Chapter 2

Environmental governance in shipping and ports: Sustainability and scale challenges

Jason Monios
Kedge Business School, Domaine de Luminy, Rue Antoine Bourdelle, Marseille, France

1 Introduction—Environmental challenges in shipping and ports

Despite the fanfare surrounding the Kyoto Protocol and the Paris Agreement, neither introduced legally binding emissions targets for shipping. A large body of research has developed in recent years, analyzing and quantifying emissions from the maritime sector (Shi et al., 2018), which it is hoped will eventually form a baseline for future reduction targets. These emissions can be divided broadly into greenhouse gas (GHG) emissions affecting climate change and local air pollution, primarily sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM). In 2007–12 shipping accounted for 2.8% of global GHG emissions or double the level produced by air travel (IMO, 2014). Local pollutants are a more pressing issue in coastal areas due to their impact on human health. According to the World Health Organization (WHO) air pollution (in total, not just from shipping) results in four million deaths per year (WHO, 2018). Shipping contributes a significant amount to this total, especially in coastal areas. Shipping accounts for approximately 15% of NOx and 5%–8% of SOx emissions globally (Zis et al., 2016). Brandt et al. (2011) found that emissions from shipping caused about 50,000 premature deaths in Europe alone in 2000.

While emissions tends to be the main environmental issue discussed, there are numerous other environmental challenges at sea, including accidents, oil spills, and water pollution from ballast water. EMSA (2016) reports on figures for EU-flagged vessels and/or within EU waters, revealing that in one year alone there were 3296 incidents involving 3669 ships, including 36 lost ships and 115 fatalities. Sixty-two percent of these incidents were attributed to human error and 278 resulted in pollution to the water through release of bunker fuel and other residual oils and lubricants. Ballast water is another important topic

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that has taken decades to address. Microorganisms can be transported across the globe in ballast water and devastate local species as a result of the ballast water discharge. Various annual cost levels have been estimated, such as $14.2 billion in the United States and €1.2 billion in Europe (David and Gollasch, 2015). At the port level, environmental problems include noise, dust, waste, and water pollution (Bergqvist and Monios, 2019). In addition, one of the biggest challenges currently facing policymakers is how to deal with the growth in Arctic shipping (Fedi, 2019).

While addressing the challenge of climate change continues to gain traction, and actions are being taken by industry and policymakers (see next section), the reality is that it is not possible to decarbonize maritime transport using current technology (Bows-Larkin, 2015; Psaraftis, 2019). Small design enhancements (partly as a result of IMO policies—see next section) continue to optimize operations and thus reduce fuel usage, and the only truly successful strategy thus far has been slow steaming. A recent study by Cariou et al. (2019) found that the shipping sector has achieved CO_2 reductions of 33% since 2007, mostly a result of slow steaming and to a lesser extent a reduction in distance traveled due to changes in network design. The only realistic large-scale fuel is LNG which would only save around 20% carbon emissions, but in fact the world fleet using LNG is not much over 100 vessels, mostly LNG carriers, ferries, and service vessels (Corkhill, 2018). Despite a few high-profile cases (e.g., CMA CGM ordering nine vessels in 2017) there is as yet little evidence of widespread transition to LNG. In theory, if the entire world fleet combined the existing possibilities of ultra-slow steaming, switching to LNG, network optimization and vessel design, along with some small additional energy provision from batteries, wind, and solar, then the sector could perhaps go some way toward meeting the IMO's target of 50% reduction by 2050 (Bows-Larkin, 2015). Even studies that propose hydrogen and ammonia as serious fuels recognize that they are decades away from commercial availability (OECD, 2018). At the same time, according to the IPCC, emissions must be reduced to zero by 2050. This target is not possible without drastically reducing the amount of shipping. Are we prepared for that?

2 Environmental governance—The IMO

2.1 Role of IMO and main policies

The International Maritime Organization (IMO) is the maritime branch of the United Nations, formally established in 1948 and operational since 1958. Its role is the "responsibility for the safety and security of shipping and the prevention of marine pollution by ships" (IMO, 2019). An IMO convention is usually considered in force once it has been ratified by two-thirds of member states but it does not apply to countries that have not ratified it, and enforcement is reliant on the individual member states (according to whether the directive applies to flag or port states—see below), rather than the IMO itself, resulting in different levels of enforcement.

Two of the most famous IMO conventions are the International Convention for the Safety of Life at Sea (SOLAS), the current version agreed in 1974 and coming into force in 1980 (although there had been earlier versions, dating as far back as 1914), and the International Convention for the Prevention of Pollution from Ships (MARPOL). The latter is the convention regarding environmental management which is the focus of this chapter. The difference in dates represents an expanding focus of the IMO from safety and navigation (although still important as witnessed in recent regulations regarding VGM and the Polar Code—cf. Fedi et al., 2010; Fedi, 2019) to the environment. MARPOL was originally adopted in 1973 but did not enter into force until 1983 due to challenges with ratification, and there have been several updates since the original. Responsibility for discussing and evaluating new regulations is delegated to the Marine Environment Protection Committee (MEPC), which meets every 6–9 months and is currently up to its 73rd session. There are now six annexes that have entered into force during 1983–2005. The first five cover pollution and waste in the sea, but the sixth, which has received much attention in recent years, concerns air pollution.

MARPOL Annex VI was adopted in 1997 and came into force in 2005. Its main focus was on reducing air pollution by limiting NOx, SOx, and PM emissions. Annex VI has itself been subject to revisions over the years, and an amendment came into force in 2010 establishing emission control areas (ECAs). The ECAs are located in the North Sea, the Baltic Sea, North America, and the United States Caribbean area. ECAs are often referred to as SECAs because of their prominent sulfur limit of 0.1% as of 2015 (Cullinane and Bergqvist, 2014), but North American ECAs also include NOx restrictions. In addition, the amendment set a reduced global cap of sulfur levels from 3.5% to 0.5% by 2020. Carriers meet this restriction by either switching to low sulfur fuel while sailing through an ECA or installing scrubbers on the exhaust system. One concern raised in the industry at the time was whether sufficient low sulfur fuel could actually be produced if regulations require increased use (Notteboom et al., 2010; Cullinane and Bergqvist, 2014). What has in fact occurred is that the scrubber option has proved very popular. The resulting realization of the popularity of open-loop scrubbers which discharge the used water into the sea (as opposed to closed-loop scrubbers which retain most of the water used to clean the exhaust for later disposal) has led to concerns regarding whether this method should continue to be allowed, due to concerns that the discharged water, although treated, still contains some pollutants. Moreover, reliance on scrubbers both decreases energy efficiency leading to increased GHG emissions and delays much-needed longer term action on changing fuels (Lindstad and Eskeland, 2016). The revised Annex VI also imposed tighter NOx restrictions on ship engines, depending on when they were built by separating vessels into three categories: Tier I (2000), Tier II (2011), and Tier III (2016).

Despite the large contribution to global GHG emissions from shipping, there remain no restrictions on CO_2 emissions. One way the IMO has contributed to GHG reductions is by targeting ship efficiency, which would obviously reduce fuel use and hence emissions of all types. An amendment to MARPOL in 2011 introduced the Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) which require that certain new ships must adhere to the EEDI and all ships to the SEEMP (Lister et al., 2015).

The IMO has been active in the resolution of various other environmental problems in shipping. For example, the ecosystem damage from ballast water discharge had already been known for decades before action was taken. The first action was in the original MARPOL 1973 convention to initiate studies, after which the MEPC worked to develop a suitable policy during the 1990s. It was not until 2004 that a convention was finally adopted, the International Convention for the Control and Management of Ship's Ballast Water and Sediments, which nevertheless did not achieve enough signatories to be ratified until 2016 and thus came into force in September 2017 (David and Gollasch, 2015). The fact that the convention did not apply until 13 years after its adoption and 44 years since the decision to study the problem reflects the challenges of global environmental governance.

2.2 Market-based mechanisms

The IMO has also been exploring the potential of market-based mechanisms (MBMs) instead of regulations to reduce CO_2 emissions such as emission trading schemes (Franc and Sutto, 2013) and bunker fuel levies (Kosmas and Acciaro, 2017). These have the advantage of being the same for all carriers, thus providing more certainty to the market and being less likely to distort competition. A total of 11 specific measures have been considered by the IMO, originally proposed by member states from 2008, ranging from supportive funds and incentives schemes to several variants of an emission trading scheme. The analysis was contentious, and resulted in no decision, not even a reduction in the number of measures to consider in future (Psaraftis, 2019). The MBM discussion in the IMO was effectively abandoned in 2013. Meanwhile, the EU has stated that if the IMO does not adopt MBMs by 2021, then the EU will include shipping within the EU into the existing EU emissions trading scheme.

Both cap-and-trade and carbon tax have their proponents and detractors, and detailed analysis lies beyond the scope of this chapter. A fixed tax gives certainty on the price, but how much carbon will be saved remains unknown, and it is impossible to set a price in advance to achieve a set reduction. It is possible that the price will simply be absorbed and no significant impact on behavior will result, or at least not enough to meet the proposed reduction targets. The other problem is that policymakers will never set a sufficiently high price (Bows-Larkin, 2015; Krugman, 2018) for fear of alienating industry lobbyists. According to Krugman (2018): "claims that a carbon tax high enough to make a meaningful difference would attract significant bipartisan support are a fantasy at best, a fossil-fuel-industry ploy to avoid major action at worst." Psaraftis (2019) points out that a carbon tax high enough to make significant difference would need to be in the level of three figures per ton of oil. Alternatively, cap-and-trade theoretically sets the maximum carbon emissions, and then the price will be fixed by the market. A downside of both MBMs is that they do not incentivize major structural change but rather small optimizations that merely delay the required structural transition away from fossil fuels (Lohmann, 2008).

2.3 IMO targets

The lack of GHG targets by the IMO had been criticized, and in fact had already led to the EU creating their own GHG documenting requirement in 2015 (see later section). In response, the IMO introduced an amendment to MARPOL Annex VI requiring vessels above 5000 GT to record their fuel oil consumption. Fedi (2017) points out that the IMO regulation is less comprehensive than the EU regulation, partly because it uses proxies for transport work rather than including details on the cargo carried by each ship.

In April 2018, the IMO announced a commitment of the shipping sector to reduce emissions by 50% in comparison to 2008 levels by 2050. Establishing a target for the first time is certainly a positive step, but the lack of mandatory actions and the long timeframe allows the possibility of delay and further modification of the deadline, and the fact that the United States was not in agreement may limit compliance with the target. Therefore, without clear and strong global regulations, meeting this ambitious target remains difficult. Moreover, national and international CO_2 reduction targets are based on 1990 levels not 2008 (in 1990 GHG emissions from international shipping were 70% lower than 2012—DGIPPA, 2015), and in fact the IPCC target to restrict the world to 1.5 degrees of warming is carbon neutral by 2050, not 50% reduction. The longer term goal of the IMO is to "consider decarbonization in the second half of the century," which is more realistic as regards technology, as hydrogen for instance may become commercially viable by then, but that will be too late to meet global carbon targets.

To achieve their 50% goal, the short-term measures recommended by the IMO are primarily related to increasing optimization of vessel design and operations, including slow steaming. Alternative fuels are not considered realistic until the medium term (defined as applying after 2030). Interestingly, MBMs are also only considered by the IMO as a medium-term measure. What remains curious is that, despite many academic, government, IMO, and industry articles on possible reductions, there is remarkably little discussion about the fact that without targets and policies, no reductions beyond small optimizations are likely to be forthcoming. Given the lack of mandated actions in the IMO roadmap, the weaknesses of EEDI, and the fact that the MBM discussed is closed, Psaraftis (2019) is one of the few commentators to state the blunt conclusion that significant GHG reductions from shipping are "only a wish at this point in time."

3 Environmental governance—Other organizations

3.1 The national level

Shipping is mostly governed at two levels—national, as all vessels must be registered/flagged in a particular country and international, in terms of certain rules regarding safety (e.g., IMO SOLAS convention) and environmental performance (e.g., IMO MARPOL convention). These two levels frequently interact. The United Nations Convention on the Law of the Sea (UNCLOS) stipulates three kinds of states: flag states, port states, and coastal states. The flag state is where ships are registered, port states relate to the right of the state to institute inspections on vessels in their ports, and coastal states relates to the jurisdiction of vessels sailing within the territorial waters of a country.

Flags of convenience (FOCs) are a well-known issue where many carriers changed their country of registration in order to save tax, reduce labor costs due to lower labor regulations in the flag states, and benefit from the fact that these states lacked resources (and inclination) to enforce regulatory compliance for IMO environmental and safety regulations (Roe, 2013; Alderton and Winchester, 2002). Flag determines the pay and conditions (thus saving money for operators) but the actual quality of seafarers and vessels (officially at least) must meet IMO/ILO and classification society standards, respectively. Accidents arise not because of the lack of quality of the crew but due to overwork, lower quality working conditions, and lack of time and resources to follow IMO regulations as a result of demands of the employers. Roe (2013, p. 168) decries the "territorial hypocrisy," whereby shipping lines "trade off policies at national and global level to achieve the best of both worlds (and the worst for the environment, safety, security, and competition)."

One policy response to this lack of adherence to IMO regulations has been port state control (PSC), which enables port states to inspect vessels and apply penalties. An accident and major oil spill by the *Amoco Cadiz* in 1978 led to an organization of countries to improve such inspections, resulting in the Paris Memorandum of Understanding in 1982 signed by 15 EU states (later expanded to 27 members, including Canada). Other similar MoUs followed around the world. These groups work together via a shared database, with the aim to inspect 25% of all incoming vessels. A risk profile is used to identify ships to inspect, based on past inspections and other vessel and flag information (Li and Zheng, 2008). In 1995 the EU passed directive 95/12/EC on PSC (with later amendments) which made PSC mandatory for EU states. Initially the IMO had concerns about the EU-level directive but later accepted it (Blanco-Bazán, 2004; Van Leeuwen and Kern, 2013). Van Leeuwen and Kern (2013) make an interesting point regarding how EU states may prefer, individually or collectively, to institute more stringent rules as flag states, but they know that owners will simply flag out, but as port states, they can set their own rules and ensure that ships entering their ports meet international standards. So they can take steps to ensure ships sailing in their waters are safe, even if they cannot do it for their flagged fleet.

Flagging out is of concern for countries with a large amount of maritime trade, not just for environmental and work conditions, but for reasons of national security. Ships flying the national flag may be requisitioned in times of war, and the country may want to maintain a certain level of skills in the country's citizens, which is relevant not just while sailing but in port clusters and the wider sector. Thus different policies have been attempted by various countries to retain registrations on their national flag. An interesting example of multi-level governance is the modification of EU state aid regulations in order to allow member states to operate a tonnage tax, which is effectively a subsidy, replacing corporation tax for carriers with a (lower) tax on tonnage. Each country has its own version, with various requirements on, for example, training (Roe, 2013). A different approach and indeed a long-standing policy (a reaction to the lack of national shipping capacity during WW1) is the 1920 US Jones Act, which requires that all transport between US ports be carried by US-flagged vessels, which must be crewed by US citizens, whereas the UK tonnage act requires vessels to train UK citizens; it does not require them to employ them, knowing that this would be too costly and the ships would simply flag out (Oyaro Gekara, 2010). The US Act prevents that because if they flag out then they would not be permitted to work on those routes. The Act is widely unpopular, although that is partly for the additional requirement that ships also be US built, which is costly and difficult in this era due to lack of shipbuilding capacity.

3.2 The port and city level

Ports are governed usually between the city and the national level. The main governance is usually at local level via the port authority and its interaction with the city and local planning regulations and approvals, but there is usually also a national port policy which may be quite general and "hands off" (e.g., the United Kingdom) or may be more prescriptive (Monios, 2017). Planning also has a national component, as port developments are usually large enough to require national approval. This approval may be based on various criteria, and these days there is much more attention to the environmental aspect. For instance, a port development at Southampton in the United Kingdom was refused on the basis of environmental issues.

In terms of the daily operations of ports, there are many other areas of environmental management to consider that fall within the purview of the port authority in conjunction with local and national regulations. Furthermore, it is in fact local pressure that is starting to encourage ports to deal with local environmental problems. While the focus is often on air pollution, other issues include noise, dust, waste and water pollution (Acciaro et al., 2014; Lam and Notteboom, 2014; Bergqvist and Monios, 2019). These issues occur within the port (both land and water) as well as the hinterland. Considering how much port traffic has its origins and destinations far inland, cities must question to what degree the positive impacts of the port (jobs, taxes, direct revenue if it is city-owned) outweigh the negatives (congestion, pollution, sometimes only small number of jobs provided, often needing financial support for infrastructure) (Monios et al., 2018).

Key actions taken by ports include cold ironing to reduce emissions while at berth (Winkel et al., 2016; Innes and Monios, 2018), using electricity to power handling equipment (Spengler and Wilmsmeier, 2019), requiring slow steaming or use of LNG while in the port area (Winnes et al., 2015) and incentivizing of rail and barge hinterland transport rather than road (Bergqvist et al., 2015; Gonzalez-Aregall et al., 2018). These actions are mostly voluntary rather than legislated, although to some degree they are pushed by the pressure of citizen and environmental groups. Cold ironing provides a good example of multiple levels of governance working on an issue. While the EU incentivizes adoption by all major EU ports, it is not mandated, so it is usually a decision for the port authority. Some countries, such as Sweden, offer subsidies to ports for installation costs as well as subsidizing the cost of electricity to the vessels. In the United States, the state of California has introduced its own legislation that cold ironing must provide a portion of vessel power, starting from 50% in 2014 and increasing to 80% by 2020. As well as aiming to reduce emissions for both local health and to avoid climate change, ports are already beginning to face the challenge of climate change adaptation by protecting their infrastructure and operations from sea-level rise and storm surges (Ng et al., 2016).

3.3 Supranational organizations—The EU

The European Union (EU) is not eligible to become a member of the IMO but it has observer status, and has been developing its own shipping policies since 1993. According to Van Leeuwen and Kern (2013), this was not so much because it was unsatisfied with IMO policy but due to a lack of enforcement (as discussed above with flag states and PSC). After some high-profile oil spills (*Erika* in 1999 and *Prestige* in 2002), the EU brought in three sets of laws (known as the Erika packages) in 2000–05, pushing new standards on double hulls, PSC, flag states, and also creating the European Maritime Safety Agency (EMSA) (Urrutia, 2006; Van Leeuwen and Kern, 2013; Fedi, 2019).

Roe (2007, 2013) makes some interesting points regarding the EU's desire to represent its member states in the IMO, which was resisted by both the IMO and the states themselves. On the other hand, Van Leeuwen and Kern (2013) show how the EU has been effective in pushing the IMO for more stringent environmental standards and shorter timescales for implementation, particularly on double hulls, PSC, and SOx. This was done not just by lobbying the IMO but simply by pressing ahead with its own regulations covering EU jurisdictions. In 2005 Directive 2005/33/EC defined ECAs in the English Channel, North Sea, and the Baltic Sea, which set a sulfur cap of 1.5%, in addition to which ships at anchorage or in an EU port were required to use fuel with a maximum of 0.1% sulfur. These regulations were therefore much tighter than the MARPOL Annex VI regulations at the time. Directive 2012/33/EU established additional restrictions on sulfur content of fuels in line with the revised MARPOL Annex VI and discussed the possibility of extending ECAs.

The EU also implemented directives incentivizing cold ironing and LNG in EU ports. Directive 2014/94/EU on the deployment of Alternative Fuel Infrastructures states that "Member States shall ensure that the need for shore-side electricity supply for inland waterway vessels and sea-going ships in maritime and inland ports is assessed in their national policy frameworks. Such shore-side electricity supply shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits" (European Commission, 2014). The directive also says that member states "shall ensure, through their national policy frameworks, that an appropriate number of refueling points for LNG are put in place at maritime ports to enable LNG inland waterway vessels or sea-going ships to circulate throughout the TEN-T Core Network by 31 December 2025 at the latest." These directives mandate a response but not necessarily direct action, thus responsibility for such action lies with individual member states.

The EU's MRV (monitoring, reporting, and verification) regulation entered into force in 2015, requiring, as of January 2018, compulsory monitoring of CO_2 emitted by vessels larger than 5,000 GT calling at EU ports. This is the first step toward potentially setting targets and then applying MBMs, but there are no limits or actions as yet. Fedi (2017) highlights the quality of this regulation compared to the IMO version, although also noting some limitations: being only regional, possibly temporary, not including other pollutants (NOx, SOx, and PM) and missing the opportunity to incentivize cold ironing.

3.4 Industry and voluntary organizations

Various national and international port organizations exist that allow ports to share best practice and work toward more sustainable operations. In Europe, the European Sea Ports Organisation (ESPO) promotes environmental management in European ports. The current top ten environmental priorities of ESPO ports are air quality, energy consumption, noise, relationship with local community, garbage/port waste, ship waste, port development, water quality, dust, and dredging operations. In the Americas, the American Association of Port Authorities (AAPA), with 150 members in North, Central, and South America, has developed a guide for environmental management, the Environmental Management Handbook (EMH).

In 2008 the International Association of Ports and Harbors (IAPH) produced the C40 World Ports Climate Declaration, establishing the World Port Climate Initiative (WPCI). This group includes 55 ports around the world that pursue various green measures such as giving discounts to vessels scoring above a certain threshold on the Environmental Ship Index (ESI). This initiative has since been expanded with the launch in 2018 of the World Ports Sustainability Programme (WPSP). This is a joint initiative by the IAPH, the AAPA, the ESPO, The Worldwide Network of Port Cities (AIVP), and the World Association for Waterborne Transport Infrastructure (PIANC). The program's aims are linked to the 17 sustainable development goals set by the United Nations, under five key themes: resilient infrastructure, climate and energy, community outreach and port-city dialog, safety and security, and governance and ethics.

Similar voluntary industry groups exist in shipping, such as the Clean Cargo Working Group established in 2003, which developed an industry standard for measuring and reporting CO_2 emissions by carriers. The analysis includes data from more than 20 carriers, accounting for approximately 85% of global TEU capacity. Within the initiative there exist several working groups on topics such as green logistics and the Eco Stars fleet recognition scheme.

While such initiatives that focus attention on more environmental practices at sea and in ports through sharing of best practice and commitments to emission reduction are welcome, these schemes are voluntary, and therefore progress on significant emission reductions remains slow. While GHG reductions at sea have been notable (mostly through slow steaming to save fuel costs, cf. Cariou et al., 2019), GHG reductions from voluntary port schemes remain low (Sköld, 2019) and it will be a long time before they are both sufficiently stringent and widely adopted. This is understandable, given the commercial nature of shipping, but that is why regulators and policymakers must be prepared, not merely to nudge and incentivize, but to take more concrete action.

Moreover, it is essential that voluntary industry initiatives are not used as greenwash. Lister et al. (2015) showed that ship owners have lobbied actively against IMO regulations such as ECAs, and Sköld (2019) discusses how a study found evidence that shipping industry organizations such as the International Chamber of Shipping (ICS), the World Shipping Council (WSC), and the Baltic and International Maritime Council (BIMCO) have actively obstructed the development of climate change policies by the IMO (InfluenceMap, 2017). A recent study found that "the five largest publicly-traded oil and gas majors (ExxonMobil, Royal Dutch Shell, Chevron, BP, and Total) have invested over $1 billion of shareholder funds in the three years following the Paris Agreement on misleading climate-related branding and lobbying" (InfluenceMap, 2019). Where profit and planet align (e.g., reducing fuel use through slow steaming), there is a win-win situation. But the high costs associated with a major transition toward low carbon shipping (e.g., transitioning away from fossil fuels entirely) will preclude any voluntary action by industry.

4 The role of scale and institutional inertia

Roe (2013, p. 168) is highly critical of what he terms the governance failure in the maritime sector, "evidenced by the inadequacies of shipping or ports policy to address the problems of environmental, security, safety and economic concerns." Other authors are not particularly critical of the IMO, although they recognize the difficulties of obtaining policy agreement among all the many countries and other organizations. Both Roe (2009) and Van Leeuwen (2015) characterize shipping governance as polycentric, having multiple centers of power and decision-making. Roe argues that the current system remains overly rigid regarding the IMO and nation states, producing gaps in which multinational carriers can evade regulation; thus a more fluid polycentric system is required, producing policy from a wider network of stakeholders. Van Leeuwen frames the situation slightly differently, suggesting that indeed the system is already polycentric, in which other organizations are active in setting policy, such as the EU driving more stringent regulations and industry organizations developing new technologies and operating practices.

By necessity, the IMO faces challenges regulating 174 countries with different strategic interests. Ratification of conventions can take years, even decades, as shown above. Then the flag states have to turn the IMO convention into national law which may take more years. Despite these challenges, the major conventions are well ratified. SOLAS has 164 states and 99.18% of tonnage, and MARPOL has 157 states and 99.15% of tonnage. The main problem is enforcement, which, as shown above, is lacking by flag states but has been taken into hand by port states via PSC. These challenges are unavoidable. The IMO will never be granted the power to unilaterally force the global industry to act in certain ways, nor would that be desirable. Another problem highlighted by Psaraftis (2019) regarding agreement on contentious policies is that developing countries voted against both EEDI and MBMs because of the "common but differentiated responsibilities and respective capabilities" principle.

At the same time, the analysis above has shown that individual countries or blocs can institute their own laws if they are so minded. Yet, one can still recognize that the power of lobbying and selfish interests do constrain the IMO more than they should. The fact that the IMO website contains statements such as the following reveals the political challenges of making clear environmental statements: "Emissions from ships exhausts into the atmosphere can *potentially be harmful* to human health and cause acid rain and *may also contribute* to global warming" (italics mine). The lack of action on CO_2 is the primary issue, but even the other actions could be considered weaker than they should be. Lister et al. (2015) note that the lowest level of sulfur for SECAs is still 100 times the allowed level of sulfur in road truck diesel. There is also a glaring geographical imbalance, in that the current SECA locations do not cover all parts of the world, particularly poorer areas such as the highly concentrated shipping lanes in Asia, and there are none in South America or Africa. One could even argue that the favoring of MBMs by stakeholders at all levels is disingenuous, knowing that they will take decades to be agreed and will never be set at suitably stringent levels to achieve major change.

Such political challenges are familiar at all levels, from national policy to the Paris Agreement, with the United States even later withdrawing from the agreement that it had signed. Nevertheless, some countries are willing to take leadership. For example, Germany, the largest economy in Europe, has recently decided to phase out coal-fired power plants by 2038. Some countries have announced bans on fossil-fuelled car sales by 2040 and some even by 2030, while several cities have decided to ban fossil-fuelled vehicles from their streets from 2030 or even as soon as 2025. Banning fossil-fuelled ships from a country's waters by a certain date would likewise be a brave decision, but a multinational bloc like the EU could take such a strong decision, ensuring that no member country benefited at the expense of another, as long as neighboring ports outside the EU were not able to capitalize on such a policy. On the other hand, the problems resulting from the US Jones Act reveal the challenges of such a localized policy.

The future for maritime governance looks likely to be less centralized, rather than more. While the IMO will remain the major venue for policymaking, increased action at all levels is expected, from cities and regions (e.g., California cold ironing law) to national (United States setting its own agenda) and international (particularly the EU vs. the IMO regarding CO_2 targets). Fedi (2017) suggests that the divergence of the EU's MRV regulation increases the likelihood that other regional schemes could emerge, thus weakening the universality principle of the IMO.

Nevertheless, policy challenges do not result only from scale and institutional complexity. Even within a single jurisdiction the political difficulties of imposing restrictions on industry and the public are enormous. This is not helped by "scientific reticence" (Hansen, 2007) which has not underlined the seriousness of climate change, but that is changing now. There is little excuse remaining for politicians and decision makers. There are fewer places to hide for lobbyists and those arguing in bad faith for solutions known to be insufficient. Such bluster has been enabled by the dominant incrementalist policy paradigm, but that too is due for change as the latest science reveals that climate change is already happening and effects once thought over a century away are now predicted in the next two decades.

5 Conclusion

There are four major environmental policy challenges facing the existing maritime governance system. These will require strategies, actions, and, most of all, courageous responses from policymakers and actors at all levels.

First, local pollution—SOx, NOx, and PM. Air pollution is becoming one of the biggest killers in the world, with over 4 million deaths worldwide annually. Strong action is needed, at minimum ECAs covering all coastlines—looking at a world map depicting ECA locations, it is striking that no ECAs cover African, Asian, or South American coastlines. On the other hand, there is now some concern that ECAs may result in increased GHG emissions as well as the problem of sea pollution through open scrubbers (Lindstad and Eskeland, 2016), thus more thinking may be needed here. A global fleet switch to LNG would solve this problem by practically eliminating SOx, NOx, and PM, even if its CO_2 reduction is insufficient to meet carbon targets. Should the IMO go further and, rather than incentivize the switch to gas, simply ban the use of fuel oil? The IMO is not likely to introduce such a strong move so it will be up to the individual coastal states to ban these pollutants in their ports and along their coasts. How many countries will take such a decision? Will the EU take the lead? Both the IMO and the EU remain fixated on MBMs despite their lack of promise.

Second, the unavoidable subject of climate change mitigation. We have seen above that the IMO's 50% target reduction by 2050 may be possible with a combination of ultra-slow steaming, global switch to LNG plus ship designs, and top ups with battery and wind. However, there is as yet nothing even on the drawing board that can go beyond that toward full decarbonization, with no commercially feasible alternative fuel that could power international shipping at its current level, so to achieve full decarbonization the only answer, at least in the short term, is to drastically reduce the distance sailed. Are we ready for that? Do we have a choice? As LNG takeup is barely progressing, even after over a decade of hype, even reaching the 50% target becomes unlikely. Moreover, these calculations do not include transport growth. If shipping grows as predicted then the savings will be neutralized by increased emissions, pushing the target even further away. Is a stronger stick needed to drive the switch to LNG rather than the ineffective carrots offered so far? Additionally, given that LNG is only around 20% less carbon intensive than fuel oil and can thus only be considered a temporary measure, should fossil fuels be banned altogether rather than making huge investments to switch to LNG for only a few decades until hydrogen becomes feasible?

Third, we must not forget the port perspective, particularly as it concerns local pollution affecting many people who do not always benefit from the port activity. Zero local emission solutions must become standard, which may include a mix of cold ironing, use of LNG or battery power and slow steaming in the port area. The question is who should make this rule—should it be left to individual port authorities? Should cities in which ports are located take the decision, or perhaps at regional or national level? The IMO level is not appropriate for this decision, but a supranational entity such as the EU could at least provide support and subsidy toward such a move. Meanwhile, ports are facing the challenge of climate change adaptation. Strong decisions will need to be taken regarding future proofing port locations for rising sea levels and storm surges, but research shows a dangerous inertia between the different scales of government (Ng et al., 2019).

Finally, even while ports and policy makers are grappling with climate change adaptation, the situation has already become graver. The new paradigm is for deep adaptation, based on the latest science which reveals that climate change effects will not be linear and incremental but sharp, sudden, and soon (Bendell, 2018). Sea-level rise of several meters is now possible by the end of the century, with dangerous weather occurring every other day. Major disruption is now predicted within the next two decades, which will affect ports directly but also shocks will come from the wider economy as a result of massive migrations of coastal populations, threats to food and energy security, and countries spending billions on adaptation, all of which will influence demand for shipping and ports. Already, in 2017, 18 m people were made homeless by weather events (Internal Displacement Monitoring Centre, 2018). Globally, 145 m people live within one meter above the current sea level (Anthoff et al., 2006) and almost 1 billion people live in low-elevation coastal zones (Neumann et al., 2015). The International Organization for Migration estimates 200 m climate refugees by 2050 (IOM, 2019). According to the World Bank (2018), climate change will push 143 million people to migrate at least within their own countries by 2050.

These challenges raise unprecedented questions regarding the viability of existing port locations, retreat from coastlines, and many international disruptions from droughts and crop failures to migrations and war that will radically reshape current production, consumption, and hence shipping practices. To a large extent, dealing with these challenges will be made at national level, through policies to decarbonize and boost renewables and plan for the retreat of millions of residents and businesses from exposed coastal locations. Thus while maritime policy is polycentric with a strong global component, national policies for dealing with climate change adaptation can be expected to play an increasing role in the evolution of maritime transport and trade in the coming decades.

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