Smart Ship HUB

BEYOND FUEL SWITCHING

PRESERVING EFFICIENCY IN THE AGE OF BIOFUELS

Executive Summary

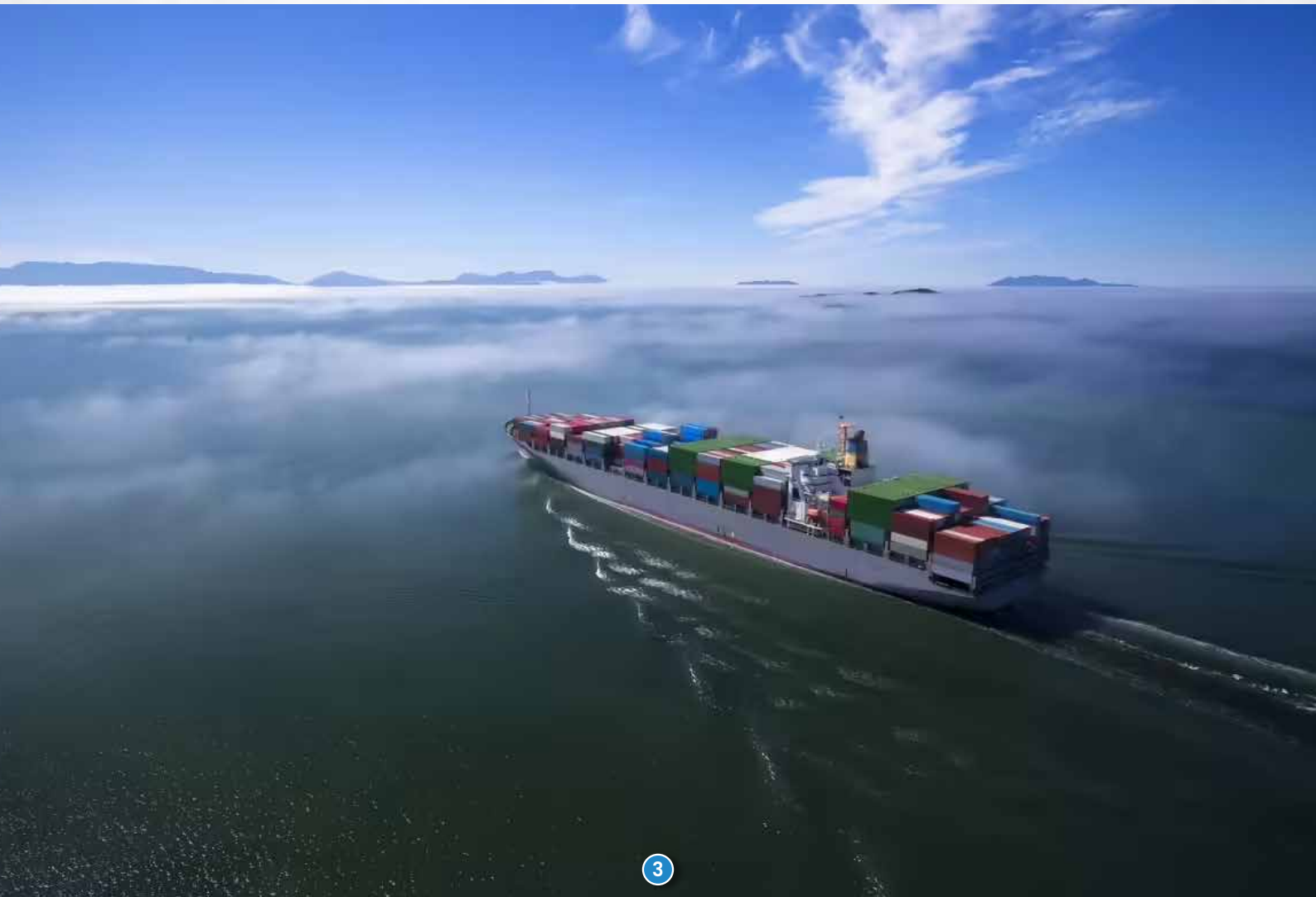
The transition to biofuels is accelerating as ship operators respond to new decarbonisation regulations. However, fuel choice alone does not determine emissions outcomes. Vessel efficiency—including hull condition affected by biofouling—influences fuel consumption, emissions performance, and operating costs. On top of this, the expanded scope of compliance now covers monitoring and reporting of hull condition. In this environment, emissions must be understood contextually. Robust and real-time data capture is critical to understanding the operating environment. This is coupled with advanced analytics to interpret performance drivers, manage variability, and maintain control over both compliance exposure and commercial results.

Introduction

Maritime shipping has seen several phases in its decarbonisation journey. The Carbon Intensity Indicator (CII) and EU Emissions Trading System (EU ETS) frameworks raised expectations around emissions performance. And the global pressure to reduce greenhouse gas output is intensifying.

Amidst these changes, biofuelling has emerged as a practical and immediately deployable technique to reduce lifecycle carbon emissions. It does not demand major changes to vessel infrastructure. This is why operators who prioritise fuel transition strategies and evaluate blends now incorporate biofuels in their operational planning. Their focus is on the fuel consumed and how it helps meet compliance targets and emissions reporting obligations.

However, fuel type is only one part of the complex equation involving ship journey regulations. Without accounting for performance aspects that influence consumption, the benefits expected from fuel transition may not be fully realised. This introduces a critical consideration for the industry: ***preserving efficiency is as important as selecting the right fuel.***



The Efficiency Variable in Fuel Transition

In the maritime industry, we evaluate fuel transition practices through the lens of carbon intensity, but a vessel's operational proficiency also plays a decisive role in real-world outcomes. A significant—and often underestimated—factor affecting this proficiency is **biofouling.**

As marine growth accumulates on the hull and propeller, their surfaces become rougher, increasing hydrodynamic resistance. Even early-stage fouling, in the form of biofilm or slime layers, can increase fuel consumption. As fouling progresses, the vessel requires greater engine power to maintain its service speed. There is a steady rise in energy demand, and emissions grow.

Regardless of the fuel type, higher fuel consumption will increase net carbon output. Even if biofuels reduce emissions on a per-tonne basis, poor vessel operational behaviour offsets a part of these gains.

The commercial impact is significant. Compared to conventional fuels, biofuels carry a cost premium. Where hull resistance increases consumption, operating expenditure rises further, affecting voyage economics and overall cost control.

Efficiency is therefore a determining factor in the success of fuel transition strategies. Without optimal vessel performance, the environmental and economic benefits expected from biofuels remain partially unrealised.

Biofouling as a Regulated Operational Parameter

The **IMO's Sub-Committee on Pollution Prevention and Response (PPR) at its 13th session, held in London** from 9 to 13 February 2026, advanced work on a legally binding framework for biofouling management to prevent the transfer of invasive aquatic species. This marks a move toward enforceable requirements for managing hull condition across global fleets.

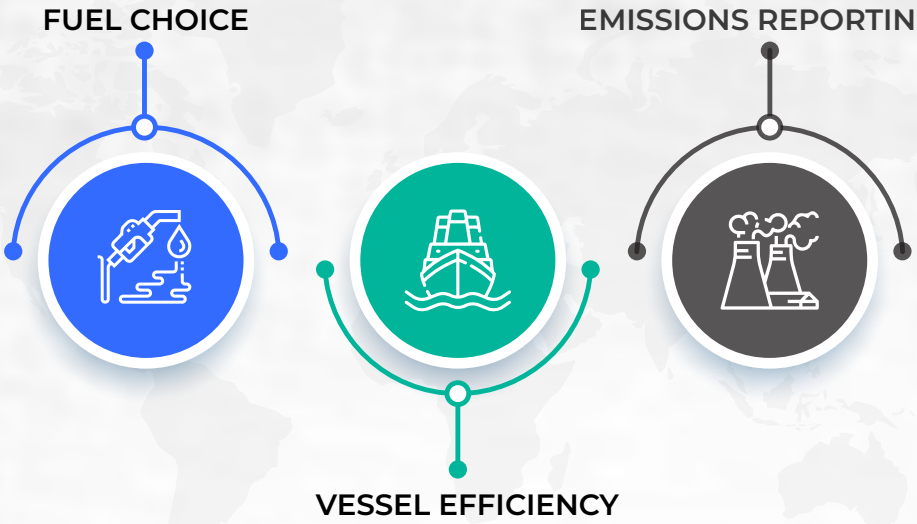
While the environmental goals stay consistent, the operational implications for shipowners are growing. IMO's proposed framework now raises expectations on how biofouling is assessed, recorded, and controlled over time. It is clearly not an issue to be addressed only during scheduled maintenance cycles.

Operators must use structured approaches for inspection, formal documentation of hull condition, and maintenance activities. Instead of organising periodic inspections, they are required to continuously monitor changes to demonstrate compliance. The records they document must be verifiable for regulatory scrutiny at any time.

This new development has repositioned biofouling management from a technical maintenance or drydock-planning task to a measurable, reportable parameter within the compliance landscape. It will now reflect upon vessel owners' operational discipline and audit readiness.

The Convergence of Fuel, Efficiency, and Emissions Reporting

As fuel strategies change in line with regulatory expectations, three operational dimensions are now interdependent:



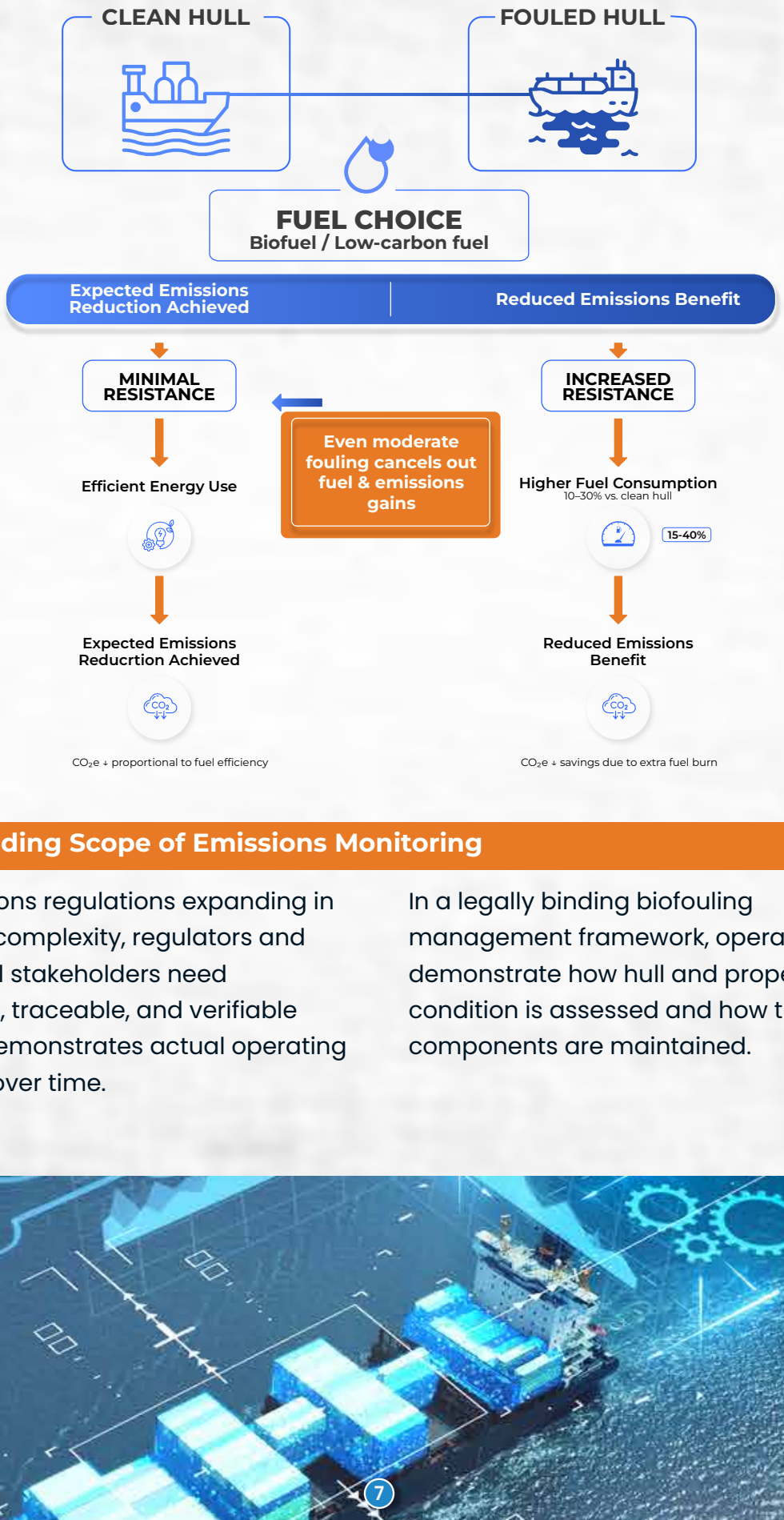
Each impacts the other, and together, they determine the credibility of a vessel's emissions profile.

Fuel choice defines the carbon intensity of operations. Biofuels reduce lifecycle emissions and meet compliance requirements. However, the actual outcome depends on how efficiently the vessel operates in real-world conditions. And the state of hull is a critical factor in determining this efficiency.

The accumulation of marine organisms—such as algae, slime, barnacles, and mussels—increases resistance and fuel consumption, lirrespective of the fuel type used. That's where we see a disconnect between the expected and actual emissions profile.

IMO has stepped forward to address this issue. It requires operators to stop reporting emissions as isolated metrics. They must interpret and explain the factors influencing their numbers — whether driven by fuel selection, operational conditions, or functional degradation.
Emissions reporting without performance context is not credible in an environment where transparency and accountability are central to compliance.

How Biofouling Erodes Biofuel Benefits



The Expanding Scope of Emissions Monitoring

With emissions regulations expanding in scope and complexity, regulators and commercial stakeholders need transparent, traceable, and verifiable data that demonstrates actual operating conditions over time.

In a legally binding biofouling management framework, operators must demonstrate how hull and propeller condition is assessed and how these components are maintained.

Continuous observation of degradation patterns and evaluation of performance before & after repair interventions are essential for operational control and audit readiness.

This creates a need for high-resolution data across multiple dimensions. The ability to track hull condition, detect fouling-related loss in system response, and align maintenance decisions with observed trends provides the foundation for both compliance and vessel efficiency.

Data must not only be accurate but also defensible — capable of explaining performance variations and supporting compliance claims. Under increasing regulatory scrutiny, the focus is on demonstrating how the emissions footprint was measured, validated, and influenced by underlying operational conditions

Emissions Analytics: Understanding the Drivers Behind the Numbers

The real value of emission figures to judge operational effectiveness lies in understanding what drives those numbers and how they are likely to change under varying conditions. That's where ship operators need emissions analytics.

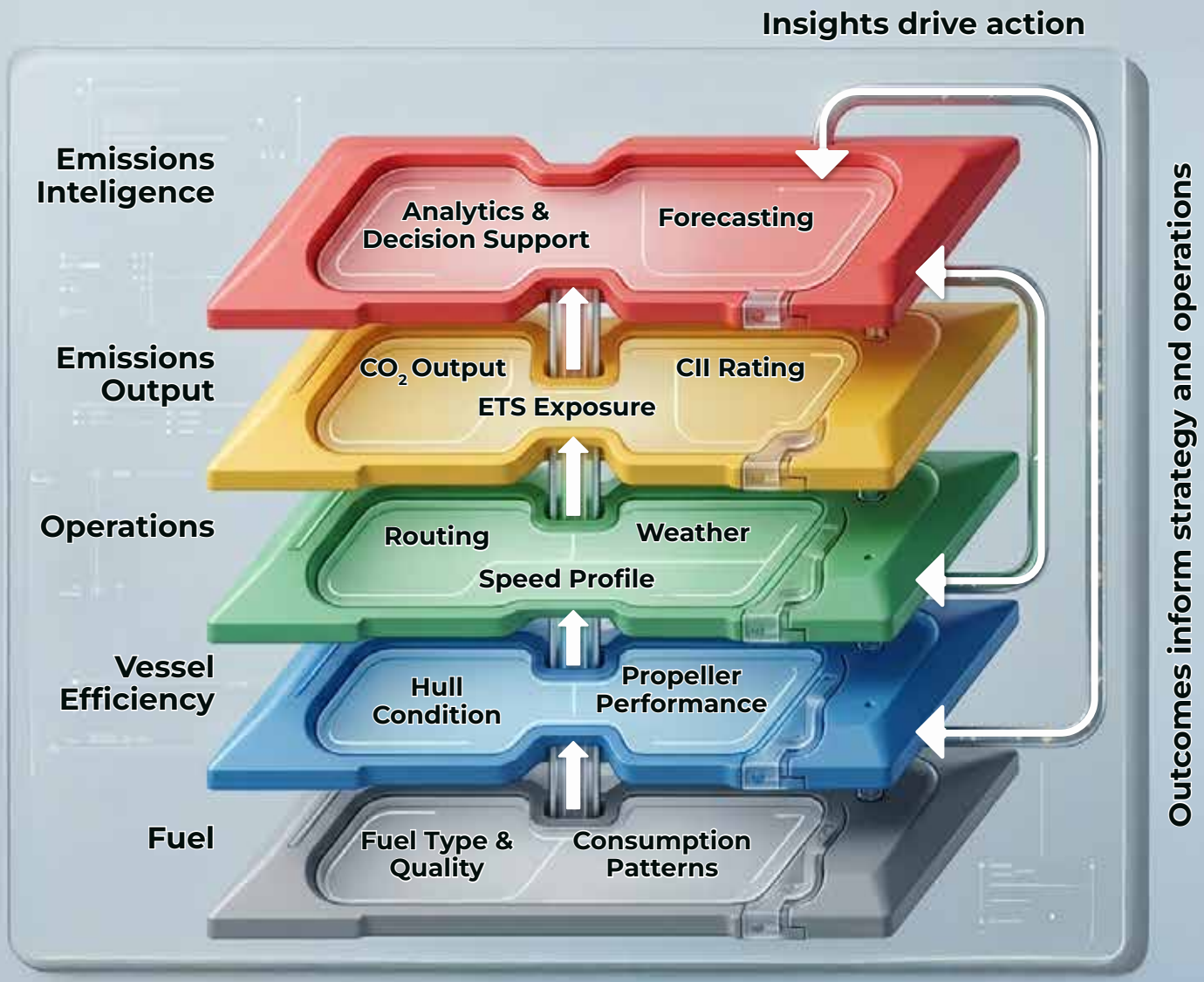
By establishing performance baselines and tracking deviations over time, operators can distinguish between expected variation and emerging inefficiencies. They can examine changes in emissions intensity in relation to factors such as hull condition, voyage profile, or fuel characteristics. The analysis enables a more accurate interpretation of operational behaviour than the results from aggregated indicators.

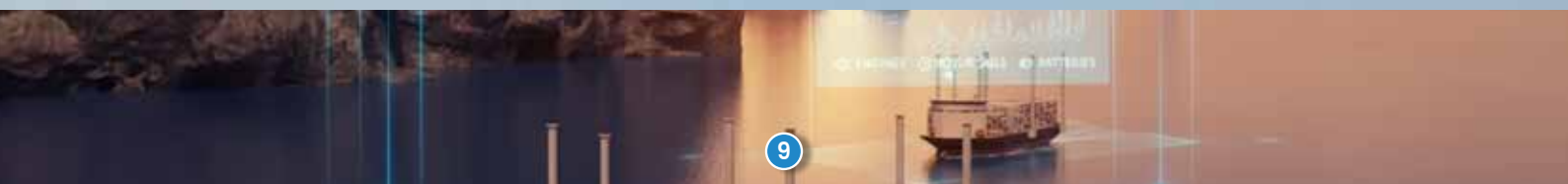
A key capability is correlating multiple data streams to identify cause-and-effect relationships. For example, a gradual increase in emissions intensity may be associated with subtle degradation patterns that are not detectable during routine checks. Early identification of such trends by sensors enables timely intervention and avoids escalation.

Leveraging emissions analytics operators can analyse historical patterns and current operating conditions to anticipate how performance is likely to be affected, and adjust maintenance plans accordingly.

In this context, emissions data is a source of insights and not a mere record of patterns. It enables more informed and controlled operational decisions.

THE EMISSIONS INTELLIGENCE STACK





The Commercial Reality: Cost, Compliance, and Control

Marine enterprises shape decarbonisation decisions based on the financial consequences associated with them. Biofuels that support emissions targets introduce a high-cost base that must be managed with accuracy. Fuel usage, therefore, directly impacts voyage economics.

COST

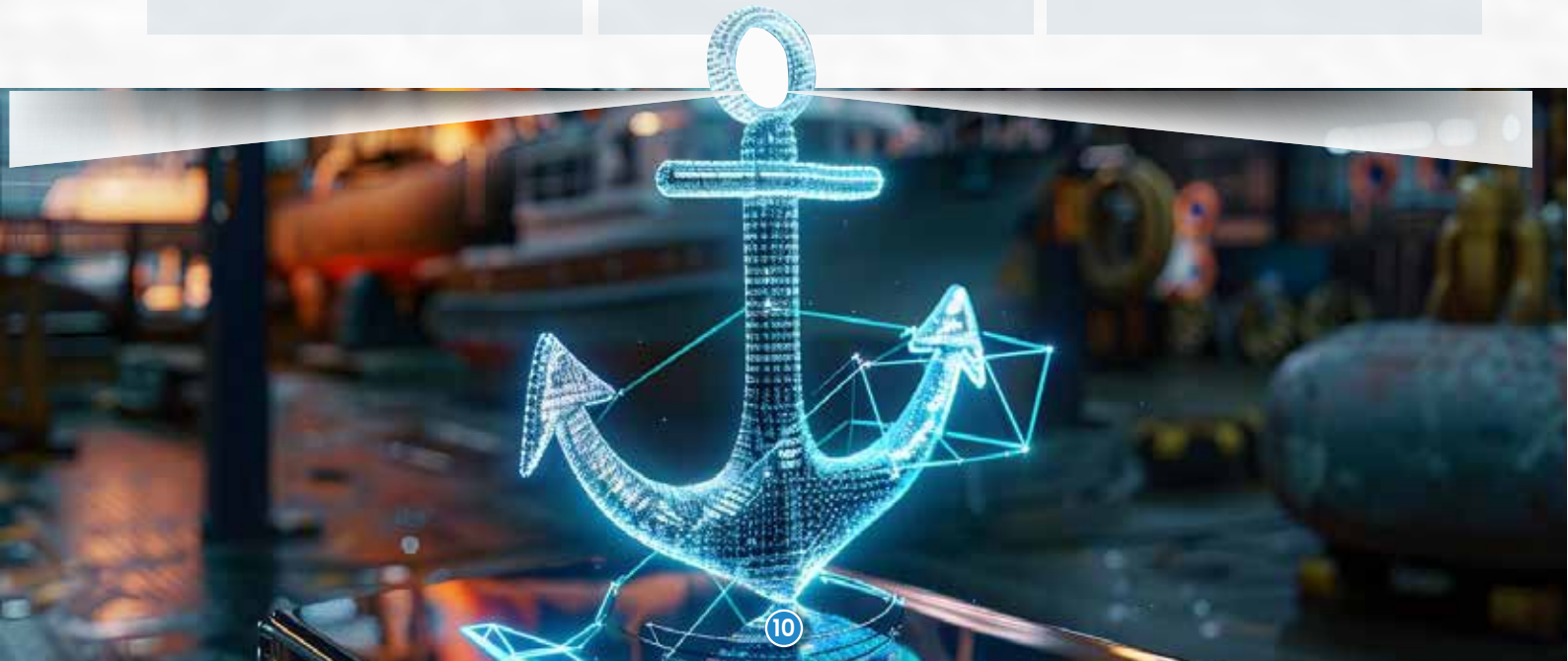
Biofuels carry a premium. Even marginal increases in consumption will significantly increase operating expenditure. When that cost is considered across multiple voyages and an entire fleet, variations erode the expected financial gains from fuel transition strategies.

COMPLIANCE

Regulatory mechanisms such as carbon pricing and efficiency ratings convert emissions operating trends into financial exposure. Emissions intensity is now linked to direct penalties under market-based frameworks.

CONTROL

Controlling these pressures requires continuous alignment between operations and commercial outcomes. Decisions for routing, maintenance timing, and fuel deployment must therefore be assessed for both technical stability and cost implications under evolving regulatory conditions.



The Next Phase of Maritime Decarbonisation

The aims of maritime decarbonisation are clear, and meeting them requires more effort by ship operators. The fuel transition will play a central role, and biofuels offer a practical near-term pathway. Meanwhile, expanding regulatory expectations place more emphasis on how emissions are measured, reported, and managed.

With this change, the emissions trajectory must be gauged in relation to operating conditions, performance factors, and fuel strategies. Biofouling is a critical variable here. It influences energy demand, affects emissions intensity, and is increasingly within the scope of regulatory oversight.

Vessels whose high-frequency data can be recorded constantly for predictive maintenance have an advantage in controlling biofouling. The information collected by IoT sensors helps to interpret performance, identify variation, and support informed decisions. Its monitoring brings visibility, and analytics provide the context required to act with confidence.

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