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Transboundary transportation of CO_2 streams by ships: regulatory barriers for scaling up carbon capture and sub-seabed storage

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Over the years, Carbon Capture and Sequestration (CCS) has been recognized as a crucial element in the toolkit of measures to combat climate change. At the European Union (EU) level, CCS plays a vital role in climate policy, particularly in reducing CO_2 emissions from hard-to-abate industries. However, no comprehensive legal framework covers all stages of CCS. These stages include carbon capture techniques, transportation by ships or pipelines, injection, site closure, and post-closure management. Each of these stages is regulated by different legal frameworks that address various topics such as geoengineering, climate change, industrial activities, property, transportation, port operations, waste management, dumping, health, and the environment. Critical legal questions remain unanswered, such as who is liable for discharges in the marine environment during the transportation of CO_2 by ships and for the long-term management of sub-seabed storage sites. As the transportation of CO_2 by ships will likely have transboundary implications, we explore the legal possibilities, limitations and risks associated with exporting CO_2 streams for sequestration under the sub-seabed.

KEYWORDS

CO2 sequestration, sub-seabed storage and transportation, long-term liability, international law, EU law

1 Introduction

Climate change mitigation is a pressing matter on the international policy agenda. Considering that the G20 (the world's major developed economies, including the EU) are responsible for almost 80 percent of global greenhouse gas emissions (UNEP, 2021), their mitigation policies are decisive for the effective reduction of emissions. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) urges states to reduce fossil fuel use substantially and to use carbon capture and storage (CCS) in all remaining fossil fuel systems to reduce carbon dioxide (CO_2) emissions (IPCC, 2022a). In a nutshell, CCS can be defined as a technology that "involves capturing carbon dioxide

before it can be emitted into the atmosphere, transporting it to a secure location, and isolating it from the atmosphere, for example, by storing it in a geological formation." (IPCC, 2006, 3).

At European Union (EU) level, there is an ambition to reach 'net zero' CO_2 emissions by 2050 and CCS has a crucial role in climate policy, especially in decreasing CO_2 emissions of hard-to-abate industries like cement, steel and paper (European Commission, 2021). CCS technology has the potential to significantly reduce sectoral emissions by capturing CO_2 before it enters the atmosphere. This technology enables industries to continue operations while gradually integrating more sustainable practices and alternative energy sources, allowing societies to benefit from the resources produced by these industries (Paltsev et al., 2021). The Industrial Carbon Management Communication adopted by the Commission on 6 February 2024 provides details on how CCS technologies can contribute to reducing emissions by 90% by 2040 and finally reaching climate neutrality by 2050 (European Commission, 2024).

Although CCS is increasingly recognized as an integral part of the portfolio of measures to mitigate climate change (IPCC, 2022b), a business case for this technology has not been fully reached due to financial constraints, unfavorable market conditions and regulatory hurdles (Coninck and Benson, 2014; Bruhn et al., 2016)[1]. To accelerate the deployment of CCS, the European Commission has proposed the Net-Zero Industry Act to facilitate investment and simplify the regulatory environment for net-zero technologies. Those technologies include, among others, CCS (European Commission, 2023a, Annex). In general, there is an increasing interest in fitting industrial facilities with CO_2 capture equipment. However, the International Energy Agency (IEA) and the European Commission have identified a potential bottleneck to scaling up CCS due to the shortage of available storage sites (European Commission, 2023a, 2; IEA, 2022a, 106). This means that achieving climate objectives depends on the availability of storage sites. Recent estimates suggest that by 2040, the required annual CO_2 storage rate should reach 6 gigatonnes per annum (Gtpa), and over 8 Gtpa by 2050 (Lyons et al., 2021, 9)[2]. In some regions of the world, including the Nordic region, most available sequestration sites are found offshore (Langlet, 2018, 172). Therefore, scaling up CCS will mostly require transboundary cooperation and the intensification of offshore storage.

Large-scale storage of CO_2 streams in the sub-seabed will also require ship transportation. This can become a viable solution for transporting CO_2 over long distances when pipeline transport is unavailable or not feasible (Weber, 2021). Knoppe et al. (2015, 191) argue that ships are preferable for transporting small volumes of carbon over distances exceeding 500 km, while pipelines are more suitable for distances up to 250 km. Al Baroudi et al. (2021, 1) share a similar view, stating that CO_2 transportation by ship is preferred "over long distances and for relatively smaller quantities," whereas pipeline transportation has "a high cost-dependency on distance." Arguably, shipping could be considered a flexible mode of transportation with lower costs than pipeline alternatives (Abraham et al., 2024, 257; Roggenkamp, 2018). However, maritime transportation is often viewed as a complementary solution to pipelines. Combining both transportation modes could enhance the overall efficiency and flexibility of the CCS value chain (Fraga et al., 2024).

The first transboundary transportation of CO_2 streams by ship occurred in 2023 when Belgium and Denmark entered into an agreement to sequester carbon (captured in Belgium) on Denmark's continental shelf (Dareen et al., 2023). In the coming years, there will be an increase in cross-border CO_2 networks, which will require a comprehensive regulatory framework to ensure their success. However, while the practice of capturing and storing CO_2 is not a novelty, CO_2 transportation by sea is still in its infancy and requires careful consideration and further research. The identification of shipping as a vital link in the value chain inevitably includes the development of port infrastructure, storage facilities in ports, and suitable ships (CO_2 carriers). The challenge for the industry is to develop options for transporting CO_2, including medium- and low-pressure solutions that integrate maritime carriage into the CCS value chain. Low-pressure transportation appears to be the preferred technical option since it could potentially increase the cargo capacity of CO_2 and consequently reduce costs (Engel and Kather, 2018, 215; Seo et al., 2016, 11; Al Baroudi et al., 2021, 15; Cha, 2024).

In accordance with Regulation (EU) 2022/869 on guidelines for trans-European energy infrastructure (TEN-E Regulation), the European Commission has identified twelve initiatives as Projects of Common Interest (PCI)[3] and three initiatives as Projects of Mutual Interest (PMI) (European Commission, 2023b)[4]. Most of these projects will develop cross-boundary CO_2 transportation systems, either by ship or pipeline. The North Sea and the Mediterranean Sea are identified as promising sites for offshore carbon storage. Being categorized as PCIs and PMIs is a mechanism to access financial assistance and to support the development of this net-zero technology as well as streamlined regulatory procedures for permits and environmental assessments. Scaling CCS depends not only on available geological storage, transportation systems, and financial assistance. Regulatory barriers, competing and overlapping legal regimes and legal lacunas can slow down CCS deployment.

In a nutshell, CCS comprises the following stages represented in (Figure 1: CCS Stages) (International Risk Governance Council (IRGC), 2008):

1 CCS has also faced criticism, mainly as a technology that continues to support the dependency on fossil fuels instead of investing in other technologies that will accelerate a green energy transition.

2 Others estimate that by 2030, "the required annual CO_2 storage rate should reach 1 Gtpa… growing to around 10 Gtpa by 2050." (Global CCS Institute 2023, 7).

3 PCI is defined in article 2(5) of the TEN-E Regulation as "a project necessary to implement the energy infrastructure priority corridors and areas set out … on the Union list."

4 PMI is defined in article 2(6) of the TEN-E Regulation as "a project promoted by the Union in cooperation with third countries … which contributes to the Union's 2030 targets for energy and climate and its 2050 climate neutrality objective."

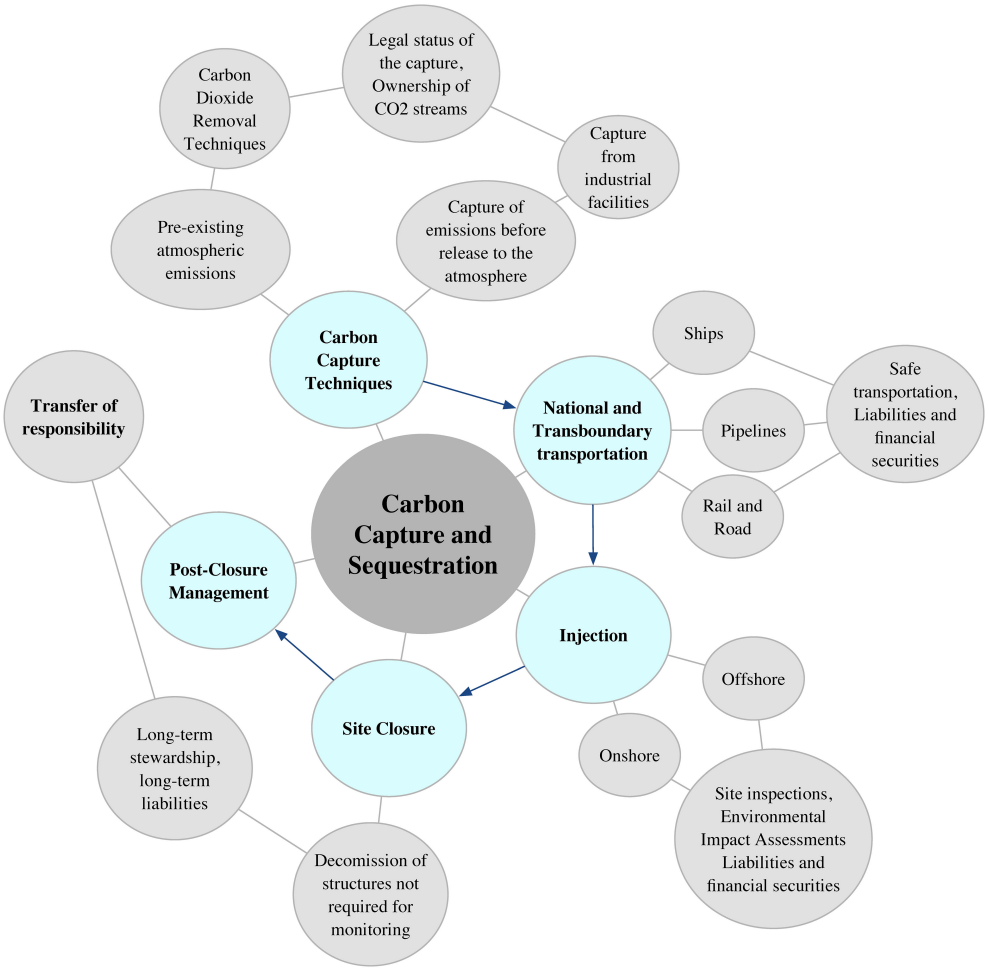

FIGURE 1
CCS stages. In this figure, the authors identify CCS stages (carbon capture techniques, transportation, injection, site closure and post-closure management) and the legal issues that may arise from each stage.

At present, there is no comprehensive legal framework that covers all stages of carbon capture and storage (CCS). These stages include carbon capture techniques, transportation, injection, site closure, and post-closure management, each of which is regulated by different legal frameworks that address various aspects such as geoengineering, climate change, industrial activities, property, transportation, port operations, waste management, dumping, health, and the environment. Furthermore, substantial gaps remain to be addressed, including liability aspects in all CCS stages, export of CO_2 streams for sub-seabed storage, and long-term post-closure management. Liability frameworks are fundamental to dealing with the risks involved in CCS. Identified risks, include leakages during transportation and injection phases as well as migration and releases from sub-seabed geological formations including site closure and post-closure management[5]. In a report concerning the Norwegian CCS projects Sleipner and Snøhvit, where 22 million tonnes are sequestered so far, the CO_2 has not interacted with the geological formation as expected (Hauber, 2023, 32; CIEL, Center for International Environmental Law, 2023). Considering that these sites are some of the most studied fields worldwide, it becomes evident that the level of uncertainty involved in CCS may be higher than originally anticipated. In the absence of a regulatory framework that considers emergency remedial actions, long-term monitoring processes and liability schemes, the consequences of leakages could lead to moderate or acute ocean acidification. The latter could cause the death of biodiversity (Ling et al., 2024).

Against this background, the authors assess from a legal perspective the regulatory framework for the storage of CO_2 streams in the sub-seabed and the possibilities and barriers to the exportation of CO_2 streams. Particular attention is given to the regional regulatory frameworks applicable in the Great North Sea, where cross-border CO_2 networks are most likely to occur. The authors also examine the potential liabilities that may arise during transportation by sea. Key

5 See paragraphs 1.9-1.13 of the First Meeting of Contracting Parties under the London Protocol. Risk Assessment and Management Framework for CO_2 Sequestration in Sub-Seabed Geological Structures (CS-SSGS) in LC/SG-CO2 1/7, annex 3, 2006. See also, paragraphs 6.8-6.10 of the Seventh Meeting of Contracting Parties to the London Protocol. Revised Specific Guidelines for the Assessment of Carbon Dioxide for Disposal into Sub-Seabed Geological Formations. LC 34/5, 2012.

regulations include the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its 1996 Protocol. Additionally, the Carriage of Hazardous and Noxious Substances by Sea Convention (HNS Convention) and its 2010 Protocol, as well as the EU Directive 2009/31/EC (CCS Directive), are examined.

The rest of the paper is structured as follows. Section 2 discusses the legal requirements that need to be met for sequestration of CO_2 streams in the sub-seabed. Section 3 analyzes the regulatory obstacles to the transboundary movement of CO_2. Sections 4 and 5 examine, from international and EU law perspectives, the regulatory framework for the transportation of CO_2 by ships and critically highlight the existing liability gaps. The last section presents the conclusions, in which the authors warn about the scaling up of CCS technology in the absence of a comprehensive regulatory framework.

2 International Law

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is the primary legal instrument that regulates, directly or indirectly (Churchill et al., 2022, 43)[6] activities taking place in the ocean. Although UNCLOS does not refer to carbon storage, this treaty establishes the preconditions for the exercise of jurisdiction at sea and also imposes a series of obligations on all states to protect the marine environment and to prevent marine pollution from diverse sources, including ship source pollution,[7] dumping of wastes and other matter into the marine environment,[8] land-based pollution,[9] pollution from or through the atmosphere,[10] pollution from seabed activities subject to national jurisdiction,[11] and pollution for activities in the Area (i.e., the deep seabed)[12].

Offshore storage of CO_2 streams has been regulated as the dumping of waste. Article 1(5)(a) of UNCLOS defines dumping as:

(i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

(ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea;

Article 1(5)(b) further states that

"dumping" does not include:

(i) …

(ii) placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention.

The classification of CO_2 streams as waste has been a subject of debate (Severinsen, 2017; Buck, 2020). For example, the injection of CO_2 for enhanced oil recovery has been excluded from the definition of dumping in accordance with Article 1(5)(b)(ii) of UNCLOS. This is because the placement of CO_2 is not related to its disposal. Enhanced oil recovery techniques are employed in mature oil fields that are soon to be depleted. For example, CO_2 is injected to recover oil that cannot be extracted using other methods (Whittaker and Perkins, 2013; Haszeldine and Singh Ghaleigh, 2018, 23; Bankes, 2021, 164; Jordal et al., 2022, 13). A similar argument could be made concerning the offshore storage of CO_2 in the sub-seabed. It can be maintained that this storage serves a wider purpose than mere waste disposal as it aims to mitigate the effects of climate change. Therefore, carbon storage in the sub-seabed falls outside the definition of dumping (Purdy, 2006, 25; International Maritime Organization (IMO), 2005). Despite the merits of such an argument, offshore CO_2 storage became increasingly framed as a dumping activity.

In recent years, there has been a renewed debate on whether CO_2 should be classified as waste or resource. As discussed somewhere else by one of the authors, wastes have an intrinsic dual nature where they are both a residue and a resource at the same time (Argüello, 2019, 40-43). In the case of CO_2, it is a waste/resource that can either be stored or utilized in the production of chemicals and synthetic fuels (Buck, 2020, 1; Bruhn et al., 2016, 38; IEA, 2022b, 10). The use of CO_2 as feedstock has raised the interest in developing carbon capture, utilization and storage (CCUS) technologies. Although CCUS is outside the scope of this paper, it exemplifies the blurring lines between resource and waste. From a legal perspective, the definition of waste will depend on the legal instrument, but there is a tendency to avoid waste-value concepts and consider instead operational approaches. This means that if an object, substance, or material of any kind is subject to disposal or discarding operations, it is considered waste[13].

Despite these controversies, CO_2 storage has been regulated under the dumping regime. According to Article 210(5) of UNCLOS, the coastal state must give express authorization for dumping in the territorial sea, the exclusive economic zone, or the continental shelf after due consideration of the matter with other states that may be affected. This is particularly relevant in cases where CO_2 streams migrate across jurisdictions (Yiallourides and Soliman-Hunter, 2024).

Additionally, states have the obligation to adopt laws and regulations to prevent, reduce and control pollution from dumping in accordance with Article 210(1) of UNCLOS. To this effect, states, through the International Maritime Organization (IMO), must adopt global rules and standards. As prescribed in Article 210(6) of UNCLOS national legislation *shall not be less*

6 As Churchill et al. explain, describing UNCLOS as a constitution for the oceans has significant legal consequences. "First, there is a presumption that any activity at sea, actual or potential, is regulated, at least to some degree by UNCLOS." p.43.

7 Articles 194(3)(b), 211, 217, 218, 219, 220 of UNCLOS.

8 Articles 1(5), 194(3)(a), 210 and 216 of UNCLOS.

9 Articles 194(3)(a), 207, 213 of UNCLOS.

10 Articles 194(3)(a),212, 222 of UNCLOS.

11 Articles 194(3)(c), 208, 214 of UNCLOS.

12 Articles 194(3)(d), 209, 215 of UNCLOS.

13 Operational definitions of wastes are found in several legal instruments. See for example, Article 2(1) of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

effective than global rules and standards. The phrase *shall not be less effective* has important legal consequences. This and other similar formulations found in UNCLOS (mostly in relation to shipping and the protection of the marine environment) are referred to as rules of reference (Oxman, 1991; Redgwell, 2014; Barnes, 2016; Argüello, 2020; Nguyen, 2021). In a nutshell, rules of reference impose an obligation on states to adopt rules that are equivalent to those international standards. In the case of dumping, the international standard represents the minimum requirement, and states have the discretion to enact more stringent regulations.

There are two main legal instruments governing dumping, i.e., the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its 1996 Protocol. Until the London Protocol supersedes the Convention, both treaties remain applicable[14]. As of April 2024, the London Convention has 87 contracting parties, 40 of which are also parties to the London Protocol. For those states that are parties to both the Convention and the Protocol, the latter has precedence over the Convention as prescribed in Article 23 of the London Protocol.

2.1 London Convention

Article III(1) of the London Convention defines dumping as "any deliberate disposal at sea of wastes or other matter" and 'sea' as "marine waters other than the internal waters." This means that the Convention is applicable in areas within national jurisdiction (i.e., territorial sea, contiguous zone, exclusive economic zone, and continental shelf) and areas beyond national jurisdiction (i.e., the high seas and the area). A narrow interpretation of the definition of 'sea' potentially excludes the disposal of wastes in the sub-seabed from the scope of the convention since the sub-seabed is not *per se* 'marine waters.' (Scott, 2023, 244; Rayfuse, 2012, 166). From an environmental perspective, this narrow interpretation is not desirable because it artificially divides the marine environment (Teclaff and Teclaff, 1991) into discrete units, such as atmosphere, water column, seabed, and sub-seabed, which, as noted by one of the authors elsewhere, leads to a:

> risk of transfer of pollution from one environmental medium to another, resulting in fragmentation. Such fragmentation produces a lack of coordination between different regimes and the proliferation of conflicting and inconsistent legal obligations (Argüello, 2019, 5)

However, a teleological interpretation would treat marine waters as a single, comprehensive entity, encompassing the entire oceanic space. Additionally, disposal of wastes in the subsoil and sub-seabed could have negative consequences in the water column. Greenpeace, for example, argues that the term 'sea' in the London Convention refers to "the geographical extent of the term and does not specifically address different compartments of the marine environment or maritime area … it is clear that … it includes the seabed and the sub-soil"[15] This interpretation is in line with UNCLOS, which recognizes that the marine environment should be treated as a whole[16]. It also supports the broader development of environmental governance based on the ecosystem approach, generally defined as a "strategy for the integrated management of land, water and living resources" (COP to the Convention on Biological Diversity, 2000, Decision V/6). De Lucia outlines important features of the ecosystem approach, such as ecological integrity, integration, information, and iteration. Integration involves holistic management that emphasizes ecological interconnections instead of fragmentation. While UNCLOS does not explicitly include the ecosystem approach, it can be inferred, for example, from Article 192, which prescribes that states have the obligation to protect and preserve the marine environment in its entirety. Recognizing these ecological interconnections also influences the manner in which states implement their environmental obligations established in Part XII of UNCLOS, including the prevention, reduction and control of dumping at sea. It also promotes increased cooperation between states and organizations involved in ocean matters. Notwithstanding the merits of narrow and teleological interpretations of the definition of "sea" under the London Convention, the parties have not reached a definitive interpretation of this term. During the 1980s and 1990s, after lengthy discussions, the parties to the London Convention eventually agreed that the disposal of radioactive waste in the sub-seabed was within the scope of the treaty (Parties to the London Convention, Resolution LDC 41/13, 2005) [17] (Curtis, 1985, 391; Scott, 2023, 244). A similar discussion took place in the early 2000s concerning the sequestration of CO_2 streams in the sub-seabed where the parties recognized the relevance of the London Convention and its Protocol in offshore sequestration of CO_2. In Reports LC 26/15 and LC 28/15, the parties decided to focus on sequestration in geological structures and assess its compatibility with the Convention and its Protocol (Parties to the London Convention and Parties to the 1996 Protocol to the Convention,

14 It is subject to debate whether the London Convention or the London Protocol represents the global rules in accordance with Article 210(6) of UNCLOS. Authors like Churchill, Lowe, and Sander (2022, 669) argue that the London Protocol represents the global rules "because it was adopted within a global forum and with the expectation that it would eventually replace the London Convention." Scott (2023, 243 and 247) has a contrary view and argues that the London Convention establishes the global rules since the protocol has been evolving far beyond the definition of dumping in UNCLOS.

15 See, Parties to the London Convention, LC 27/INF.4. Sequestration of CO2 in sub-seabed geological structures: Compatibility with the London Convention and Protocol: Legal Issues. Twenty-Seventh Consultative Meeting.

16 Third preambular paragraph of UNCLOS.

17 See, Parties to the London Convention, Resolution LDC.41(13): Disposal of Radioactive Wastes into the Sub-Seabed Repositories Accessed from Sea." LDC 13/15 Thirteenth Consultative Meeting.

Report LC26/15, 2006)[18]. However, there has been no definite clarification on the potential applicability of the London Convention in this regard.

While it is possible to argue that the London Convention applies to waste disposal in the sub-seabed, it is important to note that this instrument does not impose a complete prohibition on waste disposal in the marine environment. Instead, the Convention adopts a listing approach, which has resulted in a permissive regulatory stance towards dumping. In accordance with Article IV:

(a) the dumping of wastes or other matter listed in Annex I is prohibited;

(b) the dumping of wastes or other matter listed in Annex II requires a prior special permit;

(c) the dumping of all other wastes or matter requires a prior general permit.

CO_2 streams are not listed in Annex I or II of the Convention. Yet, paragraph 11 of Annex I prohibits the dumping of industrial wastes defined as "materials generated by manufacturing or processing operations." CO_2 fits within the definition of processing operation as it is a byproduct of industrial activities (Bankes, 2021, 174). However, the parties to the London Convention have not reached a consensus on what constitutes industrial waste (Parties to the London Convention, Report LC26/15, 2004)[19]. For example, Germany took a value-based approach considering CO_2 as waste because it is an unwanted byproduct of industrial activities—something that holds no value and must be disposed of. According to this perspective, CO_2 is classified as industrial waste when it is "gathered from production processes at industrial sites on land."[20] Similarly, the United Kingdom argues that CO_2 would be considered industrial waste if it originates from industrial activities such as those at "a power station or oil refinery."[21]. The classification of CO_2 as industrial waste has significant implications for the London Convention's application. Under the Convention's listing approach, only those wastes explicitly mentioned are subject to prohibition or control. Therefore, if CO_2 is not classified as industrial waste and listed accordingly, it may be permitted to be dumped at sea.

Overall, uncertainties remain regarding whether the London Convention applies to the sub-seabed storage of CO_2. Considering that many states are still parties to this treaty and that this instrument arguably represents the global rules in accordance with Article 210 (6) of UNCLOS (Scott, 2023, 247), there is a risk of legal fragmentation due to divergent interpretations. However, in areas within national jurisdiction, the coastal state has, according to Article 87 of UNCLOS, "the exclusive right to authorize and regulate drilling on the continental shelf for all purposes."

2.2 London protocol

Unlike the London Convention, the regulation of CO_2 sequestration is far more certain in the London Protocol. According to Article 1(4)(1)(3), the definition of dumping includes "any storage of wastes or other matter in the seabed and the subsoil." This Convention also adopts a reverse list approach, where dumping is generally prohibited except for wastes listed in Annex I. When the London Protocol was adopted in 1996, CO_2 was not originally included in Annex I, and its sequestration was consequently prohibited. However, the sequestration of wastes and other matter, including CO_2, "related to the exploration, exploitation and associated offshore processing of seabed mineral resources" is outside the scope of the Protocol as prescribed in Article 1(4)(3). As previously explained in this section, enhanced oil recovery techniques where CO_2 is injected (and incidentally sequestered) to produce oil on mature reservoirs fall outside the definition of dumping since its placement is not related to waste disposal (Yiallourides and Soliman-Hunter, 2024, 7-8; Bankes, 2021, 164-166).

In 2005, the Parties to the London Convention acknowledged the climate mitigation role of CO_2 sequestration in Report LC 27/16 and most delegations identified the Protocol, rather than the Convention, as the appropriate forum to regulate CO_2 sequestration (Parties to the London Convention, Report LC 27/16, 2005)[22]. This was likely because the Protocol was expected to supersede the Convention shortly after its entry into force in 2006. Through Resolution LP.1(1), an amendment to Annex I allowed CO_2 sequestration under three conditions:

- The disposal must take place in the sub-seabed. This excluded the possibility of sequestering CO_2 streams in the water column.
- CO_2 streams must 'consist overwhelmingly of carbon dioxide,' yet it is recognized that other substances may be included 'from the source material and the capture and sequestration processes used.'
- The disposal must not include other wastes.

The amendment to the Annex came into force in February 2007, precisely one hundred days after its adoption, as stipulated in

18 See paragraphs 6.1–6.57 of the Parties to the London Convention, Report LC26/15 of Twenty-Sixth Consultative Meeting and paragraphs 66-109 of the Parties to the London Convention and Parties to the 1996 Protocol to the Convention, Report LC 28/15 of the Twenty-Eighth Consultative Meeting and First Meeting of the Contraction Parties, International Maritime Organization 2006.

19 See paragraphs 6.1–6.6 of the Parties to the London Convention, Report LC26/15 of Twenty-Sixth Consultative Meeting.

20 Parties to the London Convention, LC 27/INF.4. Sequestration of CO2 in sub-seabed geological structures: Compatibility with the London Convention and Protocol: Legal Issues. Twenty-Seventh Consultative Meeting.

21 Id.

22 See paragraph 6.26 of the Parties to the London Convention. LC 27/16 Report of the 27th Consultative Meeting, in Agenda Item 16, 2005.

Article 22(4) of the London Convention. Moreover, the 2012 'Revised Specific Guidelines for the Assessment of Carbon Dioxide for Disposal into Sub-Seabed Geological Formations' outline procedures for CO_2 stream characterization, waste prevention audits, site selection, assessment of effects, permits, monitoring, mitigation, and remediation[23]. The advancements in international efforts to permit offshore CO_2 sequestration were swiftly followed by regional initiatives, notably in the Great North Sea Region, which has significant sequestration capacity.

2.3 The Great North Sea Region

Over the years, the North Sea (Figure 2: The Great North Sea Region) has been identified as a preferred location for sequestering CO_2 streams (Global CCS Institute, 2023, 42). Projects such as the Northern Lights, Nautilus and ECO$_2$CEE are just a few examples of ongoing efforts to develop CO_2 storage infrastructure in the North Sea (Global CCS Institute, 2023; Jordal et al., 2022; European Commission, 2023b). The Great North Sea Region is situated in the northwest of Europe, covering areas of the Atlantic Sea from 48° N latitude in the southwest to 62°N latitude in the north. The region encompasses the English Channel, the Nordic Straits of Skagerrak and the Kattegat, and the coastal states are Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, and the United Kingdom (Andersen et al., 1996, 16; Ducrotoy et al., 2000, 5; Carpenter, 2016, 256). These waters entirely fall within the national jurisdiction of the coastal states. An important regional treaty applicable in this area is the Convention on the Protection of the Marine Environment of the North-East Atlantic (OSPAR), which comprehensively regulates marine pollution sources, including dumping.

All coastal states bordering the Great North Sea are parties to UNCLOS, the London Protocol, and OSPAR. In a regulatory development akin to that of the London Protocol, OSPAR parties,

23 See Revised Specific Guidelines for the Assessment of Carbon Dioxide for Disposal into Sub-Seabed Geological Formations, LC 34/5, 2012.

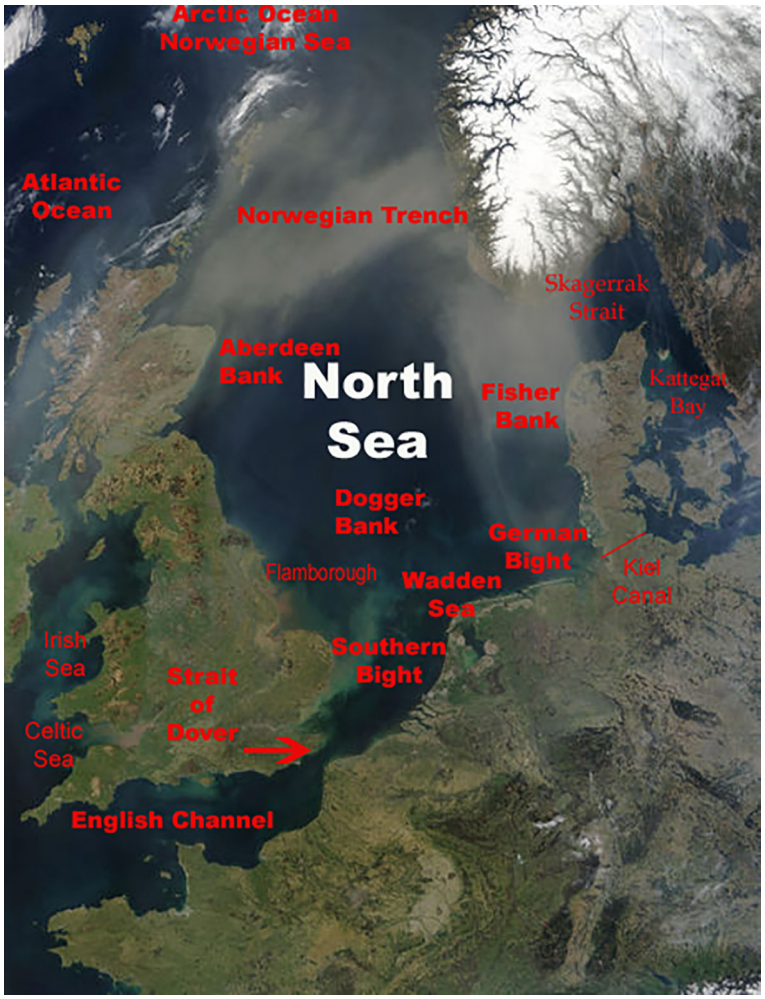

FIGURE 2
The Great North Sea Region. This figure shows the Greater North Sea area. Within this geographical delimitation, OSPAR regulates marine pollution Source: Wikimedia Commons. This work has been released into the public domain. https://commons.wikimedia.org/wiki/File:North-Sea.jpg.

through Decision 2007/2,[24] allowed the permanent sequestration of CO_2 streams in geological formations. The sequestration in the water column is forbidden in accordance with Decision 2007/1. Further amendments were also made to Annexes II and III of the Convention, which respectively address pollution by dumping or incineration and pollution from offshore sources (Langlet, 2015; Bankes, 2021; Uwer and Zimmer, 2024; Dixon et al., 2015). It is crucial to note that coastal states are not obligated to authorize such sequestration. Instead, each state has the right to authorize or regulate offshore CCS.

The 2007 Guidelines for Risk Assessment and Management of Storage of CO_2 streams were introduced alongside Decision 2007/2, which authorized CO_2 sequestration. These guidelines concentrate on the injection and post-injection stages of CCS, aiding in the assessment of suitable injection sites and managing the potential risks of leakages in the marine environment. The transportation of CO_2 streams by ships or pipelines is explicitly excluded from the guidelines.

Over the years, states bordering the Great North Sea have enacted legislation to regulate the sequestration of CO_2 in their marine environments. Norway has pioneered CCS since 1996 in the Sleipner field (Vold, 2020). Since then, other countries such as Denmark, and the United Kingdom, have granted licenses for sequestration on their respective continental shelves.

In addition to the Great North Sea Region, other areas are also making progress in implementing CCS. In January 2024, Japan enacted legislation to regulate carbon sequestration, ensuring compliance with the London Protocol (Shulman Advisory, 2024). Australia has also shown support for the transboundary movement of CO_2 for geological sequestration (Global CCS Institute, 2023, 34). In North America, Exxon Mobile identified the Gulf of Mexico as a suitable area for offshore CO_2 sequestration ((Hague, 2024, 851-852) Overall, CCS is gaining political and financial support across the globe.

3 Exportation of CO_2 streams: where are we now?

While the regulatory barriers for CO_2 sequestration in the sub-seabed have been lifted in instruments such as the London Protocol and OSPAR, not all states have available offshore storage sites in areas within their national jurisdiction, namely, the territorial sea, Exclusive Economic Zone and continental shelf. Consequently, scaling CCS will require transboundary transportation of CO_2 streams. However, Article 6 of the London Protocol prescribes that "contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea." This provision has posed a major obstacle to CCS' implementation (Redgwell and Rajamani, 2014, 103; Bankes, 2021, 176; Möllersten et al., 2021, 24; Langlet, 2015). In the legal history of waste regulation, limiting, minimizing, or controlling the export of waste stems from a regulatory approach grounded in normative and legitimacy considerations. It suggests that waste should ideally be managed as near as possible to its point of origin instead of transferring the burden of waste management to a third party (Argüello, 2019, chapters 2 and 3; Weber, 2021).

In 2009, the parties to the London Protocol decided to amend Article 6 and include the following paragraphs:

> …the export of carbon dioxide streams for disposal in accordance with annex 1 may occur, provided that an agreement or arrangement has been entered into by the countries concerned. Such an agreement or arrangement shall include:
> …
> 2.2 in the case of export to non-Contracting Parties, provisions at a minimum equivalent to those contained in this Protocol, including those relating to the issuance of permits and permit conditions for complying with the provisions of annex 2, to ensure that the agreement or arrangement does not derogate from the obligations of Contracting Parties under this Protocol to protect and preserve the marine environment (Parties to the 1996 Protocol to the Convention, Resolution LP.3(4), 2009)[25].

The amendment is a clear political indication of support for the development of a business case for CCS. Just before of its adoption, the Third Meeting of the Contracting Parties to the London Protocol agreed that the exportation of CO_2 is justified as a measure to mitigate climate change. They recommended giving a political signal that the London Protocol should not prevent the movement of CO_2 streams across borders (Parties to the London Convention and Parties to the 1996 Protocol to the Convention, LC30/16, 2008)[26]. Despite being adopted fifteen years ago, the amendment is still not in force. Only eight states have ratified it, including Estonia, Finland, Iran, the Netherlands, Norway, Switzerland, Sweden and the United Kingdom. According to Article 21(3) of the London Protocol the amendment will enter into force on the sixtieth day after two-thirds of the Contracting Parties have deposited an instrument of acceptance with the IMO.

As an interim solution, in 2019, the contracting parties decided to apply provisionally the amendment, which is a possibility as prescribed in Article 25 of the Vienna Convention on the Law of Treaties, 1969. (COP to the London Protocol, 2019). Yet, while there is no export prohibition in OSPAR, all the parties are also bound by the London Protocol. Based on this decision, several contracting parties are planning to enter into arrangements to facilitate the export of CO_2 in accordance with Article 6 of the London Protocol. On April 15, 2024, Sweden entered into bilateral agreements with Denmark and Norway that allow the export of CO_2 streams from Sweden to be sequestered in the Danish and Norwegian sub-seabed (Energimyndigheten, 2024).

24 As prescribed in Article 13(2) of the OSPAR Convention, the decisions are binding.

25 Resolution LP.3(4) on the Amendment to Article 6 of the London Protocol, 30 October 2009.

26 See paragraph 5.22 of Parties to the London Convention, Report of the Thirtieth Consultative Meeting and the Third Meeting of the Contracting Parties, LC 30/16, 9 December 2008.

4 Transportation of CO_2 streams by sea: the missing link

At the outset, we need to consider whether the carriage of CO_2 by ships is possible at all and whether there are suitable ships at present. Notably, the carriage of CO_2 by sea has already occurred in a limited context and proved to be successful, which opens the possibilities for developing it further at a larger scale (Dareen et al., 2023). Presumably, it will take some years before we have a solid fleet of CO_2 carriers since most of these ships need to be ordered from shipyards, and that requires investments and financial support from the governments.

In this context, the Longship CCS project can be recognized as a pioneering cross-border value chain for capturing, transporting, and storing industrial CO_2 emissions from multiple countries (Weber, 2021, 388). It involves government support for developing the Northern Lights company, which is owned by Equinor, Shell, and Total Energies, and its transport and storage infrastructure. As explained in this Project-

> It is planned that CO_2 will be transported by ships from the capture sites to the Northern Lights onshore facility in Øygarden. There, the CO_2 will enter the receiving terminal. Before it is being transported through a pipeline to the well. Where it will be pumped into the subsea reservoir. Heidelberg Materials and Celsio are expected to deliver approximately 400,000 tons of CO_2 each annually. This constitutes a significant part of Norway's total emissions, equivalent to about 1.6 percent (GASSNOVA, 2024).

At Northern Lights in Øygarden, CO_2 will be stored in pressure tanks. Notably, the design and operation of these facilities are like those used for liquefied petroleum gas (LPG). It is expected that initially CO_2 will be delivered from Northern Europe (Tsvetkova and Middleton, 2024). Already in 2023, Northern Lights concluded two agreements to store CO_2 from Yara's plant in Sluskil in the Netherlands and from the Ørsted bio-based power plant in Denmark (Northern Lights, 2023).

4.1 International Law: regulatory and liability gaps

From a law of the sea perspective, there are no significant obstacles to transporting CO_2 by ships[27]. This is because, according to Articles 17, 58, and 87 of UNCLOS, ships have the right of innocent passage in the territorial sea and the freedom of navigation in the Exclusive Economic Zone and high seas. However, transportation has significant maritime safety implications. CO_2 carriers must follow the International Maritime Dangerous Goods Code (IMDG Code) and the The International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) (Roggenkamp, 2018, 258). However, important gaps remain concerning liability arising during this transportation.

4.1.1 HNS Convention

As previously explained in this paper, the most closely related regulatory regime applicable to CO_2 sequestration in the sub-seabed is the London Convention and the London Protocol. Now, it is necessary to consider which international regime can apply once the CO_2 is loaded on a ship and carried by sea crossing the state boundaries. Notably, the most suitable regime that could accommodate CO_2 transportation by sea is the International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention), which was adopted in 2010, amending an original convention adopted in 1996. However, it is not yet in force due to a low number of ratifications. A minimum of 12 states must ratify the Convention for it to enter into force, but only eight states have ratified it so far[28].

The Convention was adopted to govern liability and compensation in the event of an incident at sea involving hazardous or noxious substances (de la Rue et al., 2023, Chap. 7). According (Weber and Tsimplis, 2017) to former Secretary-General Kitack Lim of the IMO, the HNS Convention is "the last piece of the puzzle" that is essential for establishing an international liability regime for HNS cargoes transported by sea (IMO, 2010).

When the Convention comes into effect, CO_2 will be considered an HNS substance. The Convention contains an open list of HNS substances; those described in Article 1(5)(iv) and (v) are particularly relevant for analyzing the status of CO_2. Subparagraph iv refers to substances "transported in packaged form covered by the International Maritime Dangerous Goods Code." CO_2 is classified as non-flammable, non-toxic gas substance under the IMDG Code (IMDG 2022 Edition). In a CCS context, CO_2 streams will be transported in bulk and not in packaged form. Yet, as explained by Weber and Tsimplis, a teleological interpretation of the Convention should also include the transportation in bulk (Weber and Tsimplis, 2017, 159). Subparagraph v, includes liquified substances in the following terms:

> liquefied gases as listed in chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended, and the products for which preliminary suitable conditions for the carriage have been prescribed by the Administration and port administrations involved in accordance with paragraph 1.1.6 of the Code;

In 2006, through Resolution MSC.220(82),[29] the IMO's Maritime Safety Committee adopted an amendment to the ICG Code where CO_2 was included in Chapter 19 (Mittler, 2023, 11).

27 Transport in this context does not involve the injection phase.

28 Canada, Denmark, Estonia, France, Norway, Slovakia, South Africa, and Turkey. Belgium, the Kingdom of the Netherlands and Germany plan to ratify the HNS Convention in 2024.

29 Maritime Safety Committee (MSC), Resolution MSC.220(82): Amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. London. 2006.

Notably, the Convention covers the consequences of an HNS incident at sea and land and air pollution. Pursuant to Article 1(1), "ship means any seagoing vessel and seaborne craft, of any type whatsoever." Article 1(5) refers to which substances are considered as "hazardous and noxious" and Article 1(6) defines the damage, which includes

(a) loss of life or personal injury on board or outside the ship carrying the hazardous and noxious substances caused by those substances;

(b) loss of or damage to property outside the ship carrying the hazardous and noxious substances caused by those substances;

(c) loss or damage by contamination of the environment caused by the hazardous and noxious substances, provided that compensation for impairment of the environment other than loss of profit from such impairment shall be limited to costs of reasonable measures of reinstatement actually undertaken or to be undertaken; and

(d) the costs of preventive measures and further loss or damage caused by preventive measures.

According to the Convention, a HNS Fund should be established under Article 13 to provide compensation for damage in connection with the carriage of hazardous and noxious substances by sea.

Apparently, there were many conflicting interests regarding the division of liability between owners and operators, and this Convention is still not in force, as noted earlier. Whether it becomes a suitable liability regime for carrying CO_2 remains to be seen. Until it is in force, shipowners may limit their liability based on the 1996 Convention on Limitation of Liability for Maritime Claims (LLMC), which will be described in the next section.

4.1.2 Limitation of liability for maritime claims

The concept of limitation of liability is well established in maritime law, with relevant provisions existing in various maritime conventions related to the carriage of goods, passengers, oil pollution, among others (Hill, 2003, 375-376).

Since no dedicated regime would apply to the carriage of CO_2 by ships, the owners/charterers should be aware of potential liability and the possibility of limiting its liability as a vital element and privilege of maritime law. Until the HNS Convention enters into force, it can be presumed that LLMC will apply. LLMC was adopted in 1972, entered into force in 1986 and later amended by a Protocol in 1996, which entered into force in 2004[30].

It covers the limitation of liability for claims included in Article 2 which refer to inter alia

> claims in respect of loss of life or personal injury or loss of or damage to property (including damage to harbor works, basins and waterways and aids to navigation), occurring on board or in direct connection with the operation of the ship or with salvage operations, and consequential loss resulting therefrom.

According to Article 1 of the LLMC, persons that can limit the liability include shipowners and salvors; further, it is elaborated that shipowners include "the owner, charterer, manager, and operator of a seagoing ship." It is also noteworthy that invoking limitation of liability does not mean an admission of liability (Article 1(7) of LLMC). Article 6 of LLMC establishes general limits of liability depending on tonnage of the vessel and is measured in Special Drawing Rights (SDRs) as defined by the International Monetary Fund[31]. Within the EU, LLMC is complemented by the Directive 2009/20/EC of the European Parliament and of the Council of 23 April 2009 on the insurance of shipowners for maritime claims.

5 EU Law: regulatory and liability gaps

Shipping will be crucial for developing the entire CCS value chain in the EU. There are proposals to develop CO_2 multimodal transportation, which will involve the use of ships, barges, trains, and trucks. Despite the recognized importance of shipping in scaling up CCS, relevant EU legislation does not currently apply to shipping and the potential liabilities that may arise from this transportation. There are two major Directives applicable to CCS at the EU level: Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive) and EU Directive 2004/35/CE on environmental liability with regard to the prevention and remedying of environmental damage (EU ELD). Since both instruments are Directives, they need to be transposed into the national legislation of the Member states and have mandatory application. However, they are part of a wider EU policy and strategy on Climate neutrality and the European Green Deal, which in turn are considered policy instruments and set out general objectives and aims for reaching zero emissions by 2050 and transforming Europe into the first climate-neutral continent in the world (Tamme, 2020).

CCS Directive is considered one of the first comprehensive CCS legal frameworks covering CO_2 storage in geological formations in the EU and its post-injection management. The CCS Directive includes certain provisions related to transportation, but it seems to omit detailed regulations on the matter. The scope and purpose of the Directive are provided in Article 1

> 1 The Directive establishes a legal framework for the environmentally safe geological storage of carbon dioxide to contribute to the fight against climate change.

30 https://www.imo.org/en/About/Conventions/Pages/Convention-on-Limitation-of-Liability-for-Maritime-Claims-(LLMC).aspx.

31 https://www.imf.org/en/Topics/special-drawing-right.

> 2 The purpose of environmentally safe geological storage of CO_2 is permanent containment of CO_2 in such a way as to prevent and, where this is not possible, eliminate as far as possible negative effects and any risk to the environment and human health.

The scope of the application is further stated in Article 2:

> This Directive shall apply to the geological storage of CO_2 in the territory of the member states, their exclusive economic zones and on their continental shelves within the meaning of the UNCLOS.

Despite broad geographical coverage on storage encompassing the whole of the EU including its maritime zones, the Directive does not include shipping of CO_2 to the storage sites but only mentions pipeline transport. This is evident from Article 2(22), which defines a 'transport network' as a network of pipelines, including associated booster stations, that transports CO_2 to storage sites.

Thus, the major drawback of the Directive is that shipping of CO_2 is not regulated as it only refers to transportation by pipelines. This implies that this instrument will not apply to the carriage of CO_2 by ships in European waters. In the 2015 Report on Review of Directive, more specifically on Environmental risks of CO_2 transportation, the Commission considers that there is no need at this stage for further regulation of CO_2 transport. The risks entailed in the transport of CO_2, according to the Commission, are no higher than those of the transport of natural gas or oil,[32] and there have been no events or suggestions to warrant any change in current regulations (European Commission, 2015). This reiterates the statement that the Directive will not apply to CO_2 carriage by sea unless modified or replaced. Other salient features of the CCS Directive include closure and post-closure obligations under Article 17 and transfer of responsibility (Article 18).

The CCS Directive can be seen as a partial solution at the EU level, especially in regions where pipeline infrastructure is insufficient or not feasible and maritime transportation is necessary. Therefore, CCS involving ship transport will encounter regulatory fragmentation even at the EU level.

5.1 EU environmental damage directive

Another relevant instrument is the EU Directive 2004/35/CE on environmental liability with regard to the prevention and remedying of environmental damage (EU ELD). The EU's position is clear as Member states are encouraged to join the HNS Convention. However, until it is in force, the EU ELD can apply to certain environmental damage.

Article 1 provides that

> The purpose of this Directive is to establish a framework of environmental liability based on the 'polluter-pays' principle, to prevent and remedy environmental damage.

Article 2 defines environmental damage, which also includes water damage, land damage, damage in general, and many other important concepts. In the Preamble, paragraph 4, it is also provided that environmental damage also includes damage caused by airborne elements as far as they damage water, land, protected species, or natural habitats. Notably, the Directive does not refer to life or damage to property. Further, Annex III lists all transport of dangerous or polluting goods.

As noted by one commentator, during the transposition of the Directive into national law, various controversial issues were highlighted such as which cases fall within the scope of the Directive; how the defenses and/or exceptions provided in the Directive should be applied; the role of financial security; and how definitions of 'significant' environmental damage and 'operator' should be construed and applied (De Soomer, 2022, 4). It was further argued that the Directive is an ambitious framework that provides some new and challenging concepts but has drawbacks in defining, allocating, and financially securing liability for environmental damage from the international shipping industry (Tsimplis, 2017, 436-437).

Article 4 states certain exceptions which also exclude the application of the Directive to

> 2… environmental damage or to any imminent threat of such damage arising from an incident in respect of which liability or compensation falls within the scope of any of the International Conventions listed in Annex IV, including any future amendments thereof, which is in force in the Member state concerned.
> 3. This Directive shall be without prejudice to the right of the operator to limit his liability in accordance with national legislation implementing the Convention on Limitation of Liability for Maritime Claims (LLMC), 1976, including any future amendment to the Convention, or the Strasbourg Convention on Limitation of Liability in Inland Navigation (CLNI), 1988, including any future amendment to the Convention.

Therefore, these provisions suggest that the application of the Directive to shipping is limited. Annex IV contains a list of Conventions (including any future amendments) to which article 4(2) refers and the HNS Convention is one of them. However, until the HNS Convention enters into force, this Directive will remain an applicable regime for incidents involving the carriage of hazardous and noxious substances if damage falls within the scope of the

32 For the nature of other substances, such as oil and gas see further in M. Roggenkamp, "Transportation of Carbon Dioxide in the European Union: Some Legal Issues" in I. Havercroft, R. Macrory, & R. Stewart (Eds.), *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (2018, 2 ed., pp. 246-265). Hart.

Directive. In case the HNS Convention enters into force, it has the potential to become a global regime that will apply to CCS, including its transportation by sea, and might also be applicable at the EU level.

6 BIMCO standard form CO_2 charterparty

In the absence of an international regime, contractual solutions can become a viable alternative. Since goods and commodities are transported based on contracts of carriage or charterparties, it is important to carefully draft contracts that cover the key obligations of the parties, liability division, and other essential issues relevant to the transport of CO_2.

Due to the nature of the cargo, it can be presumed that CO_2 will occupy the space of the whole vessel and be covered by charterparty agreements between the shipowner and the charterer. In this case a special standard charterparty form needs to be developed to envisage the salient feature of CO_2 transportation by ship.

It is notable that such a standard form is already under consideration by BIMCO (known for numerous standard form contracts and clauses used in shipping all kinds of cargo) and will be published in 2025.

While it is possible to employ existing charter parties for such contractual agreements, the unique and challenging conditions and potential liabilities associated with CO_2 carriage and storage warrant the development of a dedicated charter party contract specifically addressing the needs of shipowners and charterers involved in the transport of CO_2. It is important that the drafters in the absence of any international regime take the opportunity to include the detailed clauses which can include inter alia provisions regarding liability in case of leakage, requirements for specialized equipment and crew training. Other provisions such as emergency response procedures could be relevant as well.

7 Conclusion

Carbon Capture and Sequestration (CCS) has emerged as a critical tool in the fight against climate change, particularly in hard-to-abate industries. However, the lack of a comprehensive legal framework covering all aspects of CCS raises important legal questions, such as liability for discharges in the marine environment during the transportation of CO_2 by ships, leakages during the injection stage, and the long-term management of sub-seabed storage sites. Addressing these legal challenges will be necessary to enable effective and sustainable CCS implementation.

This paper mapped existing legal instruments applicable to the sequestration of CO_2 in the sub-seabed, and the transboundary transportation by ships. The transportation of CO_2 by ships includes public and private law considerations. Conspicuously, public law issues allude to safety standards and regulatory requirements, prevention of pollution, and states' obligations and responsibilities, while private law considers contractual obligations, the division of obligations and liabilities between various parties, and issues related to limitation of liability for maritime claims.

The main instruments for sequestering CO_2 in the sub-seabed and transporting CO_2 streams by ships are summarized in the following tables (Table 1: International Law and CCS and Table 2: OSPAR, EU Law and CCS).

TABLE 1 International Law and CCS.

Legal Framework					
Legal Instruments	UNCLOS	London Convention	London Protocol	HNS Convention and Protocol	LLMC
Main characteristics	General jurisdictional regulatory framework for activities taking place in the ocean.	Regulates dumping at sea, namely, the disposal at sea of wastes.	Regulates dumping at Sea. All coastal states in the North Sea are parties to this Convention This instrument will eventually supersede the Convention	The Convention deals with liability arising from the carriage of hazardous and noxious substances.	It is a general instrument dealing with limitation of liability in maritime law.
Applicability	Imposes a series of obligations on all states to protect the marine environment and to prevent marine pollution.	The Convention has a permissive approach towards dumping. It adopts a listing approach.	Unlike the London Convention, this instrument also defines dumping as the storage of wastes in the seabed and the subsoil.	The convention covers several types of damage, including for example: • loss of life or personal injury. • loss of or damage to property outside the ship. • environmental damage. • costs of preventive measures. CO_2 is an HNS Substance.	Establishes which legal subjects that can limit their liability in case of specific loss or damage. These include salvors, owners, charterers, managers, and ship operators.
Legal gaps	Do not regulate CCS directly. The Convention requires that parties agree on specific standards	It is open to interpretation whether CO_2 streams fall within the definition of industrial waste. If so, sequestration in the sub-seabed would be	Allows the sequestration of CO_2 in the sub-seabed. Sequestration in the water column is prohibited. The Protocol was amended to allow the	The Convention is not in force yet.	It will be applicable until the HNS Convention enters into force.

(Continued)

TABLE 1 Continued

Legal Framework					
Legal Instruments	UNCLOS	London Convention	London Protocol	HNS Convention and Protocol	LLMC
		prohibited as stated in Annex I of this Convention. It is also open to interpretation the meaning of 'sea' under the Convention. In this paper we argue that it should be understood as the water column, the seabed and the sub-seabed.	export of carbon dioxide streams for disposal. Yet the amendment is not in force. In 2019, the parties decided to apply provisionally the amendment.		

TABLE 2 OSPAR, EU Law and CCS.

Regional and EU law Legislation			
Legal Instruments	OSPAR Convention	EU CCS Directive	EU Environmental Damage Directive
Main characteristics	The Convention regulates marine pollution sources, including dumping in the North Sea.	In the EU, it is the most comprehensive legal framework governing CO_2 storage in geological formations in the EU and its post-injection management.	General framework in the EU to address environmental liability
Applicability	Allows the sequestration of CO_2 streams in geological formations. The sequestration in the water column is prohibited.	It regulates onshore and offshore CO_2 storage.	It applies exclusively to environmental damage.
Legal gaps	Parties to the OSPAR Convention are also parties to London Protocol. The amendment to export CO_2 streams under the latter instrument is not in force yet.	It only covers pipeline transportation and not shipping.	It will be applicable until the HNS Convention enters into force.

The momentum behind CCS and CO_2 transportation by sea requires a specific regime and integrated approach. At international level, the International Maritime Organization (IMO) is the most suitable forum. Such regulatory development could initially take the form of a non-binding instrument, that can be incorporated into contracts and thus become binding between the parties. However, scaling up CCS technology in the absence of a comprehensive regulatory framework will jeopardize the capacity of the actors involved in CCS operations to manage relevant risks.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

GA: Conceptualization, Writing – original draft, Writing – review & editing. OB: Conceptualization, Writing – original draft, Writing – review & editing.

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