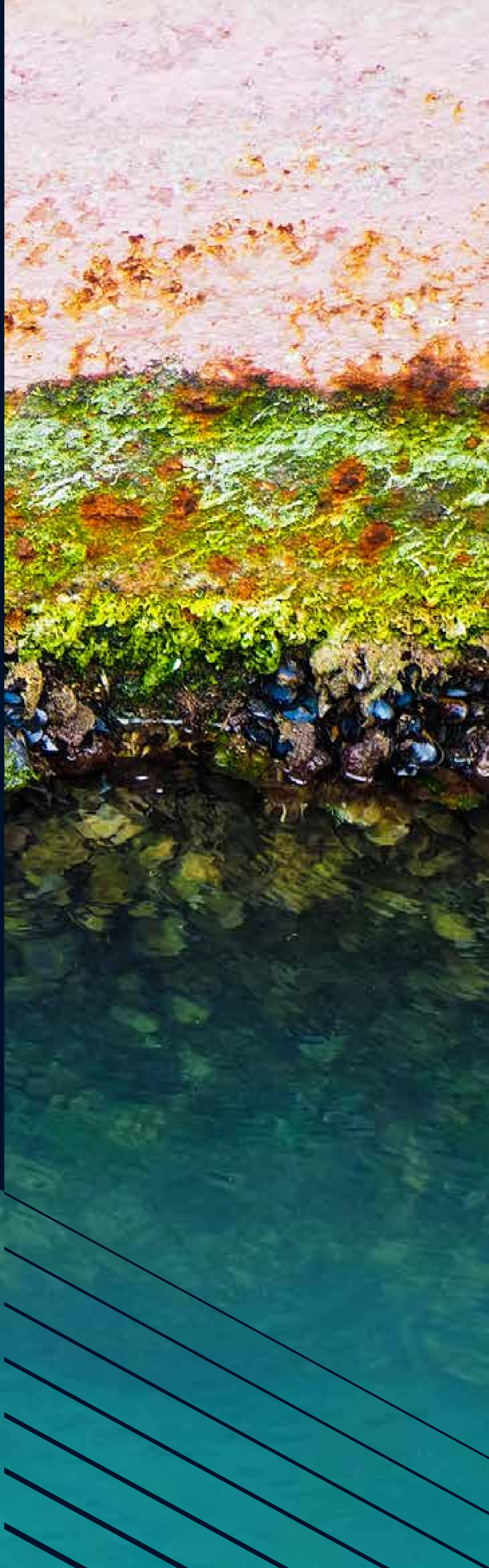
Lloyd's List Intelligence

Reflections on speed and performance claims (Part IV)

Hull fouling in practice

By Prokopios Krikris FCIArb,
consultant and arbitrator



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Prokopios Krikris has broad experience in charterparties, including contract drafting, operations, claims and arbitration. He has worked across commercial, technical, legal and operations departments, overseeing ship operations and major repairs on board.

In addition to his work as a consultant, expert, and arbitrator, he has held senior roles such as Operations Manager, Post-Fixture Claims Manager, and Legal Director. Prokopios holds a Master's in Maritime Studies, a Master's in Maritime Law (distinction), a postgraduate qualification in Contract Law (First Class, 19.2/22), a CIArb diploma in Maritime Arbitration, and many accreditations from CIArb, Lloyd's, and RICS, in dispute resolution.

He has published extensively on speed and performance, piracy-related costs and laytime disputes, delivered training in various companies, and handles charterparty claims beyond performance issues. He is a Fellow of CIArb, a Member of Baltic Exchange and a LMAA Supporting Member.

The series "Reflections on Speed and Performance Claims" presents the reasoning applied by arbitrators in their decisions and sets out various observations based on the parties' arguments submitted in several cases.

Reflections on speed and performance claims (Part IV)

Hull fouling in practice

By Prokopios Krikris FCIArb, consultant and arbitrator

Introduction

Hull fouling is a challenge every shipowner, operator and charterer faces. Marine growth on a vessel's hull increases drag, reduces speed and raises fuel costs. Beyond these technical effects, fouling often leads to disputes under time charterparties, raising issues of responsibility, evidence and cost.

This article provides a clear and practical overview of the subject, examining fouling risks, evidence, engine parameters such as slip and rpm, expert assessments and loss calculations. These matters have been widely addressed in arbitration and English law and remain central to performance claims. The aim here is not to provide an exhaustive study, but to share practical observations that balance legal and factual considerations and explain market practices in performance analysis, considering the recent debate[1] of "alternative methods" in evaluating the vessel's performance.

Background

Biofouling increases hull roughness, raising frictional resistance and reducing vessel speed and fuel efficiency. This often leads to disputes over hull cleaning delays, de-fouling costs, underperformance claims and bunker quantity. It also impacts bunkering operations, as higher fuel consumption and longer voyages may require additional bunkers or route deviations.

Fouling may be established either through direct physical evidence or by circumstantial indicators, such as elevated slip percentages[2] in good weather conditions, engine load, bunker consumption or a combination of these. It can also be explained through logical reasoning since slip serves as a reliable indicator of fouling, weather and current. Once weather and current factors are ruled out and the slip remains high,[3] fouling is a logical explanation for the vessel's underperformance. This reasoning has been acknowledged in recent LMAA awards and in the assessments of experts on vessel performance.[4]

With respect to direct evidence, reported cases illustrate that parties have relied upon diver inspection reports, hull condition survey findings (waterline area of inspection) and laboratory analyses of fouling samples. In some instances diver reports were incomplete, or the reported extent of fouling was challenged by observed

[1] *Eastern Pacific Chartering Inc v Pola Maritime Ltd (The Divinegate)* [2023] 1 Lloyd's Rep 442; *London Arbitration 23/21*, (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.

[2] See *Bulfracht (Cyprus) Ltd v Boneset Shipping Co Ltd (The Pamphilos)* [2002] 2 Lloyd's Rep 681 at para 9; *London Arbitration 23/21*, (2021) 1094 LMLN 1.

[3] In *The Divinegate* [2023] 1 Lloyd's Rep 442, the charterers' expert gave a 5 per cent margin. In *London Arbitration* 15/23 (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023, the tribunal allowed a margin of 7.5 per cent, whereas other experts in other cases provided a range of 5 per cent to 8 per cent as an allowance. The propeller duct may also reduce the slip.

[4] *The Divinegate* [2023] 1 Lloyd's Rep 442.

reductions in speed and high slip rates under favourable weather conditions during the voyage. Accordingly, a comprehensive evaluation of all available evidence is essential, encompassing both diver reports and performance data. This is why, in most instances, the weather routing report *alone* is insufficient to evaluate the matter; however, a comprehensive weather routing report can be helpful in some cases to supplement the analysis of a third-party expert or a decision-maker.

Fouling on delivery is a common issue that is often disputed. The mere delivery of a vessel with a fouled hull does not automatically entitle the charterers to bring a claim against the owners. Liability arises only where fouling can be shown to have a demonstrable impact on the vessel's performance (causation established) and the resulting losses can be quantified with *reasonable* certainty. For this task, various methodologies exist to quantify such losses, ranging from the "good weather" method to alternative approaches (as addressed later in this article); however, the starting point of reference remains the contract.[5]

Disputes frequently arise during a voyage, either because hull cleaning arranged by the charterers has been inadequately performed, or due to disagreement as to which party bears the risk of fouling caused by prolonged idling. Disputes also arise after redelivery on the basis that the charterers have not cleaned the ship's hull before redelivery. Such disputes typically hinge on the interpretation of the relevant contractual provisions and a careful analysis of the evidence.

[5] *The Divinegate* [2023] 1 Lloyd's Rep 442; *Bulk Ship Union SA v Clipper Bulk Shipping Ltd (The Pearl C)* [2012] 2 Lloyd's Rep 533.

Hull roughness

General

As a vessel moves through calm water it encounters resistance, which is influenced by speed, hull form (including draft, beam, length and wetted area) and water temperature. This resistance increases with speed. Additional resistance can then arise from appendages, steering, wind, waves, currents and shallow waters.

A clean hull minimises frictional resistance, whereas fouling from marine growth can markedly increase fuel consumption. In addition, efficiency can be reduced as a result of propeller fouling or damage. Efficiency is maintained through regular inspections, cleaning and drydocking.

Fouling

Hull condition matters as increased roughness raises power demand and fuel consumption to maintain the same speed. Roughness may result from mechanical damage, corrosion or biofouling – the most significant contributor – since it increases resistance and propulsion requirements. Hull deterioration naturally occurs after several years of the ship being in the water due to an increase in skin friction and reduced propeller efficiency,[6] and typically the speed and consumption figures must be adjusted accordingly to account for this deterioration.

Rates of biofouling accumulation vary significantly with the type, age, and condition of the hull coating, as well as the vessel's operating patterns – voyaging, anchoring, and lay-up – and the geographical regions involved. Biofouling can include microfouling and macrofouling,[7] and each has a different contributing factor to the vessel's performance.[8] To illustrate, propeller polishing as a remedy can deliver gains in terms of power from 3 per cent to 6 per cent.

[6] See *London Arbitration 23/21*, (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
[7] IMO MEPC.207(62).
[8] Plessas, "Ship Performance Assessment Based on Observed Fouling" (Sealion Engineering, 2023).

Fouling is primarily controlled through the use of anti-fouling coatings and in-water cleaning. However, frequent cleaning can damage coatings and reduce their effectiveness, which is why fouling clauses stipulate that cleaning is to be performed in accordance with the paint manufacturer's recommendations (although this is not always feasible). Even after cleaning, hulls rarely return to their original state, which explains why using improved performance after cleaning as a benchmark to calculate loss should be treated with caution. In *London Arbitration 15/23*[9] the specialist arbitrator in recalculating loss due to fouling allowed a 7.5 per cent slip; speed deficiency was calculated over that benchmark.

The density of roughness and the location affect resistance. As the density of the roughness increases over the surface, the additional resistance also rises. While some areas, especially niche areas,[10] may become fouled without significant performance effects, accurate assessment requires both visual inspection and performance evaluation. Therefore, understanding performance evaluation is key, rather than reliance solely on fouling analysis.

Performance evaluation is complicated by variable environmental conditions (such as wind, waves and currents) and non-environmental factors (including draft and trim). To isolate the influence of hull and propeller roughness, these external effects must be minimised. Additionally, as displacement increases, draught rises, expanding the wetted surface area and further increasing hull resistance. However, alterations in trim do not *always,* in themselves, have a detrimental effect on the vessel's performance, as was established in *London Arbitration 23/21*.[11]

In *London Arbitration 15/23*[12] the tribunal disregarded periods during which the swell was insignificant, on the basis that such conditions likewise had no impact on performance. This approach is once again grounded in a process of logical reasoning, as previously discussed.

Biofouling impact

As noted earlier, biofouling makes the hull surface rougher, which increases frictional resistance and directly affects a vessel's speed and fuel efficiency:

- Speed decreases, depending on the extent and location of fouling.
- Resistance increases, since frictional drag grows with surface roughness.
- Fuel consumption rises significantly, as more power is needed to overcome the added resistance.

The impact can be calculated using a resistance formula that considers frictional resistance, water density, wetted surface area and coefficient of friction, which is influenced by hull roughness and the vessel's speed. Another formula can then be applied to calculate the effect this resistance had on the speed, using the resistance-power-speed relationship.

However, all these formulas are approximations and sometimes come with a degree of error, since "accurately assessing hull resistance presents numerous challenges due to the complex interaction between the ship's hull and the surrounding environment. Many factors, such as hull shape, surface roughness, ship speed and environmental conditions significantly impact the total resistance. Therefore, several methods have been developed to evaluate the hull resistance".[13]

The late Cedric Barclay, an experienced arbitrator during the 1970s and 1980s, with a technical background, stated:[14]

> "The effect of fouling on speed cannot be calculated with any degree of precision. ... A lot depends on the type of underwater growth. Hard mussels and barnacles (which will adhere solidly to the hull within 48 hours) can cause a large increase in resistance, while weeds and marine grass act to a lesser extent since the vegetable growths do tend to follow the streamlines and act as a heavy fur rather than as an appendage. ... Heavy fouling can cause up to 7 or 8 per cent reduction in the revolutions per minute (rpm) of the engine and perhaps 15 to 20 per cent loss of the ship's speed."

These figures in Barclay's article are supported by practice.

[9] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
[10] Areas on a ship that can accumulate biofouling.
[11] (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
[12] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
[13] J Ambiel, C Leclercq, M Cochennec, "Simple Model for Data-Driven Ship Power Prediction", 9th Hull Performance & Insight Conference (2024), page 157; http://data.hullpic.info/HullPIC2024_Tullamore.pdf (accessed 30 September 2025).
[14] Barclay, "Speed and consumption warranties: Why do ships fail to maintain their warranted speed?" [1974] LMCLQ 13, at pages 16 and 17.

Anti-fouling paints

Anti-fouling paints are used to coat the underwater surfaces of ships to prevent sea life, such as algae and molluscs, from attaching themselves to the hull, which can slow down the ship and increasing fuel consumption.[15] However, their development and application have sparked technical, economic and regulatory disputes for decades[16]. The origins of anti-fouling paints were discussed in a 1982 case,[17] where it was noted that such paints have been known since the middle of the 19th century, but it was not until the time of the Second World War and onwards that there was much understanding of the mechanism of their action. The concept of controlling the rate of release of toxic substances from marine paints was first proposed in 1947. Around this time, it was also suggested that one of the major factors influencing anti-fouling performance was the equilibrium permeability to water of any vehicle containing a soluble toxic agent. At that time, so-called soluble matrix anti-fouling paints based on rosin were well known, which functioned by simultaneous dissolution of medium and toxic pigment.

These concerns, coupled with broader environmental protection issues, have led many countries to enact legislation, with some imposing particularly strict measures.

Arbitration

The condition of the anti-fouling paint, as well as the manner and location of its application, were issues for determination in several court and arbitration cases. In *London Arbitration 17/98*[18] the owners asserted that the ship's bottom had been cleaned, touched up and coated with anti-fouling paint. On the basis that such a coating should have a life span of about two years, they had contended that there was nothing wrong with the state of the ship's bottom. The charterers responded by saying that the assertion that the life span of anti-fouling measures should be about two years was generalised. In the present case, the events occurred some 15 or 16 months after the anti-fouling paint had been applied. They had also pointed out that much depended on the condition of the ship's hull when the anti-fouling coating was applied, as well as on its actual application and, of course, upon the use of the ship in the intervening period.

The tribunal found that the owners' evidence was unsatisfactory. While there was a report from the yard that had carried out the anti-fouling work, it contained only the barest details and there was nothing specific as to the previous condition of the ship's bottom, nor as to precisely how the coating had been applied or whether it was sufficient in all the circumstances. The charterers' claim succeeded in placing the ship off hire for the time spent cleaning, and the owners' claim for cleaning costs was unsuccessful.

In *London Arbitration 24/05*,[19] the ship waited for a prolonged stay at Brazilian ports and the charterers asserted that the anti-fouling paint applied at the vessel's drydocking had been applied at a below-specification dry film thickness and was of a relatively low quality. However, the tribunal held that the prime cause of the vessel's bottom fouling was its prolonged stay in Brazilian waters in an area where no anti-fouling paint could be expected to perform adequately for port stays in excess of 14 days.

15 See www.imo.org/en/ourwork/environment/pages/anti-fouling.aspx (accessed 30 September 2025).
16 *M'Millan v Dick & Co* (1903) 10 SLT 631.
17 *International Paint Co Ltd's Application* [1982] RPC 247 (Court of Appeal).
18 (1998) 489 LMLN, *Lloyd's Maritime Law Newsletter*, 4 August 1998.
19 (2005) 681 LMLN 2(2), *Lloyd's Maritime Law Newsletter*, 21 December 2005.

Risk of fouling

Fouling intensity during lay-up or idle periods depends on several factors, including distance from shore, water depth, sunlight, daylight duration and water quality. Fouling tends to be greater closer to shore; anchoring at outer anchorages with strong currents is preferable to reduce growth.

"Niche areas" are areas on a ship that can accumulate biofouling due to different hydrodynamic forces, their susceptibility to coating wear or damage, or from being inadequately coated or not coated at all.

Tropical barnacles are the most common form of biofouling and can rapidly colonise ship hulls in warm, plankton-rich waters, especially when vessels are stationary or slow-moving. Growth is fast in coastal waters but limited in open-ocean passages.

The world's seas and oceans can be grouped into three main zones. In polar regions, the fouling risk is generally low, except around midsummer when light and temperature favour growth. In temperate zones (5°C to 20°C), the risk is moderate, with peak activity from spring to early autumn. In subtropical and tropical waters above 20°C, the fouling risk is high year-round, with certain species becoming more active at different times.

As a guide, John Willsher, a fouling control development manager, identified the key factors influencing hull fouling in vessels during lay-up and highlighted how geographical location impacts the severity of fouling, which can be summarised as follows:[20]

> "Polar zones: <5ºC, low fouling risk. Fouling will occur for a short time period, typically either side of mid summer.
>
> Temperate zones: 5–20ºC, medium fouling risk. Fouling will occur throughout the year peaking in spring to early autumn (micro), macro – typically April to September.
>
> Tropical/sub tropical zones: 20ºC+, high fouling risk. Fouling continues throughout the year with a multiplicity of species. Constant low-level fouling."

If the following factors are present, hull fouling will worsen:

- Trading in shallow waters.
- Trading in coastal waters.
- Low speed ships <10 knots.
- Low activity ships – 50 per cent or more stationary.
- Frequency of port calls.

Based on the author's experience, vessels stationed in river ports with cold seawater (below 6°C) for extended periods develop only light fouling, with no impact on performance. This, however, remains fact dependent. A similar situation arose in *London Arbitration 14/23*[21] regarding a prolonged stay in a port located within the Mississippi River. The owners' claim for the costs of inspection and cleaning at the next port failed.

Paint runs

A recurring question in practice is whether paint runs[22] provide a self-cleaning effect or whether short shifting periods simply restart the clock under the fouling clause, as this affects the liabilities of the parties in terms of cleaning costs or loss of time. Such issues are common not only in disputes but also in day-to-day operations, especially when vessels lie idle for several days and operators or owners must decide on the most cost-effective course of action.

A high-speed run for several hours could possibly remove light fouling or refresh the biocide layer in some systems. Still, such runs do not consistently remove fouling and are not cost-effective when performed merely to maintain anti-fouling activity. In some instances, paint specialists have advised that for a ship being idle for 20 days, two to three hours of sailing is insufficient time to activate the anti-fouling mechanism fully. Additionally, the guaranteed idle period of anti-fouling depends on its technology, with some variations ranging from 10 to 21 days. Therefore, the effectiveness of such short runs will depend on many factors.

This can be illustrated by *London Arbitration 25/17*,[23] where the anti-fouling paint manufacturers confirmed that the proposed three-hour trip would have achieved

[20] "Time to lay up", *Maritime Risk International*, June 2009, Volume 23 No 5, page 14.

[21] (2023) 1144 LMLN 1, *Lloyd's Maritime Law Newsletter*, 13 October 2023.

[22] Relatively short trips of a couple of hours, done in the hope of keeping the hull's anti-fouling system active.

[23] (2017) 986 LMLN 3, *Lloyd's Maritime Law Newsletter*, 15 September 2017.

nothing. In addition, the question of whether such a trip would have ameliorated the fouling was put to a firm of well-known technical consultants, whose answer was that the proposed short passage was “most unlikely to be sufficient to achieve the criteria for self-polishing” and that hull fouling could be expected.

Moreover, barnacle recruitment and growth on vessels are inversely related to vessel speed. Under increased vessel speeds, newly attached organisms may not survive (they will lose attachment). Vessels with short port calls and long voyages are also subject to minimal permanent barnacle fouling.

However, paint runs are not always possible. In some instances, according to the author’s experience, ship agents have advised that the vessel could not leave the anchorage to perform a short sea passage at open sea, as this would have resulted in the loss of a berthing turn and significant delays thereafter.

Any short runs should only follow proper inspection, otherwise unnecessary bunker consumption and subsequent hull cleaning costs or delays may arise. The liable party would bear both the additional bunker expenses and the cleaning costs.

Another common disputed issue concerns the “aggregated” period between two ports or between a place and a port, so as to count against the agreed period that triggers the fouling clause: for example, the parties agreed 20 days for remaining in place or ports. For instance, the BIMCO Hull Fouling Clause for Time Charterparties refers to the prolonged stay of a vessel for 20 days in a “Tropical Zone” or a “Seasonal Tropical Zone”. What happens if the ship remains or shifts between ports that are only a few hours apart? Will that reset the clock after departure from the first port?

One previous case involved a stay in two ports, approximately 70 nm apart, during the tropical season. The total aggregate period was 22 days, and the dispute centred on the interpretation of the BIMCO Hull Fouling Clause 2013. As there was no direct authority on the point, the parties placed weight upon the BIMCO Explanatory Notes and the common law position when assessing the wording of the clause. The key points were that both ports were in the same place and the ports were geographically close, with relatively little time being spent travelling between them, such that the concern of inactivity remained throughout, and therefore the rationale of the clause was engaged.

Although not a fouling dispute, in *London Arbitration 15/92*[24] the issue was whether Bangkok and Kosichang were to be treated as two ports or one. The tribunal held that Bangkok and Kosichang were commonly considered as being the same port in commercial circles. They were listed as one port in the Guide to Port Entry; only one set of port expenses was attracted for loading at both places; the same port authority was in control; and no clearance was issued for a ship leaving Bangkok for Kosichang. See also *London Arbitration 10/03*,[25] dealing with whether the ship discharged at one or two ports.

Evidence

Most fouling disputes have been resolved based on evidence such as divers’ reports, hull photographs taken alongside, visual inspections, local surveyor reports, condition surveys, the type of anti-fouling paint and the vessel’s prior trading pattern, together with performance reports before and after lay-up. Expert evidence had been adduced in some cases.

Slip

Slip is an indicator of the forces opposing a ship’s movement through the water, such as fouling, currents and weather. It is also influenced by trim and draft. A ship moves forward because the propeller pushes it through the water. In theory, each turn of the propeller should move the ship forward by the same distance as the propeller’s pitch. For example, if the pitch is 5.0 m, one turn should move the ship 5.0 m ahead. In reality, the ship moves a little less than this because water resistance and wind slow it down.

Some of the formulas used are:

- Propeller speed = shaft rpm x 60 x Propeller pitch(m) / 1852(m).
- Propeller slip (per cent) = [Propeller speed (knot) - Vessel speed (knot)] x 100 / Propeller speed (knot).
- Slip (per cent) = (engine distance - ship distance) x 100 / Engine distance.

In an article by MAN Energy Solutions[26] it is argued that the apparent slip ratio (which is calculated by the crew)

[24] (1992) 327 LMLN, *Lloyd’s Maritime Law Newsletter*, 16 May 1992.
[25] (2003) 619 LMLN 3, *Lloyd’s Maritime Law Newsletter*, 7 August 2003.
[26] “Basic Principles of Ship Propulsion”, 2018, www.man-es.com/docs/default-source/document-sync/basic-principles-of-ship-propulsion-eng.pdf (accessed 30 September 2025).

provides useful knowledge as it gives an impression of the loads applied to the propeller under different operating conditions. The apparent slip ratio increases when the vessel sails against the wind or waves, in shallow waters, when the hull is fouled, and when the ship accelerates. Under increased resistance, the propeller speed (rate of revolution) must be increased to maintain the required ship speed.

Tribunals have long considered the slip figures in vessel's performance analysis, including in fouling disputes.

In *London Arbitration 15/23*[27] the arbitrator, having reviewed the data on slip, noting that wind and sea conditions were fair with insignificant swell, and finding the vessel's speed through the water to be no more than 11.2 knots, he concluded the "constant" slip factor to be about 22 per cent. Although the condition of the underwater hull and propeller was uncertain, based on his findings, he was satisfied that they were fouled and so found. It appears that the tribunal granted a nearly 7.5 per cent slip allowance by correcting the speed to 13 knots, and the increase in slip of 14.5 per cent yields approximately 11.2 knots.

In *The Divinegate*[28] the charterers' expert made an allowance for the minimum resistance that a vessel will experience in real life because a propeller (and hull) travels through water and will lose distance as a result of hull friction and weather (among other forces). The loss of distance resulting from these forces is described as the vessel's "slip" and is measured as a percentage. The slip will vary depending upon the conditions but the experts agreed that, operating in good weather conditions and without a favourable current, a laden vessel will have a slip of between 5 per cent and 10 per cent.

The charterers' expert noted that the slip can be negative, ie the vessel's actual speed is greater than the theoretical speed, and this can occur if there is a following current (based on the author's experience, some ships exhibited negative slip in ideal conditions, and with positive currents. Even with light fouling and strong positive currents, the slip can be negative). It should be noted that propeller modifications must be examined, as in many recent cases they have been added to enhance propeller efficiency.

Turning to rpm fluctuations, these are normal and typically caused by load, weather, and vessel motion, and do not *always* indicate engine issues or fouling. In *The Divinegate*[29] the charterers' expert considered the owners' argument that the crew were not operating at the requested speed due to bad weather conditions. The expert took into account the engine load indicator, pressure and temperature readings, the absence of any entries referring to weather and the steady fuel consumption, just below the warranted level, which showed no speed reduction for safety reasons or to achieve a better passage for the crew on board.

In *London Arbitration 4/11*[30] the tribunal said although there was a Force 4 wind on the ship's nose, it seemed to the tribunal that there was a sufficiently strong prima facie case of deficiency vis-à-vis the warranted speed, that the owners needed to show positively, rather than through expert inference, that the sea state was actually such that the time in question should not be taken into account (or, to put it another way, that there was no breach of the warranty).

Speed–power curves

The "Third-Power Law" (or "cube law") serves as a widely recognised approximation or rule of thumb to establish the correlation between power and vessel speed, commonly expressed as P = Constant x V^3, with the constant being ship-specific.

The cube law has been referenced in literature, with application in ship performance analysis.[31] In a paper published at the 9th Hull Performance & Insight Conference in 2024,[32] the authors state: "The formula derives from generic considerations for power and resistance as functions of speed. It assumes constant resistance coefficients and propeller efficiency. These assumptions can only be used for small deviations from a given point on a baseline. Abusing the simple 'law' may lead to wrong conclusions".

The cube law was explained in another paper in 2011,[33] reflecting a sketch of speed and fuel consumption relations, with the author of that article stating: "It is commonly known that speed and fuel consumption in shipping are related by a technical rule the 'cube law',

27 (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
28 *Eastern Pacific Chartering Inc v Pola Maritime Ltd (The Divinegate)* [2023] 1 Lloyd's Rep 442, at para 74.

29 [2023] 1 Lloyd's Rep 442, paras 79 to 80.
30 (2011) 826 LMLN 2, *Lloyd's Maritime Law Newsletter*, 22 July 2011.
31 See Hull Performance & Insight Conference (HullPIC), 2016 to 2024.
32 V Bertram, R Marioth, "Third-Power Law – Friend or Foe?", 9th Hull Performance & Insight Conference (2024), page 5; http://data.hullpic.info/HullPIC2024_Tullamore.pdf (accessed 30 September 2025).
33 "Ship Speed and Fuel Consumption Quotation in Ocean Shipping Time Charter Contracts", *Journal of Transport Economics and Policy*, January 2011, volume 45, no 1, pages 41 to 61.

see for instance Hughes[34] (1996): C = a.S^3, where C is the fuel consumption, S is the ship speed, and a is a proportionality factor".

There are both proponents and opponents of the use of power curves in the analysis of performance and the substantiation of performance claims.

Several reported SMA arbitrations suggest that speed–power curves were used during the 1970s for performance analysis; however, their methodological flaws led tribunals to reject this approach.

Initially, speed-power curves were employed by specialist firms to conduct performance analysis. In *The Adelfoi*[35] published in 1972, the charterers engaged weather analysis experts who compared Adelfoi's log data with performance curves based on 10,000 voyages of 70 similar vessels, supplemented by weather reports from ships on comparable routes. Their computer analysis concluded *Adelfoi*'s speed "in a calm" was only 11.9 knots. Relying on this 1.1-knot shortfall, the charterers claimed a hire loss of 26.2 days, applied to all steaming time after the first three voyages (where they conceded the vessel achieved the represented "about 13 knots"). Although the logs showed no "breakdown or defect in hull or machinery", the charterers asked the panel to infer that the drop from 105/109 rpm to about 100/104 rpm on later voyages was due to an unreported engine defect, entitling them to a refund under clause 15.

The panel felt that any computer input based on the imprecise nature of unverified weather reports from vessels at sea not employing uniform standards of data recording could only render the resultant output inconclusive. Nor could the panel accept testimony given that any one set of curves could have equal application to *Adelfoi*. The panel thereupon employed formulae of their own, taking into consideration: (1) the vessel's attained speeds in good weather up to Force 4; (2) wind, sea and current conditions on all passages both loaded and light; (3) engine performance including an unrealistic constant fuel consumption in the logs of 20 tons daily regardless of weather or engine power notch setting; (4) the description of weather conditions in vessel's log books appeared exaggerated and other data unreliable; and (5) the panels interpretation that the vessel's contracted speed in good weather was 12.6 knots after allowing 0.5 knot for "about" and adding 0.1 knot for the vessel not being always fully laden. The resulting decision and award of the arbitrators stated that the vessel's speed was deficient and caused loss of time to the extent of 9.165 days over the charter period. The decision reflects an apparent inflated claim being advanced by the charterers' experts.

In *The Panagiotis Xilas*[36] published in 1975, the charterer adduced expert evidence to testify to the logic of the Bendix system of measuring vessel performance. To measure the effect of sea and swell (as caused by wind) on the vessel, Bendix[37] devised speed curves for various speeds and hull forms. These curves were derived from various private and government studies and modified by

[34] Hughes, *Ship Performance: Some technical and Commercial Aspects* (1996), Lloyd's of London Press.
[35] SMA 681.

[36] SMA 1035.
[37] An automotive and aerospace company.

Bendix to what it considered to be a more realistic level than the theoretical curves. The curves show the effect on hull speed of various wave heights at different angles to the vessels heading. The effect is indicated as slip in terms of nautical miles per time frame. The effect of ocean current is also expressed as slip in terms of nautical miles per time frame.

The panel rejected the methodology employed and stated that the methodology developed by Bendix was professionally handled and well directed. However, there remained areas which were noticeably elusive and subject to errors of sufficient magnitude to leave serious questions in the mind of the panel.

One of the areas identified by the panel was the use of speed–power curves. The panel noted: "The speed curves which are used, although improved substantially from those in the past, for which Bendix is to be commended, still require further refinements which should be made before they can be considered sufficiently reliable for measurement of vessel performance. They are few in number and embrace diverse types of ships".

It was clear to this panel that additional speed curves are required to properly reflect the effect of sea and swell on a greater number of different hull forms of vessels operating at varying speeds. Instead, the panel preferred to employ an alternative methodology which was based on a "percentage-based" application of the speed deficiency.

In the early days when weather routing companies first appeared, there is evidence that they applied speed–power curves, a practice that was later abandoned. In *The Costa Rican Trader*[38] published in 1967, the charterers claimed for breach of the performance warranty, and the owners denied on the basis that the voyage was under bad weather based on the logs. Several months after completion of the voyage, a weather routing company, at the request of Charterers, prepared a report supported by charts, graphs and "speed curves" prepared from its own direct reports from reporting vessels and from US Government weather charts for the period concerned.

This report and exhibits were intended to prove the ship was incapable of 11 knots under any conditions. The arbitrators, having regard to all evidence, concluded that the ship did not breach the performance warranty and any delay on the voyage was due to bad weather.

And more recently, in *The Trisun*[39] published in 1986, the key issue was fuel consumption during the voyage. By comparing bunker use at sea with remaining reserves, it could be determined whether cargo had been converted into bunkers. Engine consumption, voyage distance and rpm were analysed for each leg, with daily averages calculated. Both parties presented expert evidence on the vessel's energy needs. Much documentation was entered into evidence concerning the vessel's consumption. Still, the most persuasive evidence on this issue was introduced by the owner and consisted of a telex sent by the consulting firm which represented the owner.

Their view was based on the vessel's performance curves published by the engine manufacturer. They dealt only with the main engine and did not encompass any additional fuel required for the auxiliary machinery. It was also clear that this estimate of main engine consumption was very conservative and was based on 85 rpm which was slightly less than the actual rpm of the vessel during the voyage. It only gave a 2.5 per cent allowance for the use of heavy fuel. The performance curves were developed using a fuel with calorific value of 10.25 Kcal/kg which is higher than that of the fuel actually consumed during the voyage. The owners' and charterers' experts used a calorific value of 9.6 or 9.8 Kcal/kg. It was clear, therefore, that the 2.5 per cent allowance would not cover the difference in fuels. Moreover, a 2.5 per cent allowance for normal fouling must be considered conservative. Most importantly, no allowance was made in the calculation for the vessel's age, despite the fact that the ship was almost 10 years old, and a 10 per cent increase in fuel consumption based on age alone could be considered reasonable.

Therefore, the "extra" consumption required did not match the engine consumption in the logs, and there must have been burned cargo to supplement its bunker consumption.

[38] SMA 203.

[39] SMA 2327.

London arbitrations

The issue of speed-power calculation has recently arisen in reported cases, including *London Arbitration 23/21*,[40] *London Arbitration 15/23*[41] and *London Arbitration 4/25*[42] – the latter expressly referring to "cubic" parameters. Unlike earlier SMA awards, where arbitrators relied on expert evidence presented by the parties, the arbitrators in these London Arbitration cases appear to have applied their own knowledge and experience, without being guided by expert testimony. Whether an arbitrator will recalculate loss is a matter of further discussion and not within the scope of this article.

Clean v deteriorated hull

The deterioration of the hull and propeller will result in a decrease in the attainable speed at a given power. Similarly, an increase in power is required to obtain a certain speed. Thus, the speed–power curve will shift upward when the hull/propeller deteriorates.

Take, for example, *London Arbitration 15/23*,[43] where the tribunal made a finding that fouling affected performance. It is observed that an increase in speed by 1.8 knots increases fuel consumption calculated as 1.8×1.8×1.8=5.83 mt. The observed difference between 5 mt and 5.83 mt is attributed to the constant in the applied formula. The constant can be calculated by using this formula: a=Σ (Ci/ Vi^3), i= 1...n.

Since power and fuel consumption are interrelated – though not in a strictly linear manner – the same approximation can be employed to estimate the relationship between speed and fuel consumption. However, it is important to emphasise that this remains an approximation.

More sophisticated models consider a variety of additional parameters beyond vessel speed, including draft, engine load, course over ground, fuel characteristics, wind and wave direction, swell height and direction, currents, and water depth, among other factors, to achieve a more comprehensive and accurate analysis of this type.

Speed–power curves continue to be applied in practice today, but not as much for performance analysis. For instance, in EEXI Technical Files, the speed–power curve (EEDI[44] Draught) reflects the changes before and after SHaPoli.[45] The vertical axis shows the brake power (kW), and the horizontal axis shows the ship speed (knots). The estimation process of speed–power curves is based on model test results. The same application of curves to illustrate changes in speed before and after EPL (engine power limitation) was used to demonstrate the drop in speed resulting from a reduction in brake power.

Fouling sample analysis

A sample analysis by biological experts was considered in *The Pamphilos*[46] as to whether fouling pre-existed before the extended stay at the loading port. In that case the ship remained at the loading port of Sepetiba, Brazil, for some 21 days idle prior to berthing, and underperformed on her voyage to the discharge port. The owners defended the underperformance claim due to prolonged stay following the charterers' orders, but they could not claim the cleaning costs and time thereafter, as this was "fair wear and tear", so there was no breach of clause 4 of the NYPE form.

A unilateral sample collection (and by extension a diving inspection) does not normally render such evidence inadmissible. Colman J noted that if parties will not cooperate on matters such as inspection, the taking of samples and disclosure of documents, the resolution of their disputes by arbitrators becomes far more difficult and expensive. That, however, does not normally render inadmissible evidence which has been obtained unilaterally and without cooperation with the opposite side, although such evidence may be of little weight.

Laboratory analysis

Following *The Pamphilos*, there have been similar instances where parties send the sample to the laboratory for analysis. Typically, the report issued by the laboratory will outline the methods used to collect, identify and age barnacles taken from the hull, or address other instructions from the parties.

The sample collection and analysis sections will refer to the company that collected the samples, the location and date, and whether the samples were taken in accordance with the lab's instructions. The protocol may (depending

[40] (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
[41] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
[42] (2025) 1177 LMLN 3, *Lloyd's Maritime Law Newsletter*, 17 January 2025.
[43] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023..
[44] Energy Efficiency Design Index.
[45] Shaft Power Limitation.
[46] *Bulfracht (Cyprus) Ltd v Boneset Shipping Co Ltd (The Pamphilos)* [2002] 2 Lloyd's Rep 681.

on the case) include the method used to remove the material (eg a paint scraper), the way it was retained underwater in a net or bag, and the preservation method (eg ethanol). It will also include the location and the number of samples taken, as well as photographs of the marine growth of each of these locations.

Another section will contain the analysis of the organisms. For example, specimens were photographed using a microscope equipped with a digital camera, and the validity of the species was verified in the World Register of Marine Species. A total of 12 barnacles from each cohort were randomly selected from the sampling locations on the vessel, and the carino-rostral diameter was measured. Mean diameter and standard deviation were calculated for each of the sample locations. Published growth rates for the barnacle species found in the samples were not available; thus, growth rates for two congeneric species were used to calculate an approximate age of the fouling barnacles.

In some instances, the origin of the organisms identified in the samples may be impractical if these organisms are found in virtually all ports worldwide. An alternative is to compare the estimated ages of the living material with the vessel's logbooks to indicate where fouling may have occurred. Moreover, dead material (where only barnacle shells remain) can only be aged up to the time of death, and the period thereafter cannot be determined. Barnacles secondarily attached to others are assumed to be younger than those they overgrow.

Another expert can challenge the laboratory analysis. In one unreported case, the expert acknowledged that barnacle ageing was imprecise but broadly agreed with the estimates. Most barnacles were dead and likely pre-dated the vessel's stay at the disputed port. They appeared in isolated patches in areas difficult to clean, suggesting remnants from earlier cleanings, with no uniform coverage or evidence of heavy settlement. No hard fouling was observed.

It appears that in this case the report focused narrowly on barnacle ageing, which required only a small sample. However, the survey and photography were neither designed nor adequate to assess overall hull fouling. A reliable assessment would require a more rigorous methodology, including extensive random photographs in a grid pattern and/or systematic video surveys covering large areas of the hull.

This case also demonstrates that, before collecting samples, it is recommended to seek instructions from the laboratory or an expert.

Divers' reports

Are charterers entitled to arrange an underwater inspection?

Some charterparties expressly grant charterers this right, providing that if fouling (sometimes specified as "substantial" fouling) is found, the owners must clean the hull and propeller at their own time and expense before departure from the loading port. Charterers may also argue that a tribunal should draw adverse inferences from the owners' refusal to permit such inspections, though the outcome depends on the circumstances.

In *London Arbitration 10/00*[47] the charterers expected that bottom fouling had occurred due to a prolonged stay at Paranagua. They urged the owners to conduct a hull inspection and cleaning (at the charterers' cost) to mitigate performance claims on the voyage. The owners rejected both requests. The ship underperformed on its voyage, given its fouled condition. The tribunal found it was not unreasonable for the owners to decline the charterers' request until the extent and effect of fouling on the vessel's performance could be assessed during the voyage.

Strikingly, "although it was possible that in such circumstances some owners might have decided to clean the vessel's bottom before sailing, the tribunal did not believe that many would have done so, the majority preferring to wait and see how the vessel performed on the first voyage after Paranagua before making any decision about bottom cleaning".

The "wait and see" approach could lead to more disputes, depending on the case. Typically, the owner will request that the master consider the state of the hull (even by visual observation of the waterline) after a prolonged stay in such warm waters and clean the hull to avoid substantial underperformance claims.[48]

The term "superficial inspection" is sometimes used, which is open to interpretation, as the scope of a "superficial" inspection is not clearly defined and appears to contemplate only visual examination.

Diver inspection reports have been used to allege hull fouling, raising debate over their sufficiency as evidence. While the divers' report can show fouling, does this affect the vessel's performance? A hull inspection report

[47] (2000) 545 LMLN 1(2), Lloyd's Maritime Law Newsletter, 28 September 2000.
[48] See the points made in *Smart Gain Shipping Co Ltd v Langlois Enterprises Ltd (The Globe Danae)* [2024] 1 Lloyd's Rep 309.

(visual, thickness, coating condition, fouling, etc) gives a snapshot of the vessel's physical state. However, performance analysis shows how that condition translates into efficiency. Therefore, both must be evaluated properly.

The IMO Marine Environment Protection Committee (MEPC) has issued several guidelines and resolutions related to hull inspection, maintenance and performance monitoring, particularly in the context of fuel efficiency and biofouling management.[49] Some divers' reports adhere to these guidelines, while others do not, but their evidential weight is not reduced solely by that.

Divers' reports typically record the vessel's particulars, inspection method, location, cleaning equipment, draft and seawater conditions, followed by an assessment of fouling or damage in parts, paint condition and anode condition, supported by photographs and often video evidence. Some reports also include explanatory notes with illustrative images for clarity. The format and comprehensiveness vary, which may influence the weight given when reports conflict or when third-party experts seek to quantify the impact of fouling on performance using standard formulas.

In specific ports, divers may be instructed to inspect the hull for drugs, during which video evidence of fouling has been used by charterers to allege an improper state of hull on delivery. In another case, following a grounding, an in-water survey arranged by owners also revealed fouling. Both instances raised debate as to whether divers' reports – often limited to video footage without quantified assessments – are sufficient evidence of hull condition.

In certain instances, parties referred to pictorial assessment reports or expert reports. For example, the NACE pictorial standard[50] provides eight sets of pictorial-based expressions of biofouling degree. The figures include pictures with light microfouling, medium macrofouling, heavy microfouling, 1 per cent macrofouling, 5 per cent macrofouling, 10 per cent macrofouling, 15 per cent macrofouling and >15 per cent macrofouling.

Fitz's Atlas[51] provides a comprehensive visual guide to coatings and application defects. Part 6 offers a comparative depiction of fouling.

Underwater inspection videos and pictures must be of good quality. Poor-quality photographs can be unhelpful, reducing their evidential weight.

Condition survey

Most NYPE charterparties require the parties to jointly conduct on-hire and/or off-hire condition surveys to assess the vessel's condition, and this is binding on the parties. These surveys typically include photographs of the hull, particularly those taken near the waterline. When carried out in ballast or after discharge, they may reveal marine growth more clearly, as was deemed useful in *The Divinegate*.

Condition surveys are typically undertaken by mariners or specialist firms, often comprising surveyors with extensive sea-going experience, technical expertise and accreditation from leading maritime institutions. Acting also as expert witnesses, their conclusions may carry evidential weight.

[49] See MEPC.378(80) (adopted on 7 July 2023).

[50] The NACE International Standard practice is a pictorial standard for the underwater evaluation of fouling degree on ships' hulls.

[51] Fitz Coatings, "Fitz's Atlas 2 of Coating Defects".

Case law and arbitration

Charterers usually invoke a range of provisions under the NYPE form in support of their claims including, but not limited to, the maintenance clause, the due despatch obligation under clause 8, the off-hire provision in clause 15, the deviation/"put back" clause, as well as bespoke clauses specifically addressing the allocation of risk and liability arising from fouling.

The majority of English cases indicate that parties have long struggled to allocate the risk of hull fouling, frequently giving rise to disputes over performance, de-fouling costs, delays and bunker consumption.

Fouling is not per se a breach of contract. The mere delivery of a vessel with a fouled hull does not automatically entitle the charterers to bring a claim against the owners. The presence of hull fouling at the time of delivery does not, in itself, constitute evidence of diminished performance. Moreover, a vessel may be delivered with a fouled hull and nonetheless remain capable of performing in accordance with the contractual descriptions of speed and consumption.

In both cases of *The Ioanna*[52] and *The Apollonius*,[53] the vessels were affected by marine growth, which resulted in significant speed reductions, as evidenced by the excessive time lost during the voyages. In *The Ioanna* an agreed statement of facts recorded that the vessel was delivered in a fouled condition, which impaired its performance, leading to an additional 7.2 days on the voyage and increased bunker consumption. In consequence, the owners acknowledged that the fouling of the vessel's hull caused a reduction in speed when compared with the warranted performance.

There have been instances where vessels were delivered with a fouled hull, but nevertheless remained capable of performing. In such cases, the tribunal dismissed the claims. This occurred in two recent LMAA arbitrations, the earlier of which was determined by a specialist arbitrator.

(a) In *London Arbitration 2/24*[54] the specialist arbitrator found that the slip over the voyage was 27 per cent and only 22 per cent during the Mediterranean passage. As the vessel was last drydocked in March 2020, more than two-and-a-half years before delivery, its underwater hull was likely suffering from marine fouling. However, given the incredibly high slip, and the fact that the vessel was able to operate within the warranted parameters promised, the owners were probably aware of this defect. They warranted speed and consumption that they knew the vessel could achieve. Since the vessel performed, there was no question about the vessel's underperformance due to the ship's related issues (inherent matters).

(b) In *London Arbitration 7/25*[55] the charterers made deductions from hire as damages for breach of the speed warranty or (alternatively) as the owners' breach of warranty due to the fact that the vessel's bottom was fouled. The arbitrator held that while divers did report some growth on the hull, it was very modest in extent. Some barnacles were inevitable after a very short spell of a clean hull being in water. What was found would have had no effect on performance.

However, if the vessel is delivered with a fouled hull, which affects the vessel's performance, the owners can be in breach of one or more of their obligations under the charter.[56] Hull fouling on delivery, which causes loss of time and extra bunkers on the voyage, is a defect.[57] The position may differ when fouling occurs during service.[58]

In *London Arbitration 23/21*[59] a dispute arose under a NYPE form charterparty, which contained quite restrictive performance clauses. The arbitrator rejected the performance analysis from the weather routing company and conducted his own assessment of the loss. On the evidence, the arbitrator found that there was a speed deficiency of 1.5 knots due to the fouled state of hull on delivery. The arbitrator held that these losses fell within line 22 and clause 15 (off-hire regime), and the charterers were entitled to a reduction in hire for the time lost on passage and the extra fuel consumed consequent upon the deficiency.

[52] *Ocean Glory Compania Naviera SA v A/S P V Christensen (The Ioanna)* [1985] 2 Lloyd's Rep 164.
[53] *Cosmos Bulk Transport Inc v China National Foreign Trade Transportation Corporation (The Apollonius)* [1978] 1 Lloyd's Rep 53.
[54] (2024) 1151 LMLN 3, *Lloyd's Maritime Law Newsletter*, 19 January 2024.
[55] (2025) 1182 LMLN 3, *Lloyd's Maritime Law Newsletter*, 28 March 2025.
[56] See *The Apollonius* [1978] 1 Lloyd's Rep 53; *SK Shipping Europe plc v Capital VLCC 3 Corporation (The C Challenger)* [2021] 2 Lloyd's Rep 109; *Arab Maritime Petroleum Transport Co v Luxor Trading Panama (The Al Bida)* [1986] 1 Lloyd's Rep 142 and *The Ioanna* [1985] 2 Lloyd's Rep 164.
[57] *The Ioanna* [1985] 2 Lloyd's Rep 164; *London Arbitration 23/21* (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
[58] *Santa Martha Baay Scheepvaart and Handelsmaatschappij NV v Scanbulk A/S (The Rijn)* [1981] 2 Lloyd's Rep 267.
[59] (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.

Cleaning costs and performance

The next issue is whether the risk of fouling was foreseeable at the time of concluding the charterparty, which is a result of the employment and indemnity clauses (a position that may differ now, following the bespoke terms dealing with fouling). If it were, the de-fouling costs fall on the owners as ordinary expenses of trading the ship and in taking steps to maintain their ship. Owners cannot recover said costs under an implied indemnity.[60] If the owners assumed the risk of underperformance due to fouling, the owners cannot defend the claim on the basis that this was caused by compliance with the charterers' orders.[61]

In *The Kitsa*[62] the vessel remained idle for 22 days during which time the hull became seriously fouled by barnacles. The owners claimed the cost of de-fouling from the charterers on the basis of an implied indemnity, but Aikens J rejected their claim and said that the arbitrators were entitled to come to such a conclusion and held that the owners had taken the risk of bottom fouling through inactivity.

In *The Pamphilos*[63] it was approved that owners have a defence to an underperformance claim when caused by a charterers' employment orders. However, by redelivering a ship with fouling, which is an ordinary incident of trading by owners following a charterers' lawful orders, the charterers will not be held in breach of clause 4, since fouling can be regarded as "fair wear and tear". In this case the owners' claim for cleaning costs and time loss was unsuccessful.

These authorities illustrate that owners cannot, as a matter of course, repudiate an underperformance claim. Such a claim may only be defeated where the alleged underperformance is attributable to a risk not assumed by the owners and in respect of which they are entitled to an indemnity. Accordingly, each instance is fact sensitive.

Other issues arise regarding whether the vessel is to be considered off-hire, pursuant to clause 15, in respect of time lost due to hull de-fouling and consequent speed reductions. Resolution of this issue necessarily depends upon both the factual matrix and the terms of the charterparty. In general, time lost due to hull cleaning and underperformance falls to the owners' account, save where the owners can establish that the fouling was occasioned by the vessel's prolonged stay at a location pursuant to the charterers' orders, in circumstances not contemplated by the parties at the time of contracting.

A charterer ought not to be entitled to advance an underperformance claim in circumstances where arrangements for hull cleaning were made by them but not effectively implemented. It is frequently the case that charterers arrange for hull cleaning following a prolonged stay at the loading port, as agreed terms often require this. Yet, due to incomplete or inadequate arrangements, the vessel subsequently underperforms on the voyage. Where such underperformance is attributable to the charterers' own incomplete arrangements, the charterer is precluded from pursuing an underperformance claim.

The analysis becomes more complex when engine damage or a mechanical defect causes delays incurred during the voyage, even when the charterers made incomplete arrangements at the loading port to clean the hull (one or more causes will affect the vessel's performance). In certain instances, the fouling clause expressly provides that "cleaning [is] to be carried out under the supervision of the master." Such wording is not to be construed as imposing responsibility for cleaning upon the master, save where the master has intervened in the process and his intervention had an adverse effect. Moreover, while the charterers may arrange for the hull to be cleaned, such efforts may be rendered ineffective owing to defects or conditions inherent in the vessel. In some cases, for example, extensive rusting of the hull has been present, and cleaning has been prohibited in areas where such operations would ordinarily be permitted. This may shift the risk back on the owner, as held in some SMA arbitrations.

The matter does not end there. The owners have an obligation to maintain the ship and its hull during the service. If the owners fail to do so, the charterers may claim that the owners failed to exercise due diligence and keep the vessel's hull in a state that can perform in line with its description.[64] However, this is an obligation to take reasonable steps and within a reasonable time to ensure that the ship's performance is maintained.[65] Owners are

[60] *Action Navigation Inc v Bottigliere di Navigazione SpA (The Kitsa)* [2005] 1 Lloyd's Rep 432; *London Arbitration 9/08* (2008) 748 LMLN 3, *Lloyd's Maritime Law Newsletter*, 16 July 2008.
[61] *Imperator I Maritime Co v Bunge SA (The Coral Seas)* [2016] 2 Lloyd's Rep 293.
[62] [2005] 1 Lloyd's Rep 432.
[63] *Bulfracht (Cyprus) Ltd v Boneset Shipping Co Ltd (The Pamphilos)* [2002] 2 Lloyd's Rep 681.

[64] See *The Al Bida* [1986] 1 Lloyd's Rep 142 and *The C Challenger* [2021] 2 Lloyd's Rep 109.
[65] *"SNIA" Societa di Navigazione Industria e Commercio v Suzuki & Co* (1923) 17 Ll L R 78.

not in breach of their duty to maintain simply because there is some fouling.[66] As discussed, fouling on the vessel's hull can occur, yet the ship can still perform as described.

In some instances involving long sea passages and after a prolonged stay in port before the charterparty taking place, owners should arrange to clean the ship's hull so that the ship can perform as described. This will also avoid unnecessary disputes about the vessel's performance over the course of the voyage, even if there is no good weather under a very restrictive performance clause in the charterparty. Alternatively, charterers should make arrangements to clean the hull upon delivery of the ship in their service, and when fouling is found that could reasonably be expected to have afftected the vessel's performance. The parties would then dispute the time lost (if any), cleaning and the cost of cleaning. The potential dispute in such cases can be modest compared to large underperformance claims over a long sea passage.

In *The Globe Danae*[67] the above reasoning is illustrated in various statements:

> "The reason why it needed to be at the first workable opportunity was so the owners could present the vessel to the next employment with a 'thoroughly efficient hull', for otherwise they would be exposed to a claim for underperformance"

and:

> "If the vessel is returned uncleaned, it is likely that the owners will endeavour to clean it before its new employment, since (for the reasons the tribunal gave at para 40) there would otherwise be a breach of warranty to the new charterers."

Arbitration cases

In *London Arbitration 29/22*[68] the ship was fouled at Bin Qasim after a stay of 22 days. The owners provided to the charterers a cleaning report prior delivery to prove the hull was in an efficient state on delivery. The charterers denied liability. The charterers purported to redeliver the ship without cleaning, and the owners sailed toward the next port, Khorfakkan, for inspection and cleaning. The owners were entitled to compensation for the time spent reaching Khorfakkan and carrying out the inspection and cleaning.

In *London Arbitration 17/98*,[69] following a prolonged stay at Bandar Abbas, the owners claimed the cleaning costs and the charterers placed the ship off hire during the period of cleaning. The owners had not demonstrated that the fouling occurred at that port, and their claim for cleaning costs failed, while the charterers' off-hire claim was successful. Notably, tribunal did not need to address arguments based on *The Rijn*[70] because of the view which the tribunal had taken of the facts.

In *London Arbitration 9/07*,[71] as to underwater fouling, the tribunal recognised that it might well have occurred during periods when the vessel was lying idle, for extended periods, in warm, sub-tropical waters. However, the fouling would by definition be the natural consequence of the trade upon which – with the owners' full knowledge and agreement – the vessel was employed, and it would therefore be the owners' responsibility to carry out underwater cleaning as part of the routine maintenance of the vessel.

In *London Arbitration 9/08*[72] one of the issues was whether the charterers were liable for fouling of the vessel's hull, which was severely affected by barnacles, under a wrongful prolongation of the charter, where the owners claimed the cost of the underwater cleaning and the subsequent drydocking of the vessel. The charterers rejected the claim, relying on *The Kitsa*,[73] saying that the extent of fouling was foreseeable and the owners did not provide evidence that no fouling was present at the time the vessel entered their service. The tribunal had already found that they were not liable for the prolongation of the charter, so it accepted the charterers' submission and dismissed the owners' claim for damages.

In *London Arbitration 24/05*[74] the owners claimed the costs for cleaning the hull following a prolonged stay of almost 27 days at Sepetiba bay and Rio De Janeiro. The charterers brought an underperformance claim and the owners sought to defend this by asserting that this arose from the charterers' orders for the ship to stay for a prolonged period at these ports. Since there was no continuous warranty, it was found the risk of under-performance between delivery and redelivery fell on the charterers unless the charterers could show that the ship failed to comply with the warranty at the time of its

[66] *Tynedale Steam Shipping Co Ltd v Anglo-Soviet Shipping Co Ltd* (1936) 54 Ll L Rep 341.
[67] *Smart Gain Shipping Co Ltd v Langlois Enterprises Ltd (The Globe Danae)* [2024] 1 Lloyd's Rep 309 at paras 18 and 36.
[68] (2022) 1115 LMLN 2, *Lloyd's Maritime Law Newsletter*, 2 September 2022. The summary of this award was written for *Lloyd's Maritime Law Newsletter* by the present author.
[69] (1998) 489 LMLN, *Lloyd's Maritime Law Newsletter*, 4 August 1998.
[70] [1981] 2 Lloyd's Rep 267.
[71] (2007) 718 LMLN 3, *Lloyd's Maritime Law Newsletter*, 23 May 2007.
[72] (2008) 748 LMLN 3, *Lloyd's Maritime Law Newsletter*, 16 July 2008.
[73] [2005] 1 Lloyd's Rep 432.
[74] (2005) 681 LMLN 2(2), *Lloyd's Maritime Law Newsletter*, 21 December 2005.

fixing/delivery. Generally, the ship's performance on good weather days complied with the warranties. Regarding the de-fouling costs that occurred later, the charterers stated that fouling resulted from the owners' failure to deliver a ship in an efficient state and to maintain it in that condition. There was evidence that the anti-fouling paint applied at the vessel's drydocking in 2001 had been applied at a below-specification dry film thickness and was of a relatively low quality.

The tribunal awarded the owners the cost of de-fouling, as this arose from the charterers' trade, and it was not due to the anti-fouling application.

In *London Arbitration 25/17*[75] the ship arrived at Lumut, Malaysia to discharge its cargo. Three weeks after arrival the master reported signs of marine growth around the waterline. The charterers asked the ship to proceed to sea for a short period but the vessel did not do so because the master queried the effectiveness of such, and when he did so the charterers failed to confirm their instructions. The ship performed its next charter with a different charterer who advanced a performance claim. The owners claimed that charterers were in breach of clause 4 of the charter, and claimed damages that included the settlement of the performance claim with the next charterers along with hull cleaning costs. The tribunal made a finding that the ship's hull became fouled at Lumut and the ordered three-hour voyage was only a cosmetic exercise and would have had no effect.

Notably, the fouling clause in the present charterparty included the provision that redelivery in a fouled condition was not protected by the fair wear and tear exception, and the tribunal therefore found that delivery in that condition was a breach of clause 43. The tribunal considered the performance claim submitted by the next charterers and found that it was indefensible, and the owners were justified in settling in the sum sought. The tribunal also found that the underperformance claim arose due to the events at Lumut and not due to engine damage as the charterers had asserted, a claim which lacked proof.

The charterers breached clause 43, and damages flowed from that breach. In summary, when there is a follow-up charterparty, whether charterers would be held liable for an underperformance claim will depend on many factors: (1) the applicable terms that define liability and the agreed remedies; (2) whether the underperformance claim arose from that breach; (3) whether the owners had a defence to the claim in the follow-up fixture and settled on proper terms; and (4) whether other issues affected performance on the follow-up fixture (there can be fouling and engine damage). In this case, the issues were clear.

In *London Arbitration 15/19*[76] the issue was whether the time and expense of hull cleaning undertaken by the owners after redelivery, but following a lengthy port stay before redelivery, were recoverable from the charterers. Clause 104 of the charterparty, "Prolonged Port Stays", stated: "Should the result of this diver inspection indicate that there is excessive marine growth on the hull, ...

75 (2017) 986 LMLN 3, *Lloyd's Maritime Law Newsletter*, 15 September 2017.

76 (2019) 1033 LMLN 2, *Lloyd's Maritime Law Newsletter*, 5 July 2019.

Owners to arrange underwater scrubbing of the hull in Charterers time and at Charterers expense, prior to vessels departure from the port or anchorage". The ship was at Hazira, India, from 22 June to 27 July, a 25-day period. Prior to redelivery, based on a visual examination of the hull area as supported by photographs, the master believed the hull was fouled, yet the charterers redelivered the ship without any divers' inspection and cleaning. The vessel entered its next service and the owners diverted some 15 nm from the planned voyage to Port Louis for inspection and cleaning. The inspection showed 10 to 15 per cent coverage on the port and starboard sides, with barnacles measuring 2 mm on the flat bottom and rear areas. Owners claimed the time lost, bunkers consumed, port expenses and cleaning costs. The dispute centred on the interpretation of "excessive marine growth" and, given the improved speed after Port Louis by almost 0.4 knots, this indicated that the fouling affected the vessel's speed.

In *London Arbitration 24/19*[77] the charterers brought an underperformance claim due to breach of a very restrictive clause ("Winds not exceeding BF4, No deck cargo, no swell, no adverse currents, the sea state up to Douglas Sea Scale (Max 1.25 m)"). The tribunal rejected the claim for breach of the performance warranty for want of proof, and based its decision on a quite literal application of the warranted terms. Given that the ship's speed was 2 knots less than expected, the tribunal had to evaluate the potential reasons resulting in this speed deficiency: adverse weather, underwater fouling and technical problems. Line 5 of the main body of the NYPE form was deleted and lines 21 and 22 were amended. Despite the extensive disclosure, the charterers were unable to identify any point which suggested the ship had engine problems. The claim failed.

In *London Arbitration 4/25*[78] the charterers relied on two performance reports from a weather routing company and made deductions from hire. The owners rejected both reports as containing periods in excess of the agreed weather benchmark conditions or having too short periods to assess performance. The weather routing company applied the about margins (0.5 knot on speed and 5 per cent on the bunkers) in their calculations. The tribunal considered the high reported slip, which evidences significant hull fouling likely to impair performance, but the weather routing company made no reference to it and also disregarded the benchmark conditions. Therefore, the tribunal rejected the performance reports but considered the weather analysis, which was from reliable sources. Having regard to slip and rpm on both voyages, it was most likely that hull fouling precluded the vessel's performance. The tribunal considered the increase in rpm required to reach the *minimum* warranted speed (so even if there was fouling, the comparison applies). Given the higher ship's resistance from fouling, the master kept engine reserves to avoid an exponential increase in consumption.

In *London Arbitration 15/23*[79] the tribunal rejected both reports submitted by the owners' side and the charterers' side due to wrong application of the methodology. Having regard to slip figures and rpm data, the arbitrator applied the cubic rule and found that an increase in speed by 11.2 knots to 13 knots (about 13.5) would result in a bunker increase of 5 mt daily (this can be translated as 1.8 x 1.8 x 1.8, being further adjusted by a coefficient in the formula). In calculating the resulting loss, the arbitrator applied the "about" in speed: 1864 / 13 - 1864/11.2 = 23 hours.

Charterparty clauses

Slow steaming attributable to hull fouling engages multiple provisions of the charterparty. In addition to the usual speed and performance claims, such circumstances frequently give rise to disputes concerning bunker quantities. In certain cases the prolongation of the voyage has resulted in increased overall bunker consumption, necessitating deviation for bunkers or redelivery of the vessel with a bunker shortfall. In response, owners have counterclaimed for hire (disputing deductions made by charterers) and for damages arising from redelivery with insufficient bunkers, thereby requiring the purchase of replacement bunkers at market prices higher than those stipulated under the charterparty.

The BIMCO Hull Fouling Clauses of 2013 and 2019 are commonly incorporated (the latter providing further clarification on several points). However, there is also a discernible trend for parties to adopt bespoke clauses allocating the risk of fouling, either by amending the period of permitted delay at port or by agreeing a lump-sum payment on redelivery in lieu of hull cleaning. The contractual wording adopted may be either broad or restrictive in defining the charterers' liabilities upon redelivery of the vessel in a fouled condition.

[77] (2019) 1041 LMLN 4, *Lloyd's Maritime Law Newsletter*, 25 October 2019.
[78] (2025) 1177 LMLN 3, *Lloyd's Maritime Law Newsletter*, 17 January 2025.
[79] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.

Loss calculation

Following the decision in *The Divinegate*,[80] considerable discussion has emerged in the market regarding alternative methods of calculating underperformance in circumstances where no good-weather periods are available but the vessel clearly underperforms due to fouling or engine damage, and the charterers can prove this by adducing credible evidence.

This is not a search for a "magic formula", as the issue has been present for decades and has been the subject of repeated consideration in arbitration decisions. The proper approach lies in a fact-specific analysis of each case to assess loss, where no good weather is available, yet there is credible evidence that can establish fouling or engine issues that result in underperformance. Equally, there are circumstances in which good weather is recorded but the resulting analysis is still misleading based on the traditional method.

By way of illustration, a vessel may encounter a 24-hour period of good weather during which higher rpm and engine consumption are observed, producing a speed of 14.5 knots compared with 13.5 knots. A weather routing report may then indicate significant savings in both time and fuel consumption. However, such a conclusion is artificial where, on all other days, the vessel has substantially underperformed as a result of fouling. The increased speed on that short interval is attributable to elevated rpm and consumption, not to the vessel's true performance capability.

Therefore, any applied methodology must be consistent with the requirements of law, facts, and practice. The difficulty with some (not all) alternative approaches is that they fail to satisfy one or more of these criteria. This recurring issue persists, and the root cause lies in a lack of proper understanding of one or more of the three essential components noted above, by third parties analysing performance.

For instance, the *Divinegate* decision highlights the inherent risks associated with alternative methodologies, particularly when they result in an inflated calculation of loss. Courts and tribunals remain alert to the danger of over-compensating a party, a concern discernible upon closer reading of *London Arbitration 15/23*[81] and *London Arbitration 23/21*.[82] In both instances, the arbitrator applied his technical expertise to recalculate performance figures as a matter of fact – findings not subject to appeal – while simultaneously ensuring that the application of law prevented any award that might result in over-compensation.

Other alternative methods fail in their application of both facts and law. A notable example arises with weather routing companies that decline to provide results when no periods of "good weather" are identified, even in circumstances where the vessel demonstrably underperforms due to fouling or engine damages. Even in these circumstances, a reliable and objective loss calculation must be established, and the burden lies with the charterer to do so.

In *The Didymi*[83] the court applied the logical inference that if a vessel underperforms in good weather, it is likely to underperform in adverse conditions. While this reasoning has merit, practical realities may differ: favourable weather or currents can, in certain instances, enable a vessel to achieve higher speeds even in "bad" weather, thereby negating any actual loss of time. In *The Didymi* the effect of the currents was not considered, which led to the logical reasoning that the deficiency applies equally to all periods. This was clarified in *London Arbitration 12/24*,[84] where the vessel underperformed in all weather conditions, but the "good weather" speed alone was deficient. The claim failed on this basis, as the charterer had sustained no actual loss.

In several London and New York arbitration decisions[85] the arbitrators dismissed a performance claim when there was no actual loss or damage. Therefore, going back to *London Arbitration 12/24*, what was the charterers' loss when a ship performed in all weather conditions? The arbitrator criticised the charterers for bringing such a claim. What was the reasoning behind the arbitrators' decision (as some say the arbitrator ignored *The Didymi* since the good weather method showed loss)?

[80] [2023] 1 Lloyd's Rep 442.

[81] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.

[82] (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.

[83] *Didymi Corporation v Atlantic Lines and Navigation Co Inc (The Didymi)* [1987] 2 Lloyd's Rep 166.

[84] (2024) 1169 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 September 2024.

[85] SMA 3817, SMA 3182 and SMA 3168.

In *Robinson v Harman*,[86] Parke B said:

> "The rule of the common law is, that where a party sustains a loss by reason of a breach of contract, he is, so far as money can do it, to be placed in the same situation, with respect to damages, as if the contract had been performed."

That statement has been described as the fundamental basis for assessing damages, the ruling principle and the "lodestar".[87]

In some instances, a literal or mechanical application of *The Didymi* risks departing from that principle by producing over-compensation. All in all, there is a fine balance to be struck between under-compensation and over-compensation, and achieving it is seldom straightforward. The resulting discrepancies are therefore particularly significant. This does not mean that *The Didymi* should be disregarded; instead, its application must always be tailored to the particular facts of each case. It is not just to mechanically apply any formula, ignoring all other relevant tests. The final outcome requires appropriate filtering, which lies beyond the remit of weather routing companies. Based on the author's experience, this aspect is often inadvertently overlooked, even by specialists.

Moreover, quantifying loss is often relatively straightforward. There are, however, cases in which its precise measurement is inherently impossible. Evidential difficulties in establishing the measure of loss are reflected in the degree of certainty with which the law requires damages to be proved.[88]

Consequently, a mechanical reliance on formulas or academic commentary can therefore be misleading, and may fail to satisfy one or more requirements – whether as a matter of law (damages assessment), or as a matter of fact, where the evidential weight is diminished, particularly if contradicted by the official methods stipulated in the contract or by layers of complexity making it highly speculative.

[86] (1848) 1 Exch 850.

[87] See *Morris-Garner v One Step (Support) Ltd* [2018] 1 Lloyd's Rep 495, at para 32: "That statement has been endorsed on many occasions at the highest level, most recently in *Bunge SA v Nidera NV* [2015] 2 Lloyd's Rep 469, para 14, where it was described as the 'fundamental principle of the common law of damages'. It has also been described as the 'ruling principle' (*Wertheim v Chicoutimi Pulp Co* [1911] AC 301, page 307), the 'fundamental basis' for assessing damages (*British Westinghouse Electric and Manufacturing Co Ltd v Underground Electric Railway Co of London Ltd (No 2)* [1912] AC 673, page 689), and the 'lodestar' (*Golden Strait Corporation v Nippon Yusen Kubishka Kaisha (The Golden Victory)* [2007] 2 Lloyd's Rep 164, para 36)".

[88] *Morris-Garner v One Step (Support) Ltd* [2018] 1 Lloyd's Rep 495, para 37.

Alternative methods

Any meaningful assessment of this issue must begin with an examination of the origins of performance methodologies and their subsequent evolution. This requires close consideration of both case law and arbitration awards under the SMA and LMAA, as it is likely that early approaches were shaped by cross-influences between the two (with SMA awards being published before the LMAA award summaries). Such a review can provide valuable guidance in addressing this long-standing problem and is likely to remove any misconceptions that persist in the market.

The development of approaches to performance analysis was based on logical and analytical reasoning, a practice that dates back several decades. The rationale was that a failure by the vessel to achieve the warranted performance must be carefully examined to establish whether it is attributable to:

(i) misrepresentation by the owners;

(ii) a defect or breakdown of the hull, machinery, or equipment, as contemplated under clause 15 of the NYPE form;

(iii) intentional reduction of the main engine's speed, for whatever reason; or

(iv) the influence of external factors, including wind, currents, waves, or swell.

Arbitrator Dudley B Donald's 1960 dissent in *The Brookhurst*,[89] offers a notable historical perspective. In it he asserted that if the speed deficiency was not due to the weather, then it was defect in or breakdown of any part of the vessel's hull, machinery or equipment, or failure of the captain under clause 8 to "prosecute his voyages with the utmost dispatch", or misrepresentation. These ideas were later echoed in the English High Court in *The Pearl C*[90] – save for the point of misrepresentation. This was described as a legitimate reasoning process. This "process of elimination" has broader application and reflects a practical reality.

Even recently, in *London Arbitration 24/19*[91] the tribunal had to consider three possible reasons as to why the vessel achieved 2 knots less than expected, namely:

[89] SMA 87.

[90] *Bulk Ship Union SA v Clipper Bulk Shipping Ltd (The Pearl C)* [2012] 2 Lloyd's Rep 533.

[91] (2019) 1041 LMLN 4, *Lloyd's Maritime Law Newsletter*, 25 October 2019.

(1) adverse weather; (2) underwater fouling; and (3) technical problems. There was no allegation about misrepresentation.

In this instance, the arbitrator remained within the scope of the parties' submissions. As the charterers did not substantiate their allegations with credible evidence, the claim was unsuccessful. This may be contrasted with *London Arbitration 23/21*.[92]

To address the issue of loss calculation during both favourable weather conditions (when the weather report failed as evidence) and unfavourable weather conditions, various methods have been employed to assess underperformance resulting from fouling or hull roughness. The *slip* and *rpm* methods, for example, have been applied in the recent *London Arbitration 23/21*,[93] *London Arbitration 15/23*[94] and *London Arbitration 4/25*.[95] Neither method is novel: the rpm method was already in use in *London Arbitration 5/80*,[96] and Cedric Barclay described the slip method as early as 1974.

Barclay,[97] an engineer and a "giant in the field of maritime arbitration" as some previous authors described him, had proposed an alternative method and explained:[98]

> "... criticism of performance [would] be justified when comparing the rpm at the warranted speed with that achieved [during] passage. Allowance must be made for conditions necessitating a reduction of revolutions but otherwise provided these are kept within limits close to those of the warranty, there can be little that is wrong with the vessel. ... Diminution of RPM is, in the absence of other factors, a fair indication of some defect in the machinery.
>
> This would lead to the conclusion, which immediately occurs to an engineer, that the speed warranty in a charter-party is badly expressed. Rather than to describe a vessel as capable of about 14 knots in good weather and smooth seas, it would be more satisfactory to say:—
>
> Propeller Pitch is x inches. The ship is warranted to be able to average y rpm in weather not exceeding Beaufort 6. Slip in loaded trial condition was 4 per cent.
>
> The slip factor will automatically take care of weather. Perusal of the engine logs will immediately show any deficiencies."

It seems that Barclay applied this benchmark in this factual assessment in *The Apollonius*[99] by considering the attained speed under 9.1 per cent slip and correcting it up to 4 per cent to conclude what capable speed the ship would do in good weather.

In *London Arbitration 5/80*,[100] there was a serious reduction in engine speeds during the charter. There had been no real disagreement between the experts on that aspect and both agreed that the measure of loss was the actual average engine rpm during the charter compared with the rpm necessary to give a fair-weather speed of 13.875 to 14.1 knots.

In early reported cases, like *The Apollonius*,[101] the experts were able to calculate the loss due to fouling. The arbitrator, Cedric Barclay, made certain findings of fact by considering the average speed under rpm and slip 9.1 per cent, was 13.60 knots and concluded that the speed capability of the ship would be 14.2 knots. It appears that the margin of allowance for that period was quite restrictive, ie about 4 per cent. By adjusting the speed 13.60 knots (slip 9.1 per cent) basis 5 per cent (expected 4 per cent slip), it yields a speed of around 14.2 knots. Expert evidence resulting from examination of the vessel's performance was that "after allowing for occasional adverse weather, the ship's theoretical best average speed under good weather conditions and in current-less water could in her fouled condition not exceed 12 knots. Because of the 'barnacles' she had dropped 2 knots".[102] The RPM was down from 101 to 91, indicating increased frictional resistance of the hull.

There was an allowance for weather and currents, so that the remaining shortfall was due to fouling with the slip leading the way. This appears to align with *London Arbitration 15/23*[103] and *London Arbitration 23/21*.[104]

92 (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
93 (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
94 (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
95 (2025) 1177 LMLN 3, *Lloyd's Maritime Law Newsletter*, 17 January 2025.
96 (1980) 8 LMLN, *Lloyd's Maritime Law Newsletter*, 21 February 1980.
97 Cedric Barclay, MSc, CEng, FRINA, FIMarE, FICS, FCMS was a Fellow of the Chartered Institute of Arbitrators and a member of the council from 1961 to 1976. He was also President, London Maritime Arbitrators Association, for the period 1974 to 1976. Barclay dominated the maritime arbitration field for many years. He died on 15 March 1989. ("Cedric Barclay Memorial Lecture No 1", *Arbitration: The International Journal of Arbitration, Mediation and Dispute Management*, 1992, volume 58 issue 3, pages 159 to 174.
98 Barclay, "Speed and consumption warranties: Why do ships fail to maintain their warranted speed?" [1974] LMCLQ 13, at pages 20 to 21.

99 *Cosmos Bulk Transport Inc v China National Foreign Trade Transportation Corporation (The Apollonius)* [1978] 1 Lloyd's Rep 53.
100 (1980) 8 LMLN, *Lloyd's Maritime Law Newsletter*, 21 February 1980.
101 [1978] 1 Lloyd's Rep 53.
102 [1978] 1 Lloyd's Rep 53, page 56 col 2.
103 (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
104 (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.

Speed–power curves began to appear in New York arbitration in the 1970s, introduced by performance specialists as evidential tools. During that period, most disputes in London and New York were heard by commercial arbitrators and individuals with technical expertise, which meant that both experts and tribunals were generally familiar with the underlying principles.

Following *The Didymi*[105] weather routing companies began to apply a standard methodology, albeit with different ways of expressing the *Didymi* methodology, with some companies mimicking others, likely due to the simplicity of the approach. Whether the issue concerned damages or off-hire, the methodology produced the same result. While convenient, this approach became entrenched as a "simplified" approach – easy for those unfamiliar with performance claims to apply, as scrutinising the engine parameters and trying to produce curves or other sophisticated formulas was time-consuming and involved several assumptions.

Moreover, in some cases, where no good-weather periods were recorded, weather routing companies produced no results, even where fouling or engine damage had clearly caused speed reductions. This appears to reflect an influence from arbitration cases, where the so-called "weather factor" generated debate and inconsistent rulings both in London and New York arbitration. Its use is well-documented in both literature and industry practice, often as an alternative framework to explain discrepancies in voyage performance. Since voyage duration – including sailing time and bunker consumption – is central to calculating the time charter equivalent, charterers required an explanation when actual results diverged from pre-charter estimates.

Next, it is the point of whether the "about" allowance applies in calculating loss under clause 15 or for damages, when fouling or engine issues affect performance. Based on *The Divinegate*,[106] *London Arbitration 23/21*,[107] *London Arbitration 15/23*[108] and *London Arbitration 4/25*,[109] it appears that the experts and arbitrators in each case have applied the speed deficiency compared to the minimum warranted speed. Ms Ambrose has further stated in *The Divinegate* that any alternative method must be reliable and consistent with the charterparty terms. If the "about" allowances are part of the charterparty warranted terms, these should apply.

Turning to bunker consumption, there is no single method for calculating consumption resulting from voyage prolongation, whether due to off-hire or damages. Weather routing companies use different approaches. *The Divinegate* did not address this issue, as no bunker consumption claim was raised. Therefore, the case will depend on its specific facts and circumstances.

Formula-based analyses

The calculation of fouling effects on speed and performance often relies on theoretical formulas derived from general principles of power and resistance as functions of speed. These models assume constant resistance coefficients and propeller efficiency, which means they rely on simplifying assumptions. As complexity is layered onto these models, the risk of unreliable results increases and put up evidential hurdles before a tribunal.

In *The Divinegate*[110] the charterers' expert relied on a hull coating expert who reviewed the photographs from New Orleans and concluded that hull fouling was severe and may have accounted for approximately a 20 per cent increase in frictional resistance (see earlier in this article, under the heading "Biofouling impact", which depends on various factors). Based on this figure, the charterers' expert calculated that the engine power would have to be increased by 12 per cent to 15 per cent to maintain the vessel's speed due to the fouling. He considered that if the engine power was not increased, then the fouling would have resulted in a loss of speed of between 0.52 and 0.61 knots, giving a net loss of time of 27.2 to 32.2 hours.

The judge noted that the hull coating expert's opinion was untested, so limited weight was to be given to the charterers' expert loss calculation that considered this opinion. Based on the academic articles that the hull coating expert formed the opinion, there was "no established formula for the practical measurement of the impact of fouling on speed. The research was based on very differently shaped warships".[111] Moreover, the

105 *Didymi Corporation v Atlantic Lines and Navigation Co Inc (The Didymi)* [1987] 2 Lloyd's Rep 166.
106 [2023] 1 Lloyd's Rep 442.
107 (2021) 1094 LMLN 1, *Lloyd's Maritime Law Newsletter*, 5 November 2021.
108 (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.
109 (2025) 1177 LMLN 3, *Lloyd's Maritime Law Newsletter*, 17 January 2025.

110 [2023] 1 Lloyd's Rep 442.
111 [2023] 1 Lloyd's Rep 442, at para 89.

owners' expert challenged the research relied on by the hull coating expert, saying that this research "did not show a reliable method for assessing the impact of fouling on the speed of bulk carriers".[112]

Accordingly, this reinforces the conclusion, discussed later in this article, that a proper assessment of the impact of fouling on a vessel's performance must be based on the specific facts of the case and an independent examination of all relevant evidence. Such evidence includes, inter alia, slip, rpm, engine consumption, prevailing weather conditions, bunker surveys, the weather routing report and other factors. An evaluation founded solely on empirical methods to determine the effect of fouling can be misleading, as an owner may incorporate the hull deterioration effect into revised performance warranties (as noted by the tribunal in *London Arbitration 2/24*[113]), without any demonstrable causal link to a reduction in speed. The ship may also be assisted by positive currents, which mitigate the resistance effect of fouling, either in part or as a whole.

Another approach was to account for the effects of weather and adverse currents, treating the remaining deficiency as attributable to fouling. For instance, some companies have applied the Molland[114] curves, which estimate the effect of wind speed and direction on vessel speed. For instance, under Beaufort 5 with a following wind, the speed reduction is minimal, whereas head or beam winds have a greater effect (a table provides a range of speed reductions in percentage terms depending on wind speed and direction). However, this method assumes the accuracy of adverse current data, requiring correction of speed over ground (SOG) to obtain speed through water (STW), and then attributing percentage reductions due to wind speed/direction. Besides, numerous other factors influence performance, and this analysis can be misleading in some cases. Moreover, in the author's experience, expert reports frequently misapply Molland's analysis.

By contrast, slip adjustment, as applied in *London Arbitration 15/23*,[115] offers a different approach.

[112] [2023] 1 Lloyd's Rep 442, at para 120.
[113] (2024) 1151 LMLN 3, *Lloyd's Maritime Law Newsletter*, 19 January 2024.
[114] Molland et al, *Ship Resistance and Propulsion: Practical Estimation of Propulsive Power*, Cambridge University Press, 2011, page 5.
[115] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.

Hull cleaning adjustments

If a vessel sailing from Coega to Tianjin bunkered en route and underwent hull cleaning arranged by the owners, its good-weather speed might increase by 1 knot. This improvement would then be treated as the deficiency attributable to fouling for the segment from the loading port to the bunkering port, and the calculations would be made accordingly by taking the average SOG prior to bunkering plus 1 knot of new speed (SOG + 1 knot). Say, based on the SOG, the ship sailed for 500 hours. Based on the new speed, the ship would have sailed 450 hours, so, the loss becomes 50 hours. The corresponding bunkers would be calculated accordingly, ie by comparing the consumption by sailing at the revised speed with the consumption that the ship would sail with the minimum speed, in order to find the extra consumption.

However, speed improvements may also result from better weather after leaving the bunkering port, reducing the portion attributable to cleaning. In addition, good-weather data may be too limited to form a reliable benchmark; comparing a sailing period of 800 hours with a sailing period after cleaning of 80 hours may lead to wrong conclusions (even as a probabilistic method, it has challenges). Finally, this approach effectively compares the vessel's delivery condition against a post-cleaning "perfect" state. As no vessel – unless fresh from drydock – can be assumed to have a flawless hull on delivery, an allowance is necessary. In *London Arbitration 15/23*,[116] the arbitrator granted a 7.5 per cent allowance for slip in good weather.

Emerging and untested methods

In recent years, certain companies have issued simplified "one-page" reports purporting to calculate optimised performance and estimated time of arrival (ETA) adjustments. Such reports present significant evidential difficulties. Likewise, the so-called "twin model" analysis has yet to be tested before courts or tribunals in any reported case. The reports sometimes are unclear about the applied methodology, applying also adjustments due to draft or weather or even no "about" allowances,

[116] (2023) 1145 LMLN 2, *Lloyd's Maritime Law Newsletter*, 27 October 2023.

thereby creating increased claims in some instances. As discussed above, any such methodology must be examined against the three essential criteria of law, fact and practice. The outcome of any inquiry into the validity of these methods ultimately depends upon that analysis.

Percentage-based practical approach

This approach does not rely on mechanical applications, “de facto standards” or a “one-size-fits-all” model. Instead, it employs an analytical process of reasoning. The methodology is grounded in identifying percentage deficiencies in speed, with due consideration of slip, rpm, fuel consumption and prevailing weather conditions. It requires a fact-specific assessment of the evidence rather than the rote application of formulas.

The results are then tested, with careful regard to the applicable law, the factual matrix and practices in performance analysis. The current author has validated this methodology through many years of practical application – both in analysing and monitoring performance during vessel transits, and in testing results against methodologies advanced by third parties and experts. A similar analytical framework is applied in cases involving engine defects or breakdowns affecting a vessel’s speed. A detailed discussion of this analysis, however, lies outside the scope of this paper.

Conclusion

Fouling remains a recurring source of dispute under time charterparties, involving intricate technical, evidential and contractual considerations. Its negative impact on vessel speed, fuel efficiency and operating costs highlights the importance of rigorous performance analysis. While claims have grown increasingly complex, it is essential to recognise that alternative methodologies need not follow the same trend. As most disputes are relatively modest, parties ultimately benefit from pragmatic and cost-effective solutions.

Since performance claims engage questions of law, fact and practice, any methodology applied must be reliable and consistent with these tests. Its use should reduce unnecessary complexity and limit reliance on excessive assumptions. Recently, there has been a noticeable trend for parties to exclude alternative methods from their charterparties. As a result, the resolution of this issue is likely to be guided by market dynamics and the respective negotiating positions of the parties.