

Effectiveness of international regulation of pollution controls: the case of the governance of ship emissions

Bloor, M., Baker, S., Sampson, H., Dahlgren, K.



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Final Report

Michael Bloor, Seafarers International Research Centre, Cardiff University
Susan Baker, Cardiff School of Social Sciences, Cardiff University
Helen Sampson, Seafarers International Research Centre, Cardiff University
Katrin Dahlgren, U&W, Stockholm

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Seafarers International Research Centre (SIRC)
Cardiff University
52 Park Place
Cardiff
CF10 3AT
Tel: +44 (0)29 2087 4620
Fax: +44 (0)29 2087 4619
sirc@cardiff.ac.uk
www.sirc.cf.ac.uk

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Executive Summary

ES1. This document replaces an interim report of January 2012 and concerns the effectiveness of international regulations on ship's sulphur emissions, based on observation of ship inspections in the UK and Sweden and on interviews with regulators, inspectors and industry stakeholders. A second, related report is planned on issues concerning the enforcement of prospective regulations on ships' carbon emissions.

ES2. There is currently a 'culture of compliance' in the industry, with the proportion of ship detentions as a percentage of Paris MoU inspections falling from 9% in 2001 to just 3% in 2010. But in this highly competitive industry, operator compliance depends crucially on the perception that one's competitors are also compliant – the 'level playing field'.

ES3. Only fragmentary lab-test evidence of compliance levels is available. On the one hand, some commercial laboratories have made available summaries of the test results from large numbers of samples sent to them for commercial purposes. These results are mainly valuable as an indicator of the proportions of off-spec fuel being supplied as bunkers, rather than as an indicator of regulatory avoidance, since ship operators practising regulatory avoidance are unlikely to send samples for testing. On the other hand, some authorities (such as the Swedish Maritime Administration and the Dutch Human Environment and Transport Inspectorate) are collecting quasi random fuel samples for testing, but the numbers of such samples are small and some of the sampling may be intelligence-led. In 2011, 2.7% of samples collected in Western Europe, and 1.4% of samples collected in the Baltic, sent to one large commercial lab testing agency (Lintec Ltd), proved to have non-compliant sulphur levels. Most of these samples were only marginally off-spec, and there were considerable local differences. Test results on 149 samples collected by the Swedish Maritime Administration (partly quasi randomly and partly during Port-State inspections) showed only 4% were non-compliant (allowing for a margin of error of +/- 0.05%). Overall, the available test evidence is insufficient to estimate compliance levels across the ECAs as a whole.

ES4. If regulatory avoidance is occurring, it may be linked to the very great cost savings to be made from operating with low-cost, high-sulphur fuel at a time when shipping industry profits and freight rates are low. The newly arrived North American Emission Control Area (from August 2012) will ensure a continuing substantial price differential between compliant and non-compliant fuel in the medium term. The considerable financial incentives associated with using non-compliant fuel suggest the need for particularly robust enforcement measures.

ES5. Enforcement practice varies across different Paris MoU States. UK Port-State control (PSC) makes documentary checks, particularly on the Bunker-Fuel Delivery Note (BDN) and the Oil Record Book (recording the changeover from non-compliant to compliant fuel). In addition to document checks, Sweden takes around 200 fuel samples per year for subsequent lab analysis. These samples have been taken since 1998 as part of the monitoring system for Sweden's environmentally differentiated fairway dues, and are taken partly on a random basis and partly as a part of PSC inspections. Although they do not form part of this UK-Swedish comparative study, the Dutch authorities have a different procedure, using kits which provide a test result within about three hours. The Swedish test results are not available until after the vessel has left port and the penalties of non-compliance are limited (no State prosecutions to date, but the flag-State is informed of the non-compliance and eligibility is forfeited for discounted fairway dues), but the crew's observation of the sample-taking is itself believed to exercise some deterrent effect.

ES6. Neither the BDN nor the Oil Record Book are documents that were originally designed to have a statutory function. The BDN in particular is not always in English, does not always state the sulphur level on the note itself (as opposed to the printed annexed documents), does not carry the

Registration Number of the bunkerer, is frequently hand-written, and (as a carbon copy) it is sometimes illegible.

ES7. Inadvertent non-compliance by ship operators may occur for several reasons: firstly, the supply of fuel by the bunkerer may be compliant according to the BDN, but nevertheless may be non-compliant in practice (one reason for the widespread use by ship operators of commercial testing laboratories); secondly, in respect of low-sulphur heavy fuel oil achieved by blending high-sulphur fuel with distillate, through the partial separation ('stratification') of the blended elements during tank storage; and thirdly, through incorrect changeover procedure from high-sulphur to low-sulphur fuel or distillate. The last reason is particularly likely to occur among vessels with single service tanks (i.e. the day tank serving the main engine, as opposed to a storage tank). Such vessels may have undergone a changeover from high-sulphur to low-sulphur heavy fuel oil prior to entering the ECA, but a small residue of high-sulphur within the service tank may remain and be sufficient to mingle with the low-sulphur (with a typical sulphur level only just below the 1% cap) and thus render the vessel non-compliant. Single service tank vessels undergoing changeover procedures which entail the partial emptying of the service tank prior to bunkering with low sulphur fuel may be at risk of engine breakdown if the emptying is taken too far or if bunkering is delayed. Although specialist advice is available on changeover procedures, changeovers have been observed to differ substantially between different chief engineers operating the same vessel at different times.

ES8. Not all bunkering operations (and associated MARPOL samplings) proceed as they should, particularly in the bunkering of smaller vessels in smaller ports. Not all vessels are equipped with the special flange to enable the crew to take a continuous 'drip' sample and sub-contractors operating delivery trucks may arrive at the ship with the samples already bottled and signed.

ES9. An important incentive for ship operators to comply with IMO regulations lies in the publication ('naming and shaming') on the Paris MoU's THETIS database (and subsequently on industry databases such as Equasis) of a vessel's inspection record. However, vessels that are non-compliant with respect to the EU directive on the burning of 0.1% sulphur fuel in port are not 'named and shamed' on THETIS or Equasis, because the 0.1% port sulphur cap is not an IMO regulation, and incentives towards compliance are consequently reduced.

ES10. It is not currently possible to enforce ECA sulphur regulations on vessels transiting the ECAs through the territorial waters of EU member States, bound for non-EU ports where PSC may be less effective, although continuous emission monitoring equipment is currently being installed in a small number of new-build vessels and experiments are continuing with remote laser monitoring of exhaust plumes.

ES11. A list of seven recommendations appears at the end of this report.

Introduction

1. This project is funded by the UK's Economic & Social Research Council (grant reference: RES-062-23-2644) and has the support of the UK's Maritime & Coastguard Agency. We also gratefully acknowledge the help of the Swedish Sjöfartsverket (Swedish Maritime Administration) and the Swedish Transportstyrelsen (Swedish Transport Agency). The project began 1/9/2010 and finishes 31/12/2012.
2. The project draws on observation of ship inspections in selected UK and Swedish ports, and interviews with inspectors, regulators and shipping industry stakeholders, with the object of assessing the effectiveness of current enforcement of controls on ships' SOx emissions in the North Sea and Baltic Emission Control Areas (ECAs). A further object of the project concerns enforcement issues associated with possible future regulations on ships' carbon emissions – this will be the focus of a second projected report.
3. In all, 50 interviews have been completed and 16 ship inspections (involving visits to seven different port-State control offices in the UK and Sweden) have been observed. In addition, some unpublished, background statistical data have been collected: records of Falmouth bunker deliveries; records of tests of fuel samples taken by the Swedish and Dutch authorities, records of fuel sample tests undertaken by Lintec, a large commercial testing company; and the results of an in-house survey undertaken by a ship operator, concerning fleet experience of fuel sampling and testing by statutory authorities. Consensus was reached on the list of report recommendations (below) by an expert panel (or electronic 'Delphi group'), composed of two shipping industry managers, two regulators, one shipping industry association representative, one Port State Control Officer and one member of an environmental NGO.

Summary of the Relevant Regulations

1. Annex VI of IMO's MARPOL convention is concerned with regulations for the prevention of air pollution; Regulation 13 is concerned with NOx emissions, while Regulation 14 is concerned with SOx and particulate matter. The initial Annex VI regulations on SOx entered into force 19/5/05 and revised regulations on 1/7/10. Mandatory measures to reduce greenhouse gas emissions (GHGs) will come into force 1/1/13, requiring all ships to have a Ship Energy Efficiency Management Plan (SEEMP) and all newly built ships to comply with the Energy Efficiency Design Index (EEDI). The signatories to Annex VI have merchant fleets totalling 85% of the world's tonnage. The regulations apply to all ships over 400 gross tons. All except the smallest ships must carry a current International Air Pollution Certificate, certified by class. Emission Control Areas (ECAs) were set up in the Baltic (2006) and the North Sea/English Channel (2007), a third ECA came into force in North America in August 2012. Initially, the sulphur limit on fuel in the ECAs was set at 1.5%, reducing to 1.00 on 1/7/10 and further reducing to 0.1% on 1/1/15. At the present time of writing, the UK has not yet issued an update to Merchant Shipping Notice 1819, reducing the sulphur limit from 1.5% to 1.0%. The world-wide sulphur cap was initially set at 4.5%, reducing to 3.5% on 1/1/12. A further world-wide reduction to 0.5% is projected for 1/1/2020, subject to a

review respecting fuel availability to be completed by 2018 – if the review is unfavourable, then the 0.5% limit will be postponed to 1/1/2025.

2. In addition to these global regulations, the EU has introduced, from January 2010, an additional requirement for all ships at berth (and at anchor within port limits) to burn fuel with 0.1% sulphur. Additionally, there is an EU ban on sales of distillate fuel with sulphur content greater than 0.1%. An earlier (1999) EU Directive had set a cap on fuel burned on inland waterways. In Sweden, since 1998, the fairway dues (levied on all berthing ships to cover the costs of ice-breaking and navigation lights) have been differentiated according to whether vessels attest to continuous burning of low-sulphur fuel and/or whether the vessels have NOx-efficient engines. In addition, all the major Swedish ports operate differentiated port charges for vessels attesting to continuous burning of low-sulphur fuel. The fairway dues are substantial: the maximum charge per port call for an oil tanker is SEK 77,000 (£7,200), plus a charge of 70 ore (i.e. 5p) per gross tonne for using fuel with a sulphur content greater than 0.5% (i.e. half that permitted under the ECA regulations)¹. The Swedish port charges vary from port to port, but are smaller than the fairway dues. In Gothenburg, Sweden's largest port, there is no extra charge for vessels using less than 0.2% sulphur, for vessels using 0.2 – 0.5% sulphur the charge is 10 ore (i.e. 0.7 pence) per gross tonne, for vessels over 0.5% sulphur the charge is 20 ore. In the view of one Swedish port official: 'My gut feeling is that it has only a marginal effect – our fees haven't been so high that they are proportional to the cost of switching to a better fuel'.
3. Revisions to the 1999 EU Directive were approved by the EU Parliament in September 2012 and are due to be adopted by European Council before the end of the year. The revised Directive reduces the sulphur limit in those EU waters outside the ECAs to 0.5% in 2020, regardless of the outcome of the IMO review on fuel availability (see item 1 above). Importantly for this study, the revised Directive empowers the Commission of the European Communities (the Commission) to require 'Member States [to] ensure sufficiently frequent and accurate sampling of marine fuel placed on the market or used on board ship as well as regular verification of ships' log books and bunker delivery notes'². The revised Directive also empowers the Commission to stipulate the terms of Member States' reporting to the Commission on their enforcement practice. However, the full details of the Commission's 'implementing acts' in respect of the revised Directive have not been made public at the present time.

The Culture of Compliance

1. Port State Control (PSC), that is the equal enforcement of international shipping regulations by the port State regardless of a ship's flag, was established (initially, by 14 European governments, in 1982 as a political response to the pollution of the Normandy coastline by the Amoco Cadiz) because some ship owners were effectively evading international regulations by 'flagging out' to commercial registries, some of which lacked the capacity and/or political will to enforce international regulations. This regulatory avoidance was hazardous to life and to the environment, but was stimulated by the potential cost savings to be made from such avoidance in a highly competitive industry. For example, the Organisation for Economic Cooperation and Development (1996) estimated that a bulk carrier carrying two fewer crew than the statutory requirement would save \$37,000 pa³.

Port State Control seeks to penalise regulatory avoidance by targeted policing and by 'naming and shaming'. In respect of targeting, ships deemed to be a greater risk of non-compliance for whatever reason (for example, age, flag, previous inspection record) can expect to be inspected more frequently – thus, an elderly coaster inspected in 2011 had been previously inspected by PSC 35 times 1992-2010. And, in respect of naming and shaming, a vessel's inspection record is published on the Paris MoU website (and re-published on industry websites such as EQUASIS), which influences commercial decisions by charterers, insurers and others, and which in turn influence the freight rates that a vessel can command in the market place. As a result, most ship operators are incentivised to proactively comply with ship regulations. Thus, the following message, which was posted on the wall in the Master's office, from the CEO of a Far Eastern shipping company: "2011 Yearly Aims:

- (i) Detention zero by PSC inspection
- (ii) Save costs. Cut down 5% against the 2010 year's budget for repairs (including dry-dock repair) and stores
- (iii) Reduce the personnel injury on board by half against 2010 year
- (iv) High risk zero and observation less than 5 items by Oil Major Inspection [i.e. the SIRE inspections operated by the industry on oil tankers]".

2. Further incentives to compliance should be noted. The differentiated Swedish fairway dues (and to a lesser extent, the differentiated Swedish port charges) currently offer financial incentives for vessels using Swedish ports to operate continuously with low sulphur fuel⁴. Additionally, some operators have found PR value in having a 'green profile': the car carrier operator, *Wallenius Wilhelmsen*, has been operating continuously on low sulphur fuel since 1995 – a decision displayed prominently on its website⁵. And Swedish ferry companies dispose of all their toilet waste ashore, although there is no statutory requirement for them to do so. For the same reason, some charterers may require operators to run vessels continuously on low sulphur fuel. Thus, the ocean-going tugs that tow oil rigs all operate continuously on low-sulphur marine gas oil because they are required to do so by the oil companies under the terms of their charters.
3. While it is difficult to estimate the relative importance of these different influences – frequent PSC policing, PSC naming-and-shaming, green profile PR, demands from charterers – it seems clear that they have led to an overall improvement in compliance levels over time. Ship detentions in the Paris MoU (covering UK, European and Canadian ports) fell from 1,699 vessels in 2001 (comprising 9% of all ship inspections) to 790 in 2010 (comprising 3% of all ship inspections)⁶. There is now said to be a 'culture of compliance' in among many ship operators trading in and out of European and North American ports.
4. Levels of compliance with the sulphur regulations ought to be estimable from published results of tests on fuel samples, but the evidence is too fragmentary. The Dutch authorities have been taking small numbers of fuel samples for testing since 1999. Alarm bells rang in the shipping press in 2011 when Meindert Vink of the Netherlands Human Environment & Transport Inspectorate presented findings from 135 fuel samples taken in the port of Rotterdam in 2010⁷. These showed that in the first six months of 2010 (when an ECA sulphur limit of 1.5% was in force), the non-compliance level was 7% (from 72 samples), whereas in the second six months of 2010 (when an ECA sulphur limit of 1.0% was in force) the non-

compliance level had risen to 46% (from 63 samples). In a follow-up presentation, Vink reported on the results of 86 samples taken in 2011: 14 vessels (16%) were found to be non-compliant and 13 vessels were detained. The samples were randomly drawn from a vessel population of approximately 34,000 ocean-going vessel arrivals and 108,000 inland vessel arrivals per annum. In a personal communication, Mr Vink has stated that his belief is that most of these instances of non-compliance were inadvertent and due to poor fuel changeover practice (see 'Problems in Effective Enforcement', items 9 and 10 below). Other test data have been published by the technical manager of one of the major test laboratories, Lintec Testing Services Ltd, based on tests of the very much larger number of samples taken for commercial purposes. While some of these samples will have been sent for testing because of commercial disputes, the great majority are sent routinely as a matter of company policy by ship operators. The Lintec data for the first quarter of 2011 showed that 1.5% of all fuel samples taken in Rotterdam, and sent to Lintec for testing, had excess sulphur content⁸. However, most of the Lintec samples were only marginally off-spec and it must be allowed that ship operators consciously seeking to avoid complying with the low-sulphur regulations would be unlikely to send samples for commercial testing. The Lintec data should be considered, not as evidence of regulatory avoidance by ship operators, but as evidence of the supply of non-compliant fuel by bunkerers.

5. The overall Lintec figure for samples with non-compliant sulphur levels drawn from Western Europe and the Baltic region for the first quarter of 2011 is 3.8%. The report does not state what proportion of the 3.8% non-compliant samples were only fractionally off-spec, but in a personal communication the author, Michael Green, has indicated to us that most of the samples that were non-compliant in respect of sulphur were only marginally off-spec; this reinforces the inference that the operators were inadvertently non-compliant, rather than engaging in regulatory avoidance. Mr Green has kindly supplied us with updated figures for the whole of 2011: 2.7% of the Western European samples were off-spec for sulphur; 1.4% of the Baltic samples were similarly off-spec; the proportion of Rotterdam samples that were off-spec was 2.3%.
6. An earlier unpublished compilation by the European Maritime Safety Agency (EMSA) of test results from commercial samples collected at time when the ECA sulphur limit was 1.5% had reportedly also shown a 5% non-compliance level⁹. So there is no clear evidence that non-compliance (inadvertent or not) has been increasing over time.
7. In addition to the supply of off-spec fuel by the bunkerer and incorrect changeover procedure by the vessel, non-compliance can also occur due to the phenomenon of 'stratification'. Low-sulphur (1%) fuel oil is achieved by blending high-sulphur fuel with distillate. Faults in the blending process can lead to subsequent partial separation (stratification) of the blended elements in the vessel's storage tanks, with higher sulphur levels at the base of the storage tanks which connect to the service tanks. Test samples taken from the service-tank/engine connection will then show non-compliant levels of sulphur. Stratification could also occur in the bunkerer's storage tanks. The extent of this problem of stratification is unknown.

8. The Swedish Maritime Administration has kindly made available the results of tests on samples that they conduct as part of the enforcement of their environmentally differentiated fairway dues. Tests on samples taken from 149 vessels in 2010 and, allowing for a margin of error in sulphur content of +/- 0.05%, show that only 6 vessels (i.e. 4%) were found to have non-compliant heavy fuel oil¹⁰. While some of these samples are collected on a random basis, others are collected as part of PSC inspections (and are thus partly intelligence-led). It should be noted that some of these samples are taken only from the service-tank/auxiliary engine connection and thus relate only to compliance with the 0.1% EU port regulations, not the IMO Emission Control Area regulations. The only other test evidence we have found within the public domain come from the Danish Maritime Administration and the German Federal Shipping and Hydrographic Bureau. The Danish administration (which reportedly aims to take around 70 test samples per annum), sampling in 2008, found 3 samples out of 54 to be of non-compliant fuel¹¹. The German bureau, reporting on the inspection work of the Water Police of the various German States in 2009, stated that 365 cases were investigated, resulting in 9 (2.5%) reports to flag-States (presumably because of non-compliant fuel)¹². However, many of the German cases investigated will have been of vessels on inland waterways and will have been solely concerned with the enforcement of the EU 0.1% sulphur limit, rather than the ECA limit.
9. In some parts of the globe (notably, parts of South America and Caribbean) low sulphur fuel has been unobtainable because of limited local demand, although this problem is likely to diminish with the establishment of the North American ECA. Operators who have been able to provide documentary evidence to the MCA of their unsuccessful efforts to obtain compliant bunkers at their last port are allowed by the MCA to proceed to bunker at Falmouth or Portland without penalty. Additionally and more importantly, a vessel may have been supplied with off-spec fuel by the bunkerer without the knowledge of the operator. Not all vessels are fitted with the special flange on the bunker fuel access pipe which enables the crew to take a proper continuous and independent 'drip' sample. And some bunker suppliers (particularly sub-contractors operating delivery trucks) may arrive with the samples already bottled and signed. Further, in the case of the many vessels with only a single service tank (i.e. the day tank supplying the main engine, as opposed to storage tanks), the excess sulphur level may simply be the result of faulty changeover procedure, as suggested by Meindert Vink.
10. Other (non-sampling) evidence bearing on compliance should be mentioned. Bunkering operations at Falmouth, which lies just at the western boundary of the ECA, has experienced a major boom from shipping without compliant fuel, seeking to bunker with compliant fuel before entering the ECA. One of the two bunkering operations in Falmouth kindly made available some of their activity data: 369 vessels bunkered there in 2006; this rose to 1304 vessels in 2008¹³. It has been suggested that a laser technology can be used to analyse the sulphur content in a ship's exhaust plume and the Swedish Maritime Administration has experimented with mounting specially designed equipment on a spotter plane. Experiments with laser technology continue, although the Swedish Maritime Administration discontinued the use of the spotter plane because of concerns about aircrew safety. The Chalmers University (Gothenburg) team undertaking the study are continuing the project with a more

manoeuvrable aircraft¹⁴. The laser kit was found to have a measurement uncertainty of 15% and a negative bias of 5% (i.e. a reading of 1.2% sulphur would be required to detect an exhaust plume above the 1.0% limit). We understand that the intention has been to use the equipment as a screening device: identifying potentially non-compliant vessels which would, on berthing, have been boarded for inspectors to take fuel samples for analysis. In 2007, the same scientific team mounted laser equipment at the entry to the port of Gothenburg to analyse 220 exhaust plumes from 80 individual ships and found 3 (4%) of these to be seemingly non-compliant¹⁵. Portable, laser-based testing kits are commercially available, and are routinely used by refineries, and could – in principle – be carried on board as part of a PSC inspection, but the kits currently retail at around £30,000 each.

11. From the available evidence, therefore, it appears that the majority of ships in the ECAs are operating with compliant fuel. However, a significant minority of vessels appear to be non-compliant. Most cases of non-compliance are inadvertent – a consequence either of being supplied with off-spec fuel by the bunkerer, or faulty fuel changeover procedure, or (possibly) fuel stratification. Ships operating continuously in the ECAs, such as ferries, coastal traders and North Sea rig supply and support vessels, are particularly likely to be compliant – such ships have undergone frequent PSC inspections and many operate continuously on low-sulphur distillate fuel (MGO). Ships calling at ports where the operator is aware that fuel may be sampled by the authorities, such as Rotterdam and the Swedish ports, may also be significantly more likely to be compliant. Vessels calling at Swedish ports are also offered financial incentives towards compliance. Note however that ships transiting Swedish waters en route for non-Swedish ports such as St Petersburg (where PSC in the past has been shown to be less effective¹⁶) are not subject to sample-testing and may well be more likely to be non-compliant.
12. It will be clear from the data already cited that very small numbers of test samples, say around 500 per annum across all EU ports, are currently being taken by the statutory authorities on ocean-going vessels: in the Netherlands, 135 and 86 samples in 2010 and 2011; in Sweden, 149 samples in 2010; in Denmark, around 70 samples per annum; and in Germany 365 in 2009, but many of these would have been from vessels on inland waterways. The Rotterdam samples would amount to around 0.06% of all Rotterdam arrivals. Our interviews with ship operators indicate that most of them are not currently aware that the chances of their vessels being tested are so small. However, one operator (who wishes to remain anonymous) conducted their own in-house fleet survey and found that, of 27 vessels that operated at least at some point in an ECA, not a single one had ever been required to provide a sample for testing by the authorities. A shipping industry culture of compliance that grew out of effective PSC enforcement may be imperilled in respect of the sulphur regulations where the chances of deliberate non-compliance being detected are so small, especially where the rewards for non-compliance in terms of lower fuel costs (see below) are so large.

Fuel Price Differentials

For many operators, fuel bills now account for about half of their operating costs. The potential savings quoted by the OECD, and reported above, for operating with less than the statutory minimum crew are dwarfed by the savings that can be made by operating with non-complaint fuel. *Wallenius Wilhelmsen's* previously cited policy of operating continuously with low-sulphur fuel was estimated by the company to have cost an additional \$2.7 million dollars in 2009. In that year the price differential between low-sulphur and high-sulphur heavy fuel oil was around \$10 per tonne. In early 2011 the price differential suddenly increased to around \$80 per tonne, following disruption to supplies of Libyan oil which has naturally low sulphur. Currently (November 2012) that differential has slipped back to \$22.50 per tonne, while the price differential between high-sulphur heavy fuel oil and distillates is around \$320 per tonne. From 2015, of course, vessels in the ECAs will be required to burn distillate. Industry analysts are clear that, short of a world economic slump, the recent enforcement of a North American in ECA (from August 2012) will ensure a continuing very high price differential between ECA-compliant and non-compliant fuel. It is estimated that, after August 2012, half of all container ship voyages will involve transiting an ECA. There are also concerns about future fuel availability, due to limited refinery capacity and burgeoning demand for distillate from China and India. As one expert interviewee put it: 'In the future world, distillate will be costly, its availability will be questionable, and its quality will be much more variable'.

The Concern for a Level Playing Field

The shipping industry is highly competitive and a combination of the current economic downturn and surplus capacity (due the arrival of many new-builds into the market place) has served to depress freight rates across most sectors. Unscrupulous operators ('free riders') can thus secure a considerable competitive advantage through regulatory avoidance. This is particularly the case for the use of non-compliant fuel, where the potential cost savings are very large indeed. The main concern of operators concerning enforcement practice regarding the sulphur regulations (as with all international shipping regulations) is that enforcement should be sufficiently effective to prevent unfair competition from free riders. Thus, a ship operator explained: 'We don't have a problem with enforcement because we fully comply. And we expect everyone else to fully comply' [emphasis as in the original]. And another operator, speaking of costly investment in abatement technologies and greener fuels described how 'We will not invest in technology unless there is compliance with [fuel] regulations ensured by all the other companies'. And a shipping industry representative stated: 'I think of course we need enforcement, the industry wants enforcement because we don't want people cutting the corners. So all the good ship-owners want everybody else to be paying the same price. And that is almost the fundamental mantra that we follow in [the industry association]'. It is a moot point whether the current low levels of enforcement by fuel testing constitute the level playing field desired by the industry. However, the current main concern of the industry is not with enforcement of the current sulphur regulations, but rather with the projected future tightening of the ECA

regulations in 2015 entailing a sulphur limit of 0.1% (which would entail continuous operation in the ECAs on high-cost distillate fuel) – see for example the industry evidence submitted to the House of Commons Transport Select Committee Inquiry on the Implementation of IMO and EU Regulations on Sulphur Emissions by Ships in October 2011¹⁷.

Problems in Effective Enforcement

1. Although the UK Maritime & Coastguard Agency can charge operators for follow-up visits to detained ships, port-state control is not a revenue-generating activity and the MCA's port-state inspection operations naturally face budgetary constraints. The MCA has to find budget cuts of 22% over the period 2011-2015, as part of the UK government's comprehensive spending review¹⁸. The MCA has not equipped its surveyors with the sampling kits used by the Swedish inspectorate or with those used by the Dutch. Nor does the MCA currently have the technical capacity to detect non-compliant ships transiting UK waters but not destined for UK ports. The cost of the analysis of the samples collected by the Danish Maritime Administration was 150 Euros per sample¹⁹.
2. As previously mentioned, the Swedish maritime authorities have experimented with a laser system for detecting sulphur content in ships' exhaust plumes, mounted on a spotter plane. In principle, this would have allowed both early warning of possibly non-compliant ships bound for Swedish ports, and would also identify possibly non-compliant ships transiting Swedish waters. Although the maritime authority discontinued the use of the spotter plane for aircrew safety reasons, the team of university researchers concerned have continued their experiments with more manoeuvrable aircraft. The same team have also experimented with mounting the equipment on a vessel in Neva Bay, St Petersburg²⁰. Additionally, it appears that a laser device mounted at port entry points (and which could also be readily shifted from port to port as part of a random surveillance system) could potentially act as a screening device for identifying possibly non-compliant berthing vessels, which could then trigger collection of test samples of the fuel by PSC. However, a land-based monitoring device would not be effective for screening *transiting* ships from the coastline of busy shipping lanes such as the Strait of Dover and the Oresund, partly because this technology detects sulphur in all the airspace between the device and the vessel (so that the results would be contaminated by the exhausts from multiple other vessels). Further, the most likely follow-up course for the authorities at present would be simply to notify the vessel's flag-State of a possible non-compliance, with likely limited consequences, although the Automatic Identification System (AIS) and the European Maritime Safety Authority's SafeSeaNet system, in principle, offer the possibility of notifying instead the port-State authorities at the vessel's next port, where that port is within the Paris MOU.
3. Continuous monitoring of emissions already occurs on power stations. And there is the potential to both install such technology on ships and to transmit the information via satellite. The robustness of the technology in a marine environment is currently unproven, and were it to be proven, then it would probably be best installed on new-build vessels and those undergoing retro-fitting of scrubbers. Continuous monitoring technology is currently being installed on four

new cruise ships under construction²¹. It would be premature to make any recommendations on continuous monitoring technology in this report.

4. The MCA relies for detection of non-compliance on document checks, rather than on fuel sampling. Paris MoU PSC inspectors (in the UK and in Sweden alike) may ask to see the Bunker Fuel Delivery Note (BDN) provided by the bunker supplier, which specifies the sulphur content of the fuel. And PSC inspectors may ask to see the Oil Record Book which records the point at which the vessel both began and later completed its changeover from high-sulphur to low-sulphur fuel. Neither of these documents was originally designed to have a statutory function and they are not particularly robust documents for that purpose. As one expert interviewee remarked: 'The bunker delivery note is no longer just a commercial document, it is a statutory document as well – [the new regulations have] brought whole tiers of regulatory control to an existing activity'. The BDN is not always written in English (the international language of the sea) – it is expecting rather a lot of inspectors to require them know that 'zwavel' is the Dutch for 'sulphur'. Some BDNs for MGO supplied in the EU (which EU regulations require to be less than 0.1% sulphur) do not state the sulphur level on the note itself, but only on the printed annex to the note. The BDN is frequently supplied by a sub-contractor, rather than a registered bunkerer and the Registration Number of the bunkerer does not appear on the delivery note. The BDN held on the vessel is a carbon copy and is thus not always readable, particularly after storage. The BDN is also frequently hand-written, as are the entries in the Oil Record Book. Both documents are thus open to fraud/forgery. Hard evidence of fraud is naturally hard to come by, however fuel samples taken by other maritime administrations have sometimes shown considerable discrepancies between the sulphur level recorded in the BDN and that found on analysis. For example, the *Grande Mediterraneo* (IMO no. 9138393) inspected in Wallhamn, Sweden, on 10/11/2010 was found to have Heavy Fuel Oil in the service tank that was 1.68% sulphur, while the BDN recorded 0.98% sulphur²². It should be noted that regulators and industry stakeholders alike were aware of the frailties of the BDN as a statutory document. One regulator reported that discussions had taken place about the future possibility of electronic bunker record-keeping, although an industry expert interviewee thought that such a move was some way off, except perhaps as a pdf document attached to an email.
5. In discussions with expert interviewees, the following types of possible fraud/forgery were identified with reference to the BDN. Firstly, forgery on the vessel ('sometimes things get altered after signature for the receipt') – this is thought to be relatively uncommon because it is easily detected by comparing the ship's copy of the BDN with that returned to the bunkerer, signed and stamped by the chief engineer. Secondly, fraud perpetrated by the bunkerer – 'if a supplier knows it has fuel with a sulphur content of 1.2% there is nothing to stop the supplier from saying it is 1.0%, yes there is an audit trail but who has access to it?' Thirdly, fraud perpetrated by the ship operator and the bunkerer in collusion against the charterer, who may be asked to pay for low-sulphur fuel when high-sulphur fuel has been supplied. And finally, fraud perpetrated by the ship's crew and a bunkerer (or personnel employed by the bunkerer) in collusion again against the charterer – an industry expert was aware of this last kind of fraud being perpetrated in relation to short quantity, but not in relation to sulphur.

6. Although Masters are required to notify maritime administrations of their estimated times of arrival (in the UK, see Merchant Shipping Notice 1831), this duty is normally delegated to the port authorities. However, some smaller ports are not notifying the MCA of arrivals and so inspections are not scheduled. Potentially, the European Maritime Safety Agency's (EMSA) SafeSeaNet system monitoring ships' AIS (radio) transmissions, or the Long Range Identification and Tracking – International Data Exchange (LRIT-IDA) also administered by EMSA, could help identify such un-notified port calls. Note that, while it used to be said that ship operators could avoid a PSC inspection in the UK by the expedient of berthing Friday afternoon to Sunday evening, in 2011 the MCA reached an agreement with the union about out-of-hours working and this is no longer the case.

7. Specifically in respect of the EU requirement to burn fuel with a maximum of 0.1% sulphur in port, because this is an EU (rather than an IMO) requirement, non-compliant vessels do not have this deficiency recorded in the Paris MoU THETIS database and or (consequently) in industry databases like Equasis (Note however that the MCA records *detentions* due to non-compliant fuel on its own website, cf. the report of the detention of the *Pleiades Spirit* in the Port of Tyne for not burning 0.1% fuel at berth on 16/8/10). Thus, non-compliance with the EU regulations has little adverse commercial impact on the vessel's freight rates, because 'naming-and-shaming' on industry websites has not occurred. Past research on PSC has shown that the effectiveness of the Paris MoU is partly dependent on its 'smart regulation' strategy of incentivising ship operators to pro-actively comply with regulations by influencing the freight rates that vessels can command through the 'naming and shaming' of the non-compliant²³. Not to name-and-shame in THETIS (a system, ironically, developed by the European agency, EMSA) those ships non-compliant with EU port fuel regulations is thus to reduce materially operators' incentives to comply. The following notes are taken from observation of a UK PSC inspection in 2010:
' [...] the surveyor gave the ship a clean bill of health on its Paris MoU inspection, but then produced a different form [from the Paris MoU form] for a UK General Inspection where he recorded the auxiliary engines and boiler as being powered with fuel with sulphur content greater than 0.1%, with the deficiency to be rectified before the next port (i.e. in this case, as soon as the ship had bunkered and performed a fuel changeover). The captain was [...] mollified by being told by the surveyor that his ship would not be listed as having this deficiency on any database, such as SIRENAC [predecessor to THETIS] or Equasis. The captain asked what he should do with the paper copy of the UK General Inspection. The surveyor said he could store it with the paper copy of the Paris MoU inspection, which would go in the enormous binder-folder where ship certificates are kept all-together. After a moment's deliberation, the captain said he would store it separately.'

8. Port-State inspections follow a discretionary methodology, allowing surveyors some latitude in the depth and foci of inspections and in the actions required from non-compliant vessels. The Paris MoU Port State Control Instruction 43/2010/05 lists the PSC inspection instructions for the low-sulphur regulations and states that the surveyor 'should use professional judgement to determine whether to detain the ship or to allow it to sail with deficiencies which do not pose an unreasonable threat of harm to the environment'. This discretionary element is welcomed by many operators, but it also leads to uncertainty about penalties which may serve to weaken

compliance. While one surveyor might typically record non-compliant fuel as a '15' deficiency ('to be rectified by the next port') his colleague in the same office might typically record it as a '99' ('an observation to the master'). Uncertainty is not confined to the type of deficiency that may be recorded. EU member states which assert their right to prosecute vessels for contravention of air pollution regulations have not always achieved prosecutions, seemingly because of legal difficulties in conclusively establishing the burden of proof (for example, could it be proven that the test sample had not been tampered with en route to the laboratory?). The Swedish Maritime Administration's programme of sampling and testing has not yet led to a single prosecution by the State Prosecutor's Office²⁴, and Denmark's testing programme detected 10 violations of the sulphur regulations in 2006 and 2007, but these resulted in only one successful prosecution²⁵.

9. One would expect some uncertainty must also arise among operators out of differences in inspection practice between different EU states, although none of the operators or shipping industry representatives interviewed in fact voiced any concern about these differences. This project has focussed on UK-Swedish practice, where (as already stated) the main difference lies in the Swedish practice of taking samples for testing: Swedish surveyors take around 200 samples per annum (not all of them on PSC inspections – there is a deliberate element of randomness in the testing). These are sent away for testing and the results are not normally available until after the ship has departed, though the flag-State is notified of non-compliant test results and non-compliant ships also lose any preferential rates of Swedish fairway dues for which they may previously have been eligible. However, the Swedish surveyors believe that for the crew to witness the sampling procedure does itself exercise a deterrent effect. It should be noted here that the authorities in Holland and Germany have made available kits such that test results are available within three hours (thus, in principle, during the course of an inspection) and this has resulted in some vessels being detained for burning non-compliant fuel. It was reported to us that the Swedish authorities had considered the deployment of these rapid testing kits but had concerns about the accuracy of the kit test results compared to laboratory testing.
10. Vessels with a single service tank (that is, the day tank that serves the main engine, as opposed to storage tanks) are particularly disadvantaged by the technical difficulties entailed in compliance. Such a vessel may take as much as a four-day changeover period to flush low-sulphur fuel (LSFO) through its service tank before sufficient high-sulphur fuel (HSFO) has been expelled to make the vessel compliant. The highly viscous HSFO leaves sticky deposits that are difficult to get rid of and, since the sulphur content of the LSFO is typically only marginally below the 1.0% limit at, say, 0.98% sulphur, only very small amounts of HSFO need to be retained in the service tank to be diluted with the LSFO in order to render the fuel non-compliant. The changeover procedure on one such inspected vessel was fieldnoted to be as follows:

'...part-emptying the settlement tank (upstream from the service tank) for 4 days and flushing through the service tank [with LSFO]. The capacity of the settlement/service tank was 17 cubic metres and each day they emptied out 4 or 5 cubic metres. The main engines took 0.55 cubic metres of fuel per hour [i.e. 13 cubic metres every 24 hours]... because the fuel used for flushing/dilution was 1.0% sulphur itself, only a tiny amount of remaining HSFO

would be required to put the vessel over the limit. Nevertheless, the vessel had been following a responsible and reasonable changeover procedure and had made best efforts to be compliant’.

11. No data are available on the percentage of the world fleet with single service tanks, but single service tank vessels are certainly very common among older vessels and embrace a wide range of ship types including tankers, car carriers and large container vessels. In 11 observed inspections in this study where the number of service tanks was known, 8 of the vessels had only single service tanks and, of these, 6 were undertaking fuel changeovers (the other two vessels operated continuously on distillate fuel). Specialist advice is available from organisations such as Lloyds FOBAS on how to calculate a correct changeover period, based on the specifications of the fuels concerned, and the capacity and throughput of the service tank. But one serving Chief Engineer interviewed reported that he had adopted a much shorter changeover period than his predecessor on the same vessel and there are grounds for suspecting that changeover practice is quite variable on the same or similar vessels. It may therefore be doubted whether all vessels with single service tanks are in fact burning compliant fuel, despite having gone through a changeover procedure. Where the changeover procedure involves partial drainage of the service tank prior to dilution with the LSFO, then there is a particular danger of engine breakdown (and consequent collision, grounding or foundering) if the emptying is taken too far. In California (which requires ships to burn low sulphur fuel within 24 nautical miles of the State’s coast), the tanker *Overseas Cleliamer* reportedly came within 15 feet of grounding on the rocks of the Marin Headlands near the Golden Gate Bridge due to engine breakdown while undertaking a fuel changeover²⁶. Partial emptying of the service tank prior to bunkering with low sulphur also carries risk of engine breakdown if the bunkering is delayed by queuing or bad weather. Operators are aware of these problems, but many of these vessels have insufficient space in the engine compartment to retro-fit an additional service tank that would obviate the need for partial drainage. Some operators are addressing the problem by arranging for the service tank to be split during dry-docking. One dry-dock manager reported that his company had experienced a big increase in requests for this kind of retro-fitting in the last 3-4 years, with a particular peak in the last 1-2 years, and that competitor dry-docks were experiencing a similar boom in split tank retro-fitting. New-built vessels carry extra service tanks, unless designed for continuous MGO operation. So this compliance problem will diminish over time.

Conclusions

1. This report does not cover issues concerning the enforcement of regulations on carbon emissions, since the regulatory framework on ships’ carbon emissions remains unclear at this time. We plan to issue a separate report on the enforcement of possible carbon emissions regulations in due course. Because of the very limited PSC experience with inspections of vessels with scrubbers, we are unable to draw any conclusions or make any recommendations on the monitoring of ships with scrubbers. However, PSC monitoring of scrubbers is unlikely to be an important issue in the short-term because very few vessels are being fitted with scrubbers: only a small number of new builds are currently being fitted

with scrubbers on a trial basis and (although we understand that some scrubber systems can be fitted without dry-docking by a riding crew) enquiries with dry dock managers indicate that dry-dock work on the retro-fitting of scrubbers is currently only scheduled for one vessel in European dry-docks. Further, since this study is concerned with the enforcement of regulations on ship emissions, we have not considered here alternative governance approaches to cutting air pollution suggested by some of our interviewees focussing on fuel sales, such as an EU fuel quality directive for maritime fuels, or the removal of registration from bunkerers supplying off-spec fuel.

2. On the enforcement of the regulations on sulphur emissions, the fragmentary evidence reported above leads us to conclude that it is clear that a minority of berthing ships in the UK and Sweden are continuing to burn non-compliant fuel. In many cases, non-compliance appears to be due to bunkerers supplying off-spec fuel, rather than conscious regulatory avoidance by ship operators. The best estimates for off-spec fuel are 2.7% in Western Europe and 1.4% in the Baltic. Other reasons for inadvertent non-compliance are faulty changeover procedure (particularly among vessels with single service tanks) and 'stratification' of fuel in storage. Swedish data from their fuel-testing programme, although based on a very small percentage of port calls, indicates a non-compliance figure due to all causes (inadvertent and deliberate non-compliance) of 4%. There is no reason to suppose compliance levels will be identical across different EU States in the ECA, and indeed it seems likely that non-compliance levels among berthing ships in Swedish ports may be lower than in the UK. Possible reasons for the relatively low Swedish non-compliance figure include:
 - The long-standing (since 1998) financial incentives to continuously burn low sulphur fuel offered by the environmentally differentiated Swedish fairway dues (the differentiated Swedish port charges appear of only marginal effect in comparison).
 - The wish by local operators and charterers to demonstrate a green profile.
 - The high proportion of berthing ships in Sweden operating continuously in the Baltic and/or North Sea ECAs.
 - The deterrent effect of the long-standing Swedish fuel sampling programme, despite the limited penalties exercised against non-compliant vessels.

It is impossible to estimate the relative importance of these different factors. No data are available on ships transiting UK and Swedish waters en route for, say St Petersburg, but it seems quite possible that rather more of these transiting vessels will be non-compliant.

3. Evidence is available which does indicate some conscious regulatory avoidance, witness the Swedish test results from the *Grande Mediterraneo* and the UK detention of the *Pleiades Spirit* above. There is a danger that the 'level playing field' desired by operators may not be met and that the industry's 'culture of compliance' may break down in this regulatory area, especially if the very small chances of detection through statutory testing become more widely appreciated. The major factor in this possible breakdown is undoubtedly the very substantial cost savings to be made by running on non-compliant fuel.
4. The substantial financial incentives to use non-compliant fuel (uniquely large in respect of the rewards for regulatory avoidance in the shipping industry) argue the need for particularly effective measures of enforcement in this particular domain of PSC. Although

there is scope for making documents like the BDN more suitable for statutory purposes, a reliance solely on visual checking of documents does not seem appropriate to this need for particularly effective enforcement.

5. If the EU 0.1% sulphur port fuel regulations are not to appear toothless, non-compliant vessels need to be 'named and shamed' on the Equasis website.

Recommendations

1. **Fuel Testing/Sampling.** That the MCA consider piloting, as part of PSC inspections, the use of both fuel sampling kits similar to those used in Sweden and those kits similar to those used in Germany and the Netherlands. The sampling kits would be used in conjunction with laboratory testing. The pilot would provide information on the compatibility of the Dutch/German kits with 'light-touch' inspections. The pilot would also provide up-to-date information on contemporary compliance levels in UK ports. Assuming that a significant number of non-compliant vessels would be identified in the course of the pilot, there would also be information generated on the suitability of different enforcement options following a non-compliant lab test result (for example, the effectiveness of notifying the flag-State of a vessel, where the vessel in question had already left port). The pilot would be solely for the purpose of evaluating different sampling-and-testing procedures and for estimating the extent of non-compliance, it would not be for the purpose of arbitrating in commercial disputes between ship operators and bunkerers. The case for undertaking such piloting has arguably been strengthened by the recent (11/9/2012) passing by the European Parliament of the revised Directive on sulphur limits which empowers the Commission in future to specify the frequency and nature of fuel sampling methods to be employed by the Member States in enforcement of the Directive.
2. **Publication of Non-Compliant Vessels on Equasis.** That all EU countries inform the European Commission of the IMO number of all vessels found to be non-compliant in respect of the EU 0.1% sulphur port fuel regulations, with a view to the Commission seeking to ensure that these non-compliant cases appear on Equasis. It is proposed that the Equasis record contain the vessel's name, IMO number, inspection place and date, and the fact that the 0.1% EU at-berth provision has been violated. It should be noted that, at present, a vessel that is detained for burning fuel in port that is in violation of the EU 0.1% sulphur at berth regulation, can only appear in THETIS and Equasis if the Port State Control Officer has recorded this regulatory violation as a deficiency under IMO's ISM code.
3. **Changes to the BDN.** We note the possibility that bunker deliveries be recorded electronically. In the absence of an agreement on electronic recording, we recommend that agreement should be sought at IMO on a new format for the Bunker Delivery Note. Consideration should be given to the following propositions: (a) that the BDN should be in English; (b) that it should always state the sulphur content (already an IMO requirement); (c) that the Registration Number of the bunkerer be recorded (whether or not delivery is by a sub-contractor); and (d) that the material of the BDN be such that erasures or alterations to the note be visibly obvious.

4. **Next Port Inspections.** That discussions be entered into with the Paris MoU staff about the feasibility of making a vessel's non-compliant fuel lab test result at the last port the occasion for a P1 inspection at the vessel's next Paris MoU port.
5. **Single Service Tanks.** Further consideration needs to be given to the potential danger posed to ships with single service tanks changing over to compliant low sulphur fuel by means of the partial emptying of the service tank. For example, it may be inadvisable for such ships to have to queue for bunkering.
6. **Laser Screening.** While Swedish experiments are still continuing with laser equipment mounted on a plane and on an inshore vessel, it would be premature to offer recommendations on the monitoring of compliance by transiting, non-berthing vessels. However, consideration could be given in future to mounting laser equipment on a vehicle rig for visiting ports and 'screening' incoming and berthing ships for possibly non-compliant fuel, with arrangements for follow-up sampling of those identified as possibly non-compliant. Alternatively, a small number of the portable laser devices used by refineries could be purchased for the same screening purposes.
7. **Port State Control Training.** There may be scope for the sharing among Port State Control surveyors of best inspection practice on monitoring compliance with fuel regulations, for example, on methods of checking the accuracy of the logged changeover procedure, based on the BDNs, service tank throughput, etc, and on the recording the violation of the EU 0.1% port fuel regulation as an ISM deficiency. Best practice could be incorporated in in-service courses for surveyors and Paris MoU training courses.

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