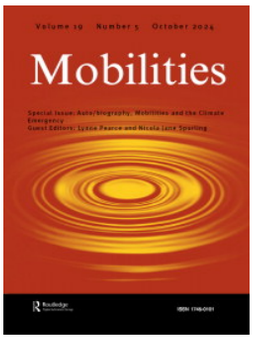

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Disrupted immobilities: giving space and time to the discussion of immobility dynamics in transport shipping

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ABSTRACT

Ships are technologies of maritime mobility. But sometimes ships are immobile—they stop and remain stationary for short or prolonged times. A degree of stasis inside and outside ports is both usual and essential for facilitating the movement of ships in global markets. This paper makes two important points: first, echoing existing literature, frequent stationarity (or waiting) is a normal occurrence in the industry. Second, it is not just mobilities that are disrupted via moments of stasis; immobilities themselves have distinct patterns that too can be disrupted. This nuance is vital: there is a need to understand the disruptions to immobilities rather than understanding immobilities as disruptions to the general condition of mobility, both within—and beyond—the shipping example. We argue that understanding disruptions to immobilities is vital to grasping the dynamics of shipping, alongside other (im)mobilites (car, train, plane), their conditions, and the politics that shape our world on the move. Using a data-driven approach, embracing AIS methods for exploring ship stationarity around US waters during the COVID-19 pandemic, this paper upends the assumptions of ship (im)mobilities through the example of wait times, calling for scholars to give space and time to everyday immobilities and their disruptions too.

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Disruptions; immobilities; shipping; positional data; AIS

Introduction

The years 2020 and 2021 were tumultuous for the global shipping sector (Grzelakowski 2022), with the COVID-19 pandemic impacting shipping through closures of ports and increased wait times at terminals. Indirectly, the pandemic also shifted the consumption behaviour of global north citizens, leading to an imbalance in the distribution of freight containers (Panwar, Pinkse, and De Marchi 2022). These disturbances accumulated and caused ripples traveling through the global system. The situation was further aggravated by the closure of the Suez Canal in March 2021. Cargo ships provide the essential connectivity of goods between cities and nations and form the foundation of the globalized economy (Martin 2013, 1022). At least 90% of all goods

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are transported by ship at one point during their production cycle (George 2013; UNCTAD 2018). The global shipping network is currently serviced by 29,278 vessels. The commercial sector can be roughly broken down into: container (5599 vessels), bulk (12,714), and liquid bulk transportation (10,965) vessels (UNCTAD 2021). The connections made by cargo ships form a complex network that responds dynamically and nonlinearly to the load that is placed upon it. Studies of shipping networks are largely quantitatively focused, data-driven, and focus on studies of global and regional vessel movements and port relations (see, e.g. Ducruet 2020; Ducruet et al. 2024 ; Kaluza et al. 2010; Ng et al. 2014; Notteboom et al. 2013). Indeed, much shipping analysis derives from the fields of transport and logistics studies, well attuned to the mobile dynamics shaping vessel movements. But there are also qualitative assessments through focus on individual ports and ships, items of cargo, and workforces (see, e.g. Borovnik 2012; Chua et al. 2022; Heins 2016; Martin 2013), deriving from mobilities studies, with some wide-ranging and nuanced research from this perspective (see Anim-Addo, Hasty, and Peters 2015; Monios and Wilmsmeier 2018).

Indeed, the study of shipping networks is not centred within one field of research, or one single discipline. This means different fields are extracting their slice of interest/information about shipping movements, often in siloes without sometimes considering overlaps, differences in argument, or even a broader perspective. Economists study transport networks but mostly consider this on the level of input-output matrices of trade between nations (Ducruet 2020; Kali and Reyes 2007). Operations research examines transport networks in the context of logistics, but the focus is on small-scale optimization rather than a systemic understanding (Brouer, Karsten, and Pisinger 2016). Environmental studies are concerned with the impacts of ships as vectors of bio invasion (Kaluza et al. 2010; McCarthy, Peck, and Aldridge 2022) or the disturbance ships cause to the environment (Robards et al. 2016). Geography is even further separated, the different fields taking the lens of past and current global shipping networks to analyse the emergence of a globalized world, the patterns of inequality between the global north and global south, and on the growth of coastal cities (Hasty and Peters 2012, see also Birtchnell, Savitzky, and Urry 2015). Broadly speaking, the work listed above typically focuses on *movement*, answering questions on where vessels are going and at what rates (Kaluza et al. 2010), describing patterns of voyages between the different assignments of vessels (Shelmerdine 2015), analysing centrality in connection (Ducruet and Notteboom 2012) and vulnerabilities to interference (Calatayud, Mangan, and Palacin 2017). Whilst immobility is an expected and mundane reality in shipping operations, less attention is given to the dynamics of immobilities in the system: what influences make vessels move or stand still (with fewer papers, e.g. on layup as a mode of stasis, than on connection as a mode of moving). An exception is the excellent work of Monios (2023) who points towards the importance of taking seriously the character of immobility (in his case, in relation to the collapse of the Hanjin shipping firm).

A framework that can be employed to understand the dynamics of shipping more completely, as Monios shows (2023, and with Wilmsmeier in 2018, see also Anim-Addo, Hasty, and Peters 2015), is *mobility*, which pays attention also to (im)mobilities—a field unified by its interest in the causes and meanings of movement—its frictions as well as flows (Cresswell 2010; Sheller and Urry 2006). The mobilities literature has long explored the dynamics between mobilities and immobilities as two interconnected dynamics: the relationship between flow and stasis (see, e.g. Adey 2006). For example, the stasis of the port is essential for facilitating the movement of ships in global circuits of trade. Here ships are required to stop for processing. Moreover, research has also investigated *disruptions* to maritime mobilities, instances of ships stilling, mobilities halting: from exceptional economic downturns to catastrophic accidents [see, e.g. Cresswell and Martin's discussion of the overturned container vessel the *Napoli* (2012), to considerations of the COVID-19 pandemic (Knutsson and Bavinck 2022)]. Work has also explored the characters or qualities of movement, such as the 'drift' (see Peters 2015). But what is interesting in the mobilities literature on shipping is that largely (if not entirely) immobilities remain either linked to 'nodes' in the system (i.e. ports, where stoppages are quite usual) or couched as exceptional—as *disruptions* to

the condition of motion. This framing works on the assumption that mobility is the norm and is hence *disrupted* when immobility occurs. In other words, immobility is the disruption of mobility. But what of the disruptions to *immobility,* when we appreciate (as transport and logistics literature reveals) that immobility itself is a norm? Moreover, what of disruptions to immobility even when it *is* exceptional? How might we better make sense of the dynamics of stasis?

The example of the *Ever Given*, blocking the Suez Canal in 2021, is a good example of such a special form of immobilisation of global shipping and shows the nuance of how we might delve deeper into the topic of disruptions. Smooth mobilities of connection are the norm, with waiting in port to unload, as an expected—and accounted for—immobility. Yet the diagonal stranding of the *Ever Given* on the banks of the Suez was presented by the media and press as an obstruction or disruption to the general condition of moving that is a norm in shipping discourse (even as nodes or stoppages are acknowledged as likewise 'normal'). Monios (2023, 320) makes the same point in his analysis of the bankruptcy of Hanjin in 2017, noting that '[t]urbulence, drifting, induced and unproductive mobilities are anathema to the just-in-time globalised logistics sector, and the case analysis reveals how hyper-mobile flows of finance acted to *reimpose* the smooth logistics surface after a brief period of immobility' (emphasis added). This demonstrates the widely acknowledged discourse of movement that persists in understanding shipping mobilities, with disruptions understood as exactly that—disturbances to the condition of moving. There is a need, then, to pay more attention to the dynamics of disruption and *disruptions to immobilities*.

Accordingly, this paper makes two important points: first, it affirms, along with shipping, transport, and logistics scholars (i.e. Notteboom 2006), that whilst accidents are more exceptional, stationarity in terms of layup or more so waiting is a normal, rather than exceptional, occurrence in the industry. Immobilities are usual, then, and not just in port. Second, and more novel, this paper builds a conceptual argument for—and beyond—the shipping example, that it is not just mobilities that can be disrupted in the shipping industry: immobilities have their own patterns and trends, and they too can be disrupted. This nuance is vital: it is not to say immobility is shipping is not normal, but there is a need to understand the disruptions to immobilities rather than understanding immobilities as disruptions to the general condition of mobility (see also Monios 2023). We argue that disruptions to immobilities, understanding and paying attention to these dynamics, are vital to better understanding shipping and indeed possibly other mobilities and the conditions and politics of motion that shape our world. Using a data-driven approach, embracing AIS methods for exploring ship stationarity around US waters during the COVID-19 pandemic, this paper upends the assumptions of ship (im)mobilities through the example of wait times and calls for scholars to pay attention to their everyday immobilities and their disruptions too.

In what follows we next offer a literature review which presents existing work on (im)mobilities and shipping from the mobilities literature (as befitting this journal) and the ways immobilities have been traditionally studied and understood in relation to global shipping networks. Here we make the case for challenging the assumptions underscoring the shipping world, one ever on the move, with immobilities understood as either nodal necessities or a disruption to this general condition. We highlight, along with shipping, transport, and logistics scholars, a regular pattern for immobilities of shipping (via the dynamics of waiting), which calls for scholars to pay attention to immobilities not just as disruptions to mobilities, but as phenomena *with their own patterns and disruptions*. We then outline our method of using Automatic Identification Systems (AIS) data as a means to expose and bring to light wait times, before presenting our findings from the US example we explored. The analysis is divided into, and driven by, four research interests: (1) what kind of immobilities do we witness in the system (a longer term layup, or waiting?): (2) what spatial patterns can we see in these normal moments of ship immobility and (3) what are their temporal patterns? And finally (4) how does an exceptional disruption (the COVID-19 pandemic) shape these normal

immobilities—not as disruption to mobility, but as a disruption to the already-existent dynamics of immobility in the shipping sector? We finally offer conclusions.

Understanding immobilities: a literature review

Whilst ships routinely wait, public interest in the immobilities of the shipping sector was arguably heightened with media attention to the many ships which were moored for extended periods during the first COVID-19 lockdowns, and which could sometimes be seen from the shore (see Müller and Peters 2024). Indeed, they could be spotted from the coast, even in those areas that are not traditionally known for being roadsteads for ships (in other words, places where vessels usually wait) (Crump and Dalling 2020; Schaben 2021). While these observations are likely linked directly to the disturbances caused by the pandemic, the observation of ships on extended period of so-called layup is, in fact*, not* novel (even if they surprise the public). Nor is simply waiting to enter port. Yet it is rather an assumed quality of shipping that vessels are *ever* in motion, servicing—and at the same time producing—the global economy and international markets (Monios 2023). Ships move for profit. News stories of disrupted mobilities (such as the *Ever Given*), or the fact ships are yet to sail mainstream through the Northern Sea Route due to 'sticky' ice conditions—in spite of a shorter route between the Atlantic and Pacific (Ferloni 2024; Savitzky 2016)—present immobility as a problem, hindering smooth flows essential for the global, just-in-time economy. Immobilities, then, are often understood as mundane facilitators to further movement (port calls and cargo drop-offs), or exceptional in hindering mobilities and hence are obstacles to overcome (i.e. *via* unblocking trade routes, re-floating ships, cleaning up accidents, with the goal towards more onwards movement). Yet immobility is interesting both as a condition of shipping (and not just in port, but in view of waiting) and disruptions to that immobility are likewise fundamental to understand to add further nuance to the dynamics of shipping (as Monios 2023). In other words: disruptions are not just linked to mobility but *immobility,* and these disruptions warrant greater attention too, not least in the mobilities literature on shipping.

Layup is a form of immobility and a consequence of the internal dynamics of the shipping market and appears as a reaction to an over-abundance of freight capacity (Sibilia 2019). Vessels actually *become* stationary in opportune areas to save on operation costs while at the same time limiting the amount of globally available shipping capacity, and thus fixing the price of transportation. Instead of immobility being exceptional, then, as it is often examined in the mobilities literature (see Cresswell and Martin 2012, on overturned freight during weather turbulence, for example) it might be considered a more regular condition of the shipping industry (as identified in the transport, logistics and shipping literature, see Notteboom 2006). Identifying operation costs is a key contributor to immobility in shipping. The phenomenon of layup is so far well known in Singapore, the most central port in the world shipping network, where it has garnered public and scientific attention due to the over 1000 Vessels that were laid up during the 2009 financial crisis (Mason 2009; Sibilia 2019). Yet there is less research on layups (or lay-offs as they are sometimes called) in areas beyond this hub in the shipping network. Moreover, there is even less work on the simple condition of waiting—where ships are not laid up (so to speak) but are stalling movement awaiting their next destination (port or otherwise).

Hence, and because immobility is often presented as a disruption to mobility (Cresswell and Martin 2012), immobility continues to appear as something special rather than ordinary. For example, work has focused on immobilities and the relationships between mobilities and immobilities in understandings worlds on the move (Adey 2006; Cresswell 2006; Hannam, Sheller, and Urry 2006; Sheller and Urry 2006) with literature on exceptional cases of shipping disasters (Cresswell and Martin 2012) or accidental beaching (Peters 2020); on stasis in relation to piracy

and cases of hijacking (West, Cooper, and Kachoyan 2010); and in reference to container politics and the use of the mobile shipping industry to hold still migrants who travel via boxes at sea (Squire 2015), or on the immobilisation of criminals being shipped to distant lands (Peters and Turner 2015). The disruptions to *immobility*—as a more normal feature of shipping—are rather more obscured [even as the dynamics of immobilities in other non-shipping setting are better examined, see, e.g. work on disruptions around infectious diseases, such as COVID-19 (Adey et al. 2021; Jensen 2021)].

Indeed, all of this is not to say academic interest in marine *immobilities* is absent per se (Hasty and Peters 2012; Merriman 2016; Monios 2023; Peters 2015; Peters and Squire 2019) but it is framed as rather more problematic, exceptional, and discrete, rather than usual, expected and normal (see the 'marine' mobilities papers previously mentioned). That said, in regard to cargo shipping dynamics specifically, most literature has manifested mainly in the field of logistics studies, which has estimated the impact short and long term *disturbances* had in the global flow of goods (Cariou and Notteboom 2022). Comparisons in the reaction of the shipping network to shock between the early pandemic and the financial crisis have shown differences in the reaction to internal and external shocks (Notteboom, Pallis, and Rodrigue 2021). Immobilities, and disturbances to them, require greater attention, as do the very character and qualities of those disruptions to immobilities (see also Peters 2015).

To further the understanding of immobilities, we show how positional ship data may help for developing links between mobilities and marine geographies research (Müller and Peters 2024; Peters and Squire 2019). Returning to layup, this is a distinct but frequent phenomenon of immobility in the shipping industry. But it is hard to separate from other rhythms of inactivity, especially the shorter stays or the waiting of ships in the ocean or other immobilities that are taking effect, such as a need for maintenance, or presence of turbulence within the smooth running of the shipping sector (Adey 2006; Cresswell and Martin 2012). Maintenance manifests in offshore wait times for repairs or crew transfer, and turbulence takes the form of prolonged waiting times at congested ports. Phases of immobility due to layup, on the ship level, separating the spread on the network from the local phenomenon of maintenance or turbulence, have so far not been studied extensively. Although we do not offer a systematic or global review here, as we show in our analysis below, disruptions to regular or normal phases of immobility are worthy of investigation. It should be noted that the study does not present a systematic pattern of layup in the study area. Whilst we argue the method is sound, the exploration of the encountered patterns merits its own discussion, especially as the results subvert initial expectations towards the behaviour of shipping under global pressure.

The COVID-19 pandemic provides a good example and in spite of the pandemic itself being unusual, it also comes to display dynamics of immobility *already* present in the shipping sector. Immobilities themselves are disrupted and manifest in distinct patterns that can be detected based on positional data through prolonged inaction. A useful source of such data is the automatic identification system, AIS. Approaching moments of ship stasis from the positional data perspective is beneficial as the mostly automated system is less influenced by human sources of error, such as bias in detection due to visibility or a reliance on shipowners to provide information on the operation of their vessels. The AIS data is standardized so the method can be applied to any scale and area where data is available in a suitable volume. All this said, a major downside to working with AIS currently is access to the datasets. Usually, they are sold by private data holders. Here the practice of the United States of America to publicize the data gathered by their national infrastructure provides a good starting ground to test the method. In the remainder of this paper we present an analysis of phases of regular immobilities based on AIS positional data for the US American Exclusive Economic Zone (EEZ). As such, we extend also understandings of immobilities of waiting beyond the Singaporean example (Sibilia 2019), which tends to make such a phenomena (not

least the layup) seem unique or special. We then analyse the identified immobile ships for their positions, spread throughout the year, and impact of the COVID-19 related shipping crisis. We next turn to our methods in more detail.

Identifying immobilities: methods and approach

The Automated Identification System (AIS) is a radio communication standard for the close to real-time transmission of ship properties, such as identity, position, speed, and current destination. This system was designed for the purpose of preventing collisions between large vessels, and to allow coastal states to have better control over their national waters. Since 2002, AIS is mandatory on all vessels above a gross tonnage 300, under the International Maritime Organisation's Safety of Life at Sea Convention (SOLAS). By recording the received data, operators of AIS infrastructure build data sets that provide an exhaustive insight into commercial shipping activity. This data is commonly used to improve the understanding of ships and how their movement influences the ocean environment.

For this analysis, we utilize a dataset that is provided for free by the Coast Guard, the Bureau of Ocean Energy Management, and the National Oceanic and Atmospheric Administration (NOAA) of the United States of America (BOEM and NOAA 2022). The unfiltered data used includes entries captured in the range of all receiver stations operated by the institutions in the years 2018–2022. The AIS relevant columns for this analysis are for recognition of patterns in the movement of single vessels, position, speed, timestamp of transmission, and vessel type for selecting commercial cargo vessels. For every whole day, the ships were filtered for their movement speed by two conditions: first, a ship during the period must not exceed a speed of 2 knots. Stationarity at sea is not absolute. Ships on the roadside are moored at buoys or anchors. Both limit the range of motion, but there is enough slack in the mooring that a slow shift in speed and position is expected and needs to be accounted for (Peters 2015; Robards et al. 2016). The second condition is that ships must not move more than one kilometre away from their starting position to prevent slow, steady moving vessels from being included. The next filter is applied to the class and position of the vessel. Only commercial cargo vessels (in other words, tanker and cargo ships) are included into the analysis as they are driving global shipping. Other vessels will show differing patterns of movement based on purpose (Robards et al. 2016).

The geographical boundaries were set from the coast (baseline) to the United States EEZ border, as ships during their processing in harbours, be it for loading, maintenance, or repairs, also remain stationary. Layup is taking place in the outer harbour limits to prevent fees (Sibilia 2019), so we exclude ships *within* the national baseline. Using the outer limits of the EEZ also has the benefit of eliminating ships that are processed in the ports of Mexico or other nations. The unfiltered data (Figure 1) shows the reception of positions within the ports of other nations.

We find in the analysis to follow that in the case of US American waters, phases of shipping immobility are strongly driven by tankers. This also manifests in the main locations for waiting ships off the coast of Galveston. Our analysis shows the pandemic has had a measurable impact on the regular annual patterns of *immobile* ships. We pay attention then, *not* to the disruptions that make mobile ships immobile, but the disruptions to *already* immobile ships.

Taking seriously disruption to immobility: patterns in shipping stasis

From the data, numbers of immobile vessels (measured by the parameters noted above) receded from 10,467 ship days in 2019 to 8562 in 2020, only to rise to new heights in 2021 with a total of 11,602 ship-days that vessels spent waiting. Taking the perspective of transport and mathematical network analysis, it is of interest how the shipping sector reacts to pressures like the pandemic, over which our date range occurs. The positional data allowed us to separate out

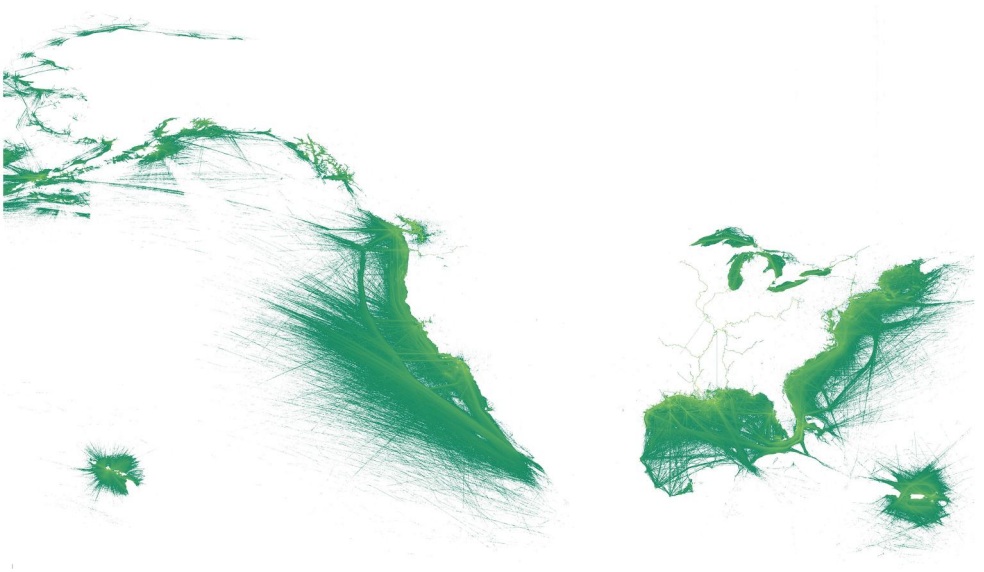

Figure 1. Representation of the area covered by the dataset on a $1' \times 1'$ raster. Shown is the density of all received positions in one year (2019). The figure was created from the raw data containing 2,757,136,868 datapoints that are representing 77,279 individual ships. The positions trace the outline of the continental US, the great lakes and major rivers.

different modes of commercial shipping: tanker transport and dry goods shipping, and the reactions to the economic environment could then be analysed by sectoral (type of transport), spatial (position), and temporal (when) dimensions. These dimensions connect to more qualitative fields of research explored under the remit 'geographies of the sea' (Müller and Peters 2024) or maritime law, also shedding more light on the dynamics of the industry. Indeed, filtering for phases of immobility allowed us to analyse shipping immobility in relation to the questions we set out earlier: (1) *what kind of immobilities do we witness in the system (a longer term layup, or waiting?)*: (2) *what spatial patterns can we see in these normal moments of ship immobility* and (3) *what are their temporal patterns?* And finally, (4) *how does an exceptional disruption (the COVID-19 pandemic) shape these normal immobilities—not as disruption to mobility, but as a disruption to the already-existent dynamics of immobility in the shipping sector?*

In relation to the first question, we looked at the relationship between ships remaining stationary and then becoming mobile again. The assumption here was that (longer term) layup is a *planned* and *mid-term* strategy that is qualitatively different from systemic immobility—or simply waiting. The expectation is that ships becoming immobile under layup will be *less likely* to regain activity each day, while a ship that encounters regular amounts of immobility events (i.e., is waiting) has a constant likelihood of regaining mobility as soon as the factors causing the stop have been sorted out. For recognizing the pattern, a distribution over the length of individual phases of immobility and their length was plotted. The relationship is linear in a semi log graph (Figure 2). A linear decay here shows that the probability of a ship still being immobile after a certain number of days declines exponentially. In the present context, this pattern of loss means that the chance of returning to a state of mobility is constant and hence independent of time spent immobile. This being the case points towards layup *not* being the main cause of immobility in the study area. If ships would enter long term layup it would mean that after some days of immobility it is less and less likely that they will become mobile again as the ships enter long term states of stationarity. The chance of a stationary vessel becoming mobile again within the next day is 44.5%. What we see here, then, is rather interesting in that greater disruption to immobility (i.e., even more layup) would be expected during the pandemic where shifts in the global economy echoed through the shipping sector. Yet our data of this zone at least,

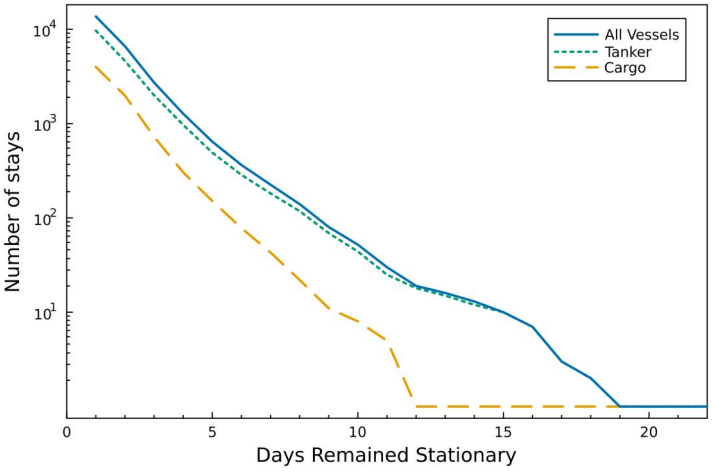

Figure 2. Semi logarithm of the quantity at which lengths of immobility occur. There is no power law distribution, so ships do have a constant likelihood of regaining mobility no matter how long they have been immobile before.

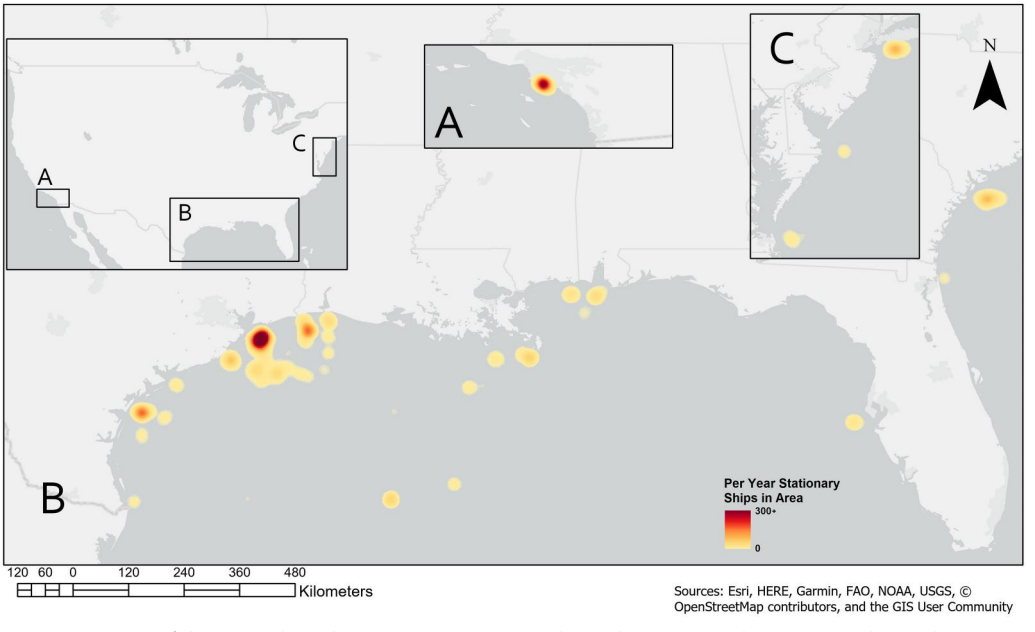

Figure 3. Heat map of the areas where ships remain stationary. In the study area, main clusters are on the southern coast of the US especially around Galveston; other areas of concentration of immobility are the east coast of New York and the mouth of the Delaware River and on the west coast offshore of Los Angeles.

demonstrates that immobilities were less disrupted than imagined, in the longer or mid-term, perhaps only with more *waiting,* than layup phenomena observed.

Our second question related to the spatial patterns of immobility that are normal within a system. Here the recorded positions of immobility from the data have been utilized to create plot hotspots. The geographical spread of phases of immobility strongly indicates that the moments of waiting are linked to major ports (Figure 3). The greatest number can be found on the Gulf of Mexico coast around Galveston and at the entry to the Mississippi River. On the west coast, Los Angeles produces a strong signal for outer harbour limit immobility; on the east coast

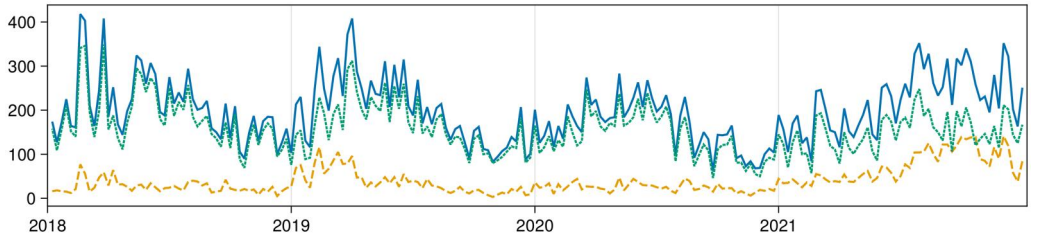

Figure 4. Long-term comparison between the analysed years. Portrayed is the total stationarity (blue), stationarity of tanker vessels (green), and stationarity of cargo vessels (yellow), all on a week by week comparison.

the ports of New York and the mouth of the Delaware River are areas where immobile ships are detected. Finally, in the Gulf of Mexico positional signals for phases of immobility are produced by the offshore oil-rigs and storage facilities showing that our exploration of immobility reproduces the spatial patterns expected from known ocean use.

In the analysis of the global shipping network, centrality is an important measure. For accessibility, especially, the 'betweenness' of centrality is of interest (Ducruet and Notteboom 2012). 'Betweenness' describes how important an area is for traversing between ports. More central areas impose larger immobility as they put the ships closer to opportunities for profitable cargo. The ports close to the hot spots of stationarity in this analysis are the most central in the US American context (Ducruet and Notteboom 2012).

Coming to question three, *what are the temporal patterns of immobility*, here we are comparing the number of immobile ships on a weekly basis. This reveals a distinct pattern. Firstly, there seems to be a seasonal behaviour. Immobility is at its peak around the start of spring with over 400 immobility events in a single week and then recedes to a minimum in late autumn (Figure 4), falling below 100 cases of immobility. The COVID-19 years deviate from this usual seasonality—disrupting the usual immobilities of waiting witnessed. In 2020 immobility does not peak as strongly (maximum of 280 stationary vessels in one week), and in 2021 the trend is reversed, as most immobility happens in autumn. The total number of immobility events per year also reflect this trend. What all this tells us, in support of the main arguments of this paper, is that firstly: *stationarity is normal*. There are patterns of immobility revealed in the AIS data which challenge the normative assumption (except in port, or in special cases) that ships are always mobile. Second, the changes brought by the COVID-19 pandemic show us that immobility should not be understood purely as a disruption to movement. Our findings here are very much at odds with regular thinking when it comes to the pandemic and immobility, as the shipping data shows how in this disruption immobility decreases in 2020 even though ports close and waiting times should, in theory, *increase*. Rather, there are disruptions to immobilities that may be worthy of exploration to understandings the workings of this global industry.

Looking at the difference in immobility, we can reveal more by looking at ship classes. The data reveals that the yearly trend is driven by tankers. There is less dry cargo ship stationarity and the overall fluctuation is smaller. An exception to this trend occurs at the end of 2021 when the number of stationary cargo ships increases to over a hundred per week leading into the overall reversed trend of immobility.

Our final question asked how an exceptional disruption (the COVID-19 pandemic) shaped normal immobilities—not as disruption to mobility, but as a disruption to the already-existent dynamics of immobility in the shipping sector. This required a link to indicators for the global economy. To connect the number of stationary vessels with economic influences, we tried to correlate the oil price with the number of waiting events observed in the data. To make this comparison, the total number of stationary ships per week was determined, then the average weekly oil price was extracted from the US Energy Information Administration (U.S. Energy Information Administration 2023). Both were standardized and plotted. This did not produce

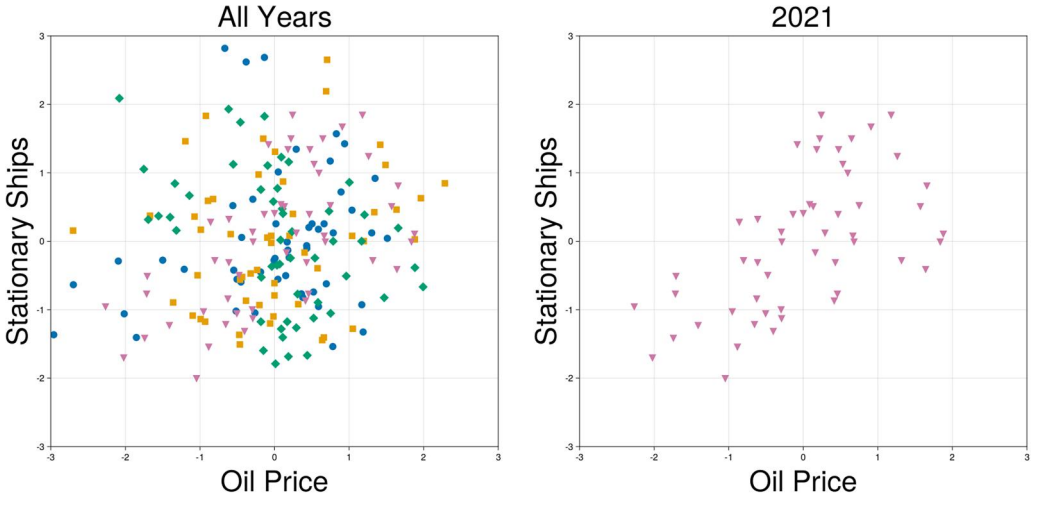

Figure 5. Relation between oil price and number of ships stationary, both standardised. On the left all years are overlapping with the coloursindicative of the years. The long-term view does not provide a correlation, but for single years a positive correlation can be drawn. As an example, just 2021 is provided on the right.

conclusive results (Figure 5). While single years, for example, 2021 are showing a connection (Figure 5), an overall trend has not been confirmed. This is a possible reaction to the COVID-19 pandemic but needs additional data to confirm. The result is a pointer that immobility is created by more factors than the direct forcing of the resource market, but it would be interesting to expand this search to gain a deeper understanding. In sum, there are further important questions to ask in investigating *disruptions* to immobilities: the way waiting ships behaviours are further (im)mobilised.

Conclusions

Using a data-driven approach, embracing AIS methods for exploring ship stationarity around US waters during the COVID-19 pandemic, this paper upends the assumptions of ship (im)mobilities through the example of wait times and calls for scholars to give space and time to everyday shipping immobilities and their disruptions too. This analysis was based on positional data produced by AIS and collected by the US Coast Guard. Using this, we showed that ship immobility is usual—a normal condition of vessel behaviour in relation to the dynamics of the industry. This confirms the research of transport, logistics and shipping fields where this behaviour in the operation of shipping (see Notteboom 2006) is already identified. But this is less accounted for in the mobilities literature where immobility is often studied as a result of exceptional events, such as accidents, which have featured most in this work. In our example, our findings show ship immobility—or waiting—is a frequent characteristic, but that this immobility can be 'disrupted'—be it seasonally (temporally), spatially, or by more exceptional events (a global pandemic). Indeed, we have showed ships have a constant likelihood of becoming mobile again independent of the time they have remained stationary before. Hot-spots of immobility are located at major shipping hubs, for example, off the ports of Galveston and Los Angeles (not just Singapore, which is much studied). A *regular* yearly cycle in immobility that existed before 2020 was subsequently disrupted during the COVID-19 pandemic. Our analysis detects an impact of the COVID-19 pandemic with the lowest amount of immobility recorded in 2020. This coincides with a global slow down in shipping, as countries around the world went into lockdown (March et al. 2021; Millefiori et al. 2021). Major exporting nations enforced strict regulations from March 2020 onwards, leading to a detectable decline in ships arriving in the United States with a 4-week

delay (Verschuur, Koks, and Hall 2021). While global shipping slowed down, this does *not* manifest as increased immobility in the study area. Studying immobilities, then, is revealing of insightful dynamics in the industry.

The finding that immobilities, in general, are driven strongly by tankers is coherent with other research that attributes low flexibility to liner shipping services even in times of crisis (Cariou and Notteboom 2022; Notteboom, Pallis, and Rodrigue 2021). While the measures adopted to cope with instability, especially in the early stages of the pandemic, have stabilized container shipping (Notteboom, Pallis, and Rodrigue 2021) the data observed here points to a long-term *disruption to immobilities* through the steep incline in stasis in the year 2021. Phases of immobility, though, have been less prevalent in the study area than initially expected for a major economy. Explanations might be inherent to the operation of global shipping. The United States is not a central node in the network of shipping and they are not an international hub for civilian ship repair and infrastructure. These two factors make Asian and European waters more attractive for long term inactivity—waiting—or layup.

An observation that arises from the study is that we find a reproduction of current global power structures. A rich nation like the US, especially in times of crisis, creates a pull that mobilises goods towards itself, to the point that container shipping breaks down in late 2021 as the empty containers clog up the system. At the same time, it is less promising to wait for opportunities of shipping at the US coast, this externalizes the potential environmental dangers caused by layup to areas that are out of sight for a western consumer basis.

In conclusion, this paper highlights AIS as a data source for research in marine (im)mobilities (see also Müller and Peters 2024). The practice of the United States to make large amounts of data publicly available is not common among data holders. While the specific format is slightly different between providers of data, an adaption to alternative sets will not present a major challenge. AIS is already a commonly used form of data for different fields of research from logistical analysis to environmental monitoring. More importantly though, our results invite further research, investigating more deeply the causes of disrupted immobilities (following Monios 2023), or expanding the study area using different AIS data sources in different areas, which may reveal different patterns and trends. Indeed, alongside advocating the use of AIS and demonstrating its use for understanding mobilities (see also Manderscheid 2016), we have made two important interventions to literature on the mobilities of shipping.

First, we note that whilst the transport, logistics, and shipping literature notes the normality of immobility in the sector, mobilities literature is more likely to see immobility as exceptional (at least this is what studies within the framework of mobilities reveal: immobility is a disruption to mobility). Yet immobilities also have particular shapes, forms, and characters—they too are disrupted in various ways (positively and negatively) as the COVID-19 date-range shipping data we used revealed. Our data aligns with the findings of shipping scholars who show that stationarity is quite normal: that patterns and trends in immobility existed, even before the instance of a disruption (in this case the COVID-19 pandemic). But drawing on/from the pandemic, we also show how this enables us to recognise that there is a need to examine disruptions to immobilities too. In sum, disruptions to *immobilities*, as well as mobilities, in shipping are vital to understand the dynamics of the industry. We urge more research to instances of immobilities and their disrupted dynamics: how long ships may be kept in dock with Port State Control rules, how long vessels are stationary at Marine Protected Area boundaries, or other more regular phenomena. This may bring to light a less noticed, but nonetheless important angle to the operation of worlds at sea. Moreover, an attention to 'disruption' as a crucial feature of many mobility systems [from air travel, train, automobilities, and other transport fields, as well as to virtual mobilities (Green 2020; Murray and Doughty 2016)] might also benefit from attention to the disruptions to the *immobilities* shaping these phenomenon (e.g., how border controls for immobilising disease spread are also disrupted?) (Adey et al. 2021; Jensen 2021). In sum, we urge an

extension of the existing rich work on immobilities, within and beyond shipping, to explore the disturbances to wider (im)mobile worlds.

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Data availability statement

The data that support the findings of this study are openly available in MarineCadastre at https://marinecadastre.gov/ais/, AIS Broadcast Points 2018–2021 (Source: BOEM and NOAA 2022).

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