fouling was less prevalent on containerships and Pure Car Carriers (PCC). For these vessels, higher service speeds reduce baseline risk, but congestion-driven anchorage raises vulnerability; the dataset still shows a sizeable barnacle presence in these classes.

For LNG carriers, cruise ships, and ferries, their lower baseline risk can be attributed to frequent movement and/or higher speeds.

Vessel type is the strongest predictor of risk



DATA INSIGHTS

Spotlight on tankers

The risk of a tanker contracting barnacle fouling is strongly influenced by sailing in warm sea surface temperatures and time spent idle in shallow coastal waters. This is where barnacle larvae are more abundant and grow to maturity much faster.

Tankers are particularly susceptible to barnacle biofouling because their operational profiles often involve prolonged stationary periods during loading, unloading, anchorage, and slow steaming, which provide ideal low-disturbance conditions for barnacle larvae to settle and attach. In addition, tankers have large flat underwater hull surfaces that offer extensive colonisation area, while their frequent movement through warm tropical and subtropical ports exposes them to regions with high barnacle larval abundance. Together, these factors make tankers more vulnerable to persistent hard fouling than many faster or more continuously active vessel types.

Tanker idling patterns

A 2022 study published by I-Tech and Marine Benchmark examined idling and the resulting barnacle biofouling, analysing tanker activity levels over a decade. The risk of tanker vessels in 'fouling idling' activity level – which is a speed of 6knots or less, in waters 15 °C or higher for more than 14 days – was assessed. All tankers with a DWT of 5,000 or more are included in the analysis.

In Figure 11 below, the temperature ranges are displayed as:

Water temperature below 15°C is blue.

Water temperature between 15- 25°C is orange.

Water temperature above 25°C is red.

The data in Figure 11 below shows:

- The number of tanker vessels idling for longer periods has increased steadily between 2009-2020.
- Between 2009 and 2020, an average of 10-12% of tanker vessels were in a fouling idle activity mode.
- During a peak in the number of vessels idling in 2020 (1,421 vessels), over half of those vessels were idling in water temperatures above 25°C.

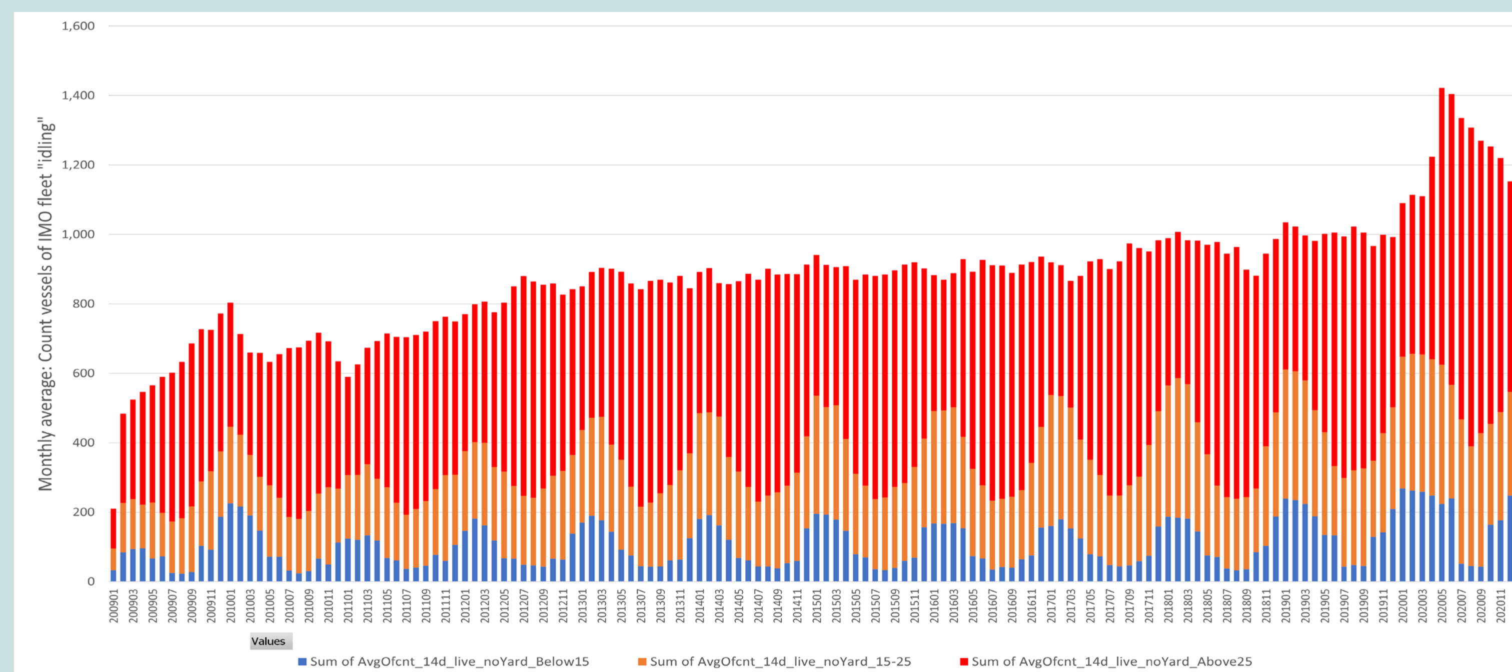


Figure 11. Tanker idling between 2009 -2020.

The importance of coating selection & barnacle fouling prevention strategies

The independent data analyses and various industry and academic papers presented in this whitepaper confirm that barnacle biofouling is a significant issue for the shipping industry, with all vessel types at risk. It is not a marginal maintenance issue that can be fixed with periodic hull cleaning, but a substantial operational and financial risk for the global fleet.

In addition to the barnacle fouling pressures ship operators face today, there is strong empirical and long-term observational evidence linking warming seas to increased abundance and spread of certain barnacle species. Although the effects of climate change (namely, warming water temperatures) will not uniformly increase barnacles everywhere on a global scale, it will expand barnacle populations in some regions and reduce populations in others. However, the net effect will be greater variability, unpredictability, and in many cases increased fouling pressure in warm, high-risk regions.

With over one-third of ships arriving at dry dock with >10% barnacle coverage and one-fifth with >20% coverage, according to data presented in this whitepaper, future strengthening of barnacle fouling risk is something ship operators should treat with great concern.

The high prevalence of extremely impactful barnacle fouling on ship hulls reinforces the need for antifouling coating systems with extended static performance, boosted by biocides that target hard fouling, even under super-static conditions, if barnacle fouling is to be reduced to much lower levels on a global shipping fleet scale.

Variations in barnacle biofouling among vessel types can be attributed to differences in root causes: 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.

Barnacle risk factors are not uniform across the global fleet. Certain ship types (notably tankers) face greater risk due to their operational patterns (e.g. increased idle time, warm-waters,, and coastal anchorages).

Several factors increase barnacle risk: barnacle larvae settle rapidly on idle ship hulls, or those sailing at a speed of <6 knots; warm waters (>25 °C) and coastal/anchorage time intensify settlement; flat bottom areas are disproportionately affected. These patterns explain why the same coating can perform differently on different ships.

Selecting high-performance antifouling coatings with proven static protection against barnacle fouling, aligning operational practices to minimise settlement risk, and adopting route- and profile-specific strategies are all critical factors for maintaining vessel efficiency and compliance.

Strategies to minimise barnacle fouling risk should include:

- **Selecting an antifouling coating product with adequate barnacle prevention control:** does it provide an extended static guarantee against biofouling? If not, look for a product that does. For example, a high-tier antifouling coating that contains Selektope (for anti-barnacle insurance).
- **Warm water routing awareness:** be aware of seasonal fluctuations in barnacle populations in certain areas and route-accordingly, where possible. If vessels are expected to trade frequenlty in warmer waters, choose antfouling coating systems with adequate anti barnacle protection.
- **Idle time management:** avoid extended <6 knots exposure periods, particularly in warmer waters; if safe and permitted, add short, slow transits during long anchorages to disrupt settlement windows.

AVOIDING BARNCLE FOULING

Selektope® and it's role in barnacle fouling prevention

The introduction of the unique and innovative antifouling biocide, Selektope to the market in 2015 has offered antifouling coatings manufacturers the ability to increase static performance and lower biocidal load in their coating products.

As an organic, non-metal active agent, Selektope is 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.

Self polishing coating (SPC) products that contain Selektope are sold by most of the larger marine coatings manufacturers. In SPC coatings, Selektope binds to pigment and other particles and is continuously released in the same way as other biocides.

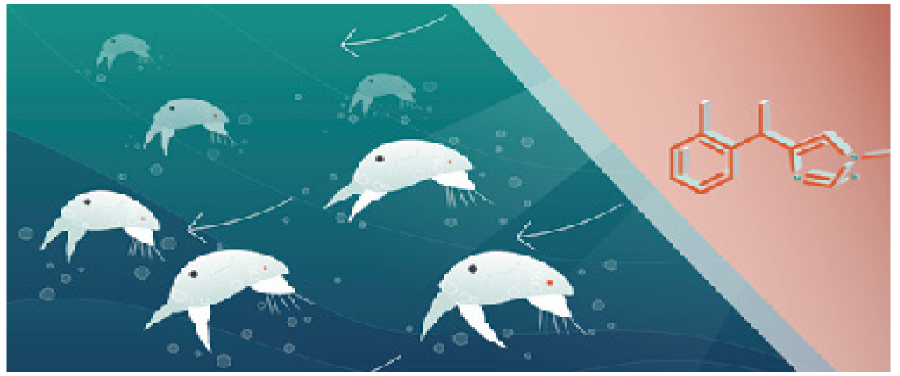
Selektope is a biocide that has highly favourable antifouling properties at low concentrations (nano Molar). To obtain full protection against barnacle fouling, 0.1 - 0.3% w/w of Selektope should be used in a paint formulation. That equates around 2 grams of Selektope per litre of paint, comparable to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

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

Selektope-containing products are offered by several leading paint manufacturers to raise extended static performance to the next level.

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.



Selektope-containing coatings and preventing barnacle fouling

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. 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 presented in Figure 12 below confirms that ships with coatings containing Selektope arrived in drydock with <10% animal fouling coverage on their hull in most cases. On the ships with barnacle fouling present, the fouling was on areas where the coating had polished through (minimised to zero).

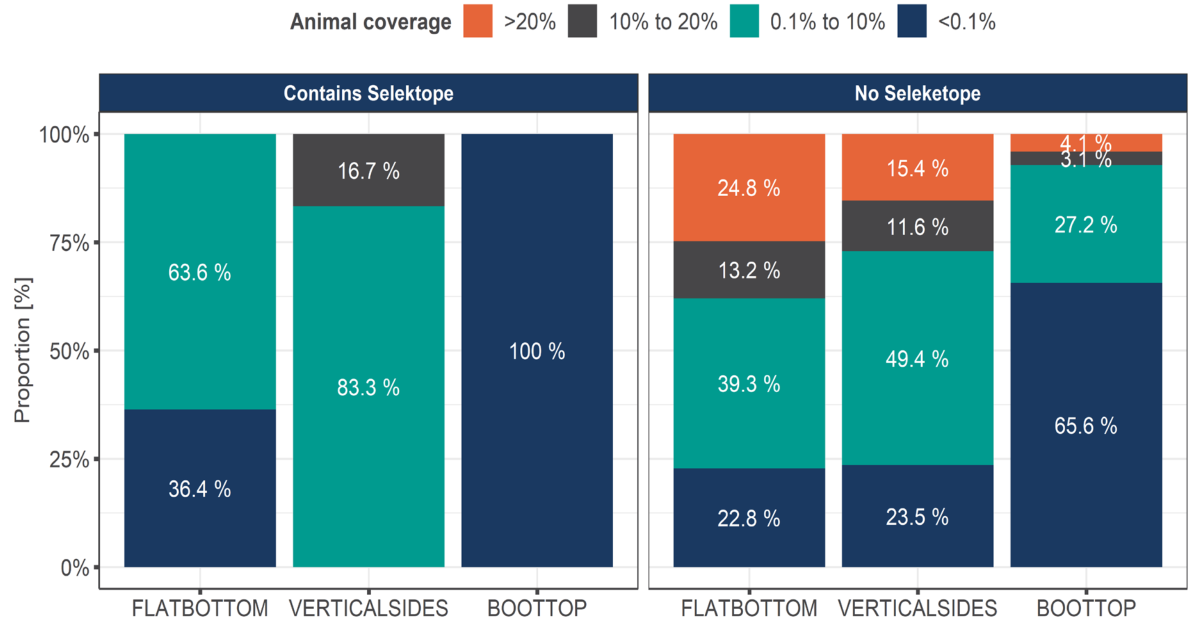


Figure 12. Animal fouling presence on vessels with Selektope-containing coatings, versus vessels inspected with non-Selektope containing coatings.