

Long-Term Offshore Systems Based on Large Floating Structures: Regulatory Analysis and Opportunities for Brazil

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How to cite this paper: Nunes, R. d. C., Chedid, T. d. S. V., Costa, H. K. d. M., Santos, M. M. d., Oliveira, K., Schrote, T. d. A., Franco, N. G., & Santos, E. M. d. (2025). Long-Term Offshore Systems Based on Large Floating Structures: Regulatory Analysis and Opportunities for Brazil. *Beijing Law Review*, 16, 858-874.

<https://doi.org/10.4236/blr.2025.162043>

Received: February 28, 2025

Accepted: June 10, 2025

Published: June 13, 2025

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Abstract

The work deals with the national and regulatory legal aspects of Long-Term Offshore Systems Based on Large Floating Structures (Very Large Floating Structures, VLFS) or, more precisely, those existing legal institutes applicable to Brazil. These structures represent a remarkable innovation in the field of maritime constructions, being an essential component of the “Greener Offshore HUBs,” which are an innovative approach to the design of offshore activity hubs aiming at the integrated and sustainable exploitation of maritime resources. These hubs aim to create structures and processes that minimize the carbon footprint, promoting greener and more efficient practices in long-stay maritime environments. Therefore, it is up to VLFS to materialize these hubs, offering support for the implementation of sustainable technologies and the creation of a versatile infrastructure in remote areas of the oceans, serving various activities, such as renewable energy production, industrial processing, offshore logistics, and even habitable areas. This article aims to analyze the regulatory aspects of the law of the sea that legally substantiate this type of structure. The results address the case study of VLFS in Brazil, the pertinent legislation, and its regulatory legal implications. Ultimately, the need to comply with Brazilian legislation and international conventions ratified by the Brazilian government for large floating structures is verified. The research sought to deepen the understanding of the object of analysis and its potential impact on offshore activities, aiming to provide a comprehensive study of these floating structures, evaluating both their current applications and the challenges faced by analyzing the legal and regulatory feasibility of these innovative structures in specific contexts, with a focus, for example, on deepwater offshore environments. Therefore, the critical

analysis of these challenges will provide valuable insights to guide future studies, aiming to overcome barriers and maximize the potential of these structures in various applications.

Keywords

Floating Structures, Decarbonization, Energy Transition, VLFS, Offshore Green Hubs

1. Introduction

Very Large Floating Structures (VLFS) are floating structures artificially constructed for the marine environment. VLFS can create airports, hotels, cities, and even industrial or power generation purposes by shipping plants to central gas processing or offshore electricity generation (Suzuki, 2005).

The first concept of VLFS that emerged in the modern world after the Industrial Revolution was the Floating Island described by the nineteenth-century French novelist Jules Verne, one of the founders of science fiction, with Armstrong Seadrome being the first to promote the use of VLFS for commercial exploration (Suzuki et al., 2006).

Initially, the VLSF was proposed in 1924 to allow air routes through the world's oceans. Its stability was demonstrated in tank tests and several related tests until Armstrong's death in 1955 (Suzuki et al., 2006).

Interest in utilizing the space provided by the seas surrounding a nation for purposes other than conventional transportation or the extraction of ocean resources increased as coastal population densities increased. In the 1950s, architects were attracted to the idea of floating cities, and such a concept was demonstrated in part at the Okinawa International Ocean Exposition in 1975, which included a semi-submersible unit of that city. Similarly, a floating airport was proposed for the new Kansai International Airport in 1973 (Suzuki et al., 2006).

Since the early 1970s, the technology for very large floating structures has developed continuously, while changing social needs have resulted in many different applications of the technology being considered (Suzuki et al., 2006).

In Brazil, considering that natural gas production in 2019 was around 139 million m³/day, with an increasing trend for 2029, which may reach levels of around 253 million m³/day, the installation of VLFS in the Pre-salt areas emerges as an alternative for the monetization of natural gas reserves at the production site, since the flow of exploited gas is complex and expensive due to the at a distance from sea coast (EPE, 2020). In this way, it is possible to consider the production of hydrogen (H₂) by reforming natural gas with CO₂ capture and storage to add value to natural gas instead of its production. It is worth mentioning that the transformation of hydrogen into other fuels can be an interesting option in places where there are few low-carbon alternatives but which are not economically viable at

current prices. Notably, the transformation of hydrogen generated at sea into ammonia also at sea takes advantage of the existing maritime transport infrastructure and demand (Cavalcante & Negri, 2022).

VLFS can enable integrated offshore natural gas processing, CO₂ conversion, LNG liquefaction, or offshore electricity generation projects, as well as for the offshore storage of fuels and as a hub for CO₂ injection in offshore CCUS systems, etc.

In this article, such solutions are thought of in the field of integrated planning for a broader energy, mineral, and economic exploitation of ocean resources in the context of the decarbonization and energy transition of the oil and gas (O&G) industry since there is an abundant potential supply of energy in the Brazilian Pre-salt, in the form of fuel gases, which, so far, have proven difficult to be transported to the Brazilian coast or for export.

The research includes a preliminary analysis of international regulatory legal aspects, where the principles and sources of the international law of the sea (customary international law, treaties and conventions, unilateral declarations, subsidiary sources of law, and soft law) will be identified, as well as the governance of the seas: terminology, norms, principles, and institutions applicable to the subject. Seen as an innovative approach, this study also aims to identify possible gaps in normative and regulatory aspects, both in the Brazilian legal scenario and in international law practices. Through legal and regulatory analyses, it is possible to suggest measures that should be developed in Brazil to allow the country to house structures similar to VLFS in the future.

2. Methodology

Through an analytical and qualitative methodology, several national and international legal and regulatory provisions were analyzed to ascertain which disciplines and regulations would be attributable to the VLFSs within an offshore mega structure focused on activities inherent to the Oil and Gas Industry. To this end, the deductive method and the exploratory and comparative research were used to select laws and regulations. About 47 scientific articles were selected and analyzed, whose themes and approaches correlate to this work's keywords.

Thus, from the presentation of the problem and its importance, through the theoretical framework and documents with the foundations and legal and regulatory aspects analyzed, the construction of the article was obtained with the approach of the origin, concepts, traits, and striking characteristics of the law of the sea through principles and sources, outlined in the face of the premises of work.

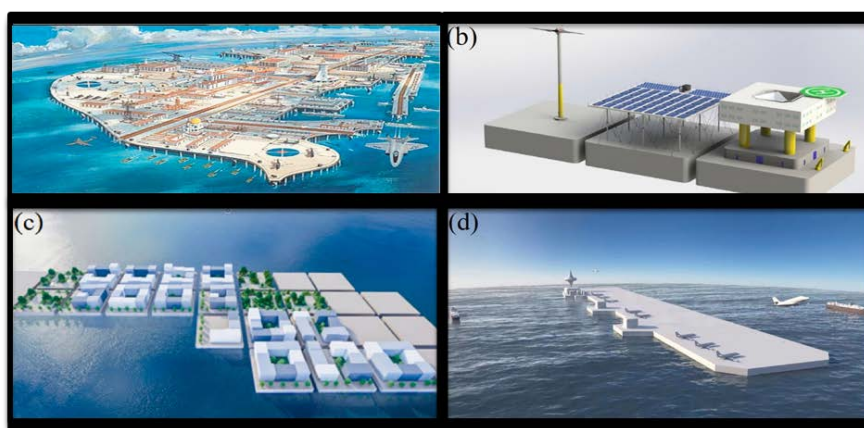
Thus, all these articles were read after analysis and critical analyses were constructed regarding 1) similarities and correlations between the articles and authors studied, 2) main regulatory aspects explored in each scientific article, 3) the scope of the principal regulations analyzed, and 4) main challenges for Brazil to comply with legislation and/or the need for improvement and creation of legislation that covers the main legal gaps for full compliance with the activity in national territory.

In addition, through these selected articles, correlations were built around the constitutions, legislation, and Sustainable Development Goals (SDGs) present in the texts, classified by the subjects addressed, which economic activity they belong to, the years in which they were implemented, and the countries that follow. The texts address various facets of the Law of the Sea, especially in the context of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), and how these principles are implemented or reflected in national legislation, with a particular focus on Brazil.

3. Theoretical Background

3.1. Technical Aspects—Structures and Applications

Some studies classify VLFS according to its geometry (Pontoon or Semi-submersibles), by location (Coastal or Offshore), or even according to its functionality (transport platform, living platform, platform for various activities and energy platform) (Pardo et al., 2015; Jiang et al., 2023). The work will focus on the latter, the energy platform shown in item “b” of **Figure 1**.



Source: Jiang et al. (2023).

Figure 1. Examples of VLFSs for various applications are (a) logistics, (b) energy, (c) live, and (d) others designed for various activities.

Energy-focused VLFS can collect or store energy, including solar, wind, wave, and other energy sources, as well as chemical energy. For instance, with the development of ocean wave energy technology, many VLFS concepts have emerged integrating wave energy converters (WECs). Generally, WECs can be used as damping devices to improve the performance of VLFS. Similarly, several researchers have also studied integrating offshore wind turbines with VLFS (Suzuki et al., 2006; Jiang et al., 2023).

The interactions between these power devices and the VLFS and their structural reliability and power production rates are critical issues. In energy storage, floating facilities have proven to be effective solutions for storing hydrocarbons off the coast of Singapore and crude oil in Japan and Congo. These floating storage facil-

ities offer efficient storage solutions, flexibility in their offshore location, and ease of transportation (Jiang et al., 2023).

In addition to the VLFS's Structure Type, there remains an unresolved question as to whether a VLFS is characterized as a vessel, an offshore facility, or anything else. The legal jurisdiction of various national and international regulatory bodies, primarily those concerned with environmental compliance regulation, will depend on such a determination and the nature of a VLFS's ownership and mission (Suzuki et al., 2006).

3.2. Regulatory Aspects

3.2.1. Absence of Specific Regulation

There are no specific legal provisions for VLFS in Brazil, as there are for oil platforms and vessels. However, several concepts and applications can be replicated in VLFS.

Well, the VLFS and oil platforms could be classified as vessels. According to Law No. 9.537/97, the concept of vessel emerged, which, in turn, brought floating platforms as “Vessel—any construction, including floating platforms and, when towed, fixed ones, subject to registration with the maritime authority and susceptible to moving on the water, by its means or not, transporting people or cargo” (Brazil, 1997).

The VLFS, therefore, must follow the rules applicable to Brazilian and foreign floating mobile platforms through the Maritime Authority Standards (NORMAM-01) and (NORMAM-04). A NORMAM-01. These rules included floating platforms in the concept of the vessel, precisely in line with the provisions of Law 9.537/1997, and are subject to registration with the Port Captaincies (CP), Police Stations (DL), or Agencies (AG), whose data will be obtained through the Vessel Registration Title (TIE) issued (Brazil, 1997).

Also, according to Law 2.180/1954, the respective vessel will need to be registered with the Maritime Court, which will maintain the general registry of naval property. This record will contain information such as the nationality, validity, safety, and publicity of the vessel's ownership, resulting in the issuance of the Maritime Property Registration Provision (PRPM) (Brazil, 1997).

It is important to remember that it is necessary to observe the origin of the country VLFS comes from, whether Brazilian or foreign. This characteristic will imply the differentiation of the regulation to be applied, whether in registration or operationalization (Scaranello, 2021).

3.2.2. Uses and Adaptations of Current Legislation for VLFS Projects

In this sense, due to the absence of national legislation regarding VLFS, the work evaluated the existing international legal institutes, legal sources, and aspects of the international law of the sea, national sovereignty, and the application of the 1982 United Nations Convention on the Law of the Sea that can be used to subsidize future legislation on VLFS here in Brazil.

The main question addressed during the research was: “What are the main laws

and regulations (nationally and internationally) that regulate the installation of VLFS in deep and ultra-deep seas, as well as the integration with industrial production in the deep-sea maritime environment?”

The search was based on the search for articles with the keywords present in this work on the Science Direct journal platform.

The methodology used in the research was Comparative Law, a recommended methodological approach that tries to identify and address issues associated with large-scale construction and engineering (Robson, 2011).

Regulatory Characteristics Identified in the Selected Articles

Through the selected articles, correlations were built around the constitutions, legislation, and Sustainable Development Goals (SDGs) present in the texts, classified by the subjects addressed, which economic activity they belong to, the years in which they were implemented, and the countries they follow. The texts address various facets of the Law of the Sea, especially in the context of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), and how these principles are implemented or reflected in national legislation, with a particular focus on Brazil.

All texts emphasize the importance of the 1982 United Nations Convention on the Law of the Sea as an international regulatory framework that defines the rights and responsibilities of States in the use of the oceans, the management of marine resources, and the protection of the marine environment. There is a comparative analysis between the international guidelines established by UNCLOS and how these guidelines are reflected (or not) in Brazilian national legislation. Law No. 9433/97, for example, mentions the management of water resources in Brazil, but with a limitation in that it does not explicitly include the seas (Diehl & Siqueira, 2006).

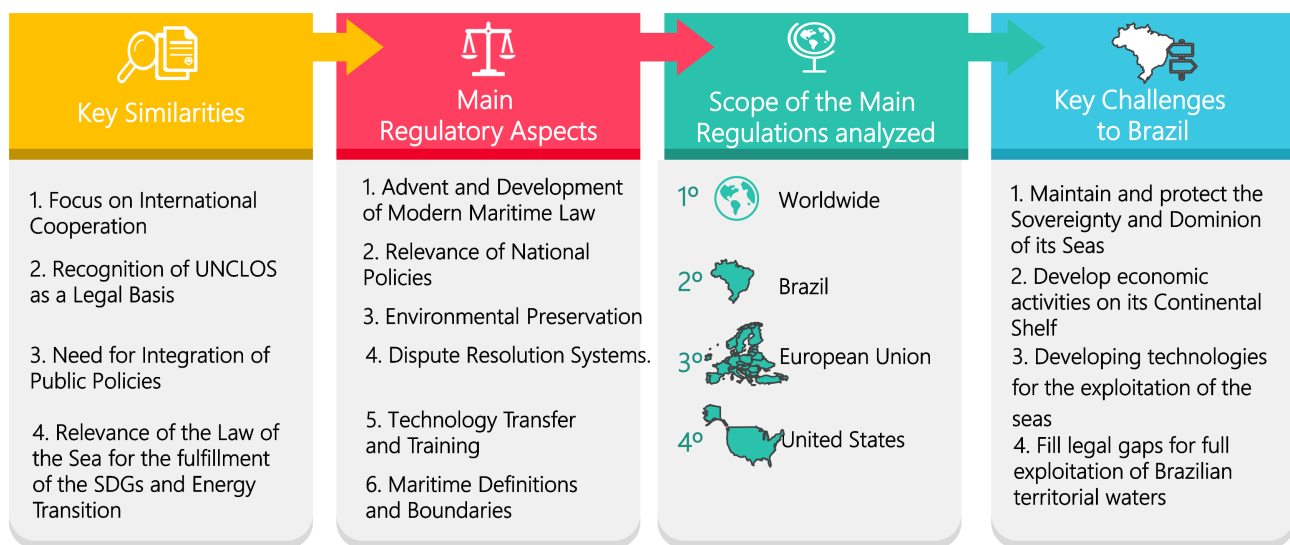
In addition, all texts discuss the need for sustainable use of marine resources, environmental protection, and the prevention of marine pollution, with mentions to specific cases and examples of Brazilian policies and projects such as the Recognition of the Continental Margin (REMAC) and the Plan for the Survey of the Brazilian Continental Shelf (LEPLAC).

Some differences noted were in thematic approaches and historical perspectives. Some texts focus more on the legal structure and principles of UNCLOS, such as the definitions of territorial sea, exclusive economic zone, and rights of way. Other texts are more specific about technological advances and their legal implications, such as using buoys and gliders for marine data collection and the associated regulatory challenges. Some texts analyze practical cases, such as the MOX plant and the issue of maritime pollution, providing examples of how UNCLOS was applied in real situations (Araújo & Oliveira, 2017).

Still, in the wake of the historical contextualization, it was found that, with the increase in demand for natural resources due to consumption patterns, population increase, and scarcity of raw materials on the continent, maritime law needed to be more complex. The laws that regulated activities in the ocean were limited

to navigation, the main interest in the maritime environment; however, with technological advancement and greater demand for the riches of the ocean floor, conflicts arose between several countries due to the exploitation of resources that this legislation was not able to cover. Thus, it was essential to develop maritime law to encompass countries in different conditions of exploitation, aiming at the establishment of equal conditions of exploitation or delegation of rights acquired by geographical position or other reasons (Lima, 2006).

Based on these findings, about 47 articles were analyzed to delimit how these legal issues are addressed in the international scenario. The main similarities in the articles found were verified, and the main regulatory aspects were addressed. In addition, the scope of the leading legal provisions studied and Brazil's main challenges in adapting to the global reality of the exploration of the seas were verified. These analyses are consolidated in **Figure 2**.



Source: Prepared by the authors themselves.

Figure 2. Consolidation of the main analyses from the selected and studied articles.

Finally, the theme encompassing all the articles is international cooperation, in which the prioritization of common interests over national interests is valued. This is shown in the signing of the United Nations Convention on the Law of the Sea, in which all signatory countries agree on regulating maritime activities, significantly affirming the interdependence of the use of the sea and the responsibility to protect its resources. With this, they guarantee respect for the fundamental principles: the jurisdiction of possession, sovereignty, and use of maritime waters, preservation, guardianship, and inspection.

The bibliographic summary played a vital role in the survey of maritime legislation, especially those focused on the offshore region, where the focus of the research is located: the Large Floating Structures (VLFS). In this sense, the selection of themes concerned addressing modern maritime law in a diversified and complete way in all its aspects, considering the beginning of its development to its main

challenges and current conflicts. With this, a repertoire conducive to studying VLFS is guaranteed. It is a field with little exploration but enormous potential for integrated and sustainable exploration.

The bibliographies also highlight the importance of governance and the global cooperation process in constructing modern maritime law, which occurred through several socio-political, socio-economic, and environmental transformations at the end of the twentieth century. In this way, numerous international organizations, non-governmental organizations (NGOs), corporations, multinationals, and social movements began to present normative and technical contributions (Trindade et al., 2016).

3.3. Governance of the Seas: Terminology, Norms, Principles, and Institutions

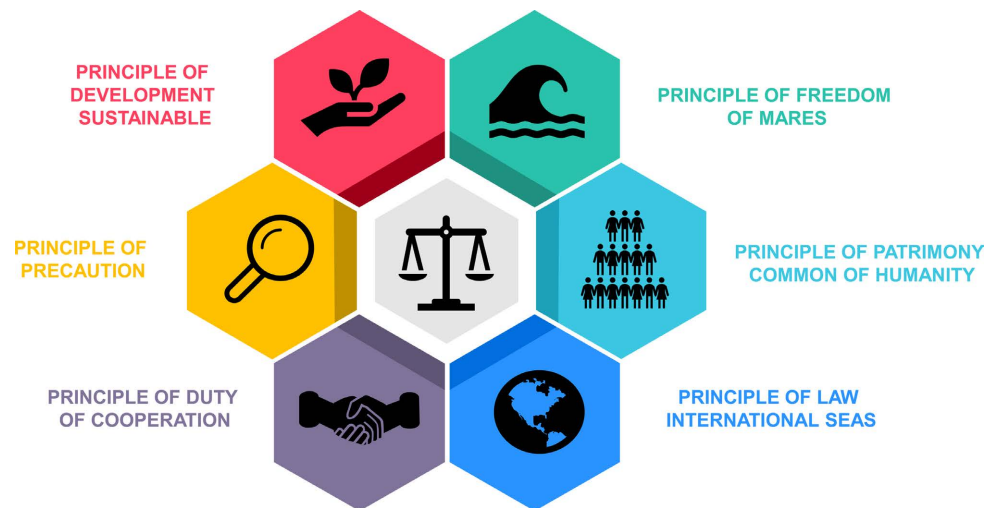
Although the 1982 United Nations Convention does not refer to “ocean management”, the convention attaches decisive importance to sovereignty issues with the common goal of addressing the maritime area. On this subject, Philip Allott notes that maritime areas recognized or established by UNCLOS are equally important areas, and, unlike the old maritime law, the convention adopts a new system where “divided zones have become the rule rather than the exception. Except for inland waters, the regulation of all UNCLOS sea zones is based on the fundamental obligations of interstate cooperation to balance competing uses of the oceans and achieve common goals.

As a result, the oceans should now be protected neither by the *mare liberum* nor the *mare clausum* but by the *mare*. As the territorial sea and the high seas have been transformed into areas of shared authority and interest between two or more state systems, the law of the sea has become less a matter of assigning rights between competing sovereign states and more an inextricably complex systemic interplay of science, technology, economics, and human values that cannot be orchestrated by random text-centric legislation alone.

Conceptually, ocean governance refers to the formal and informal rules, agreements, institutions, and concepts that define how the ocean and marine space can be used, how ocean and marine issues are monitored and advised, and what activities are allowed and prohibited, as well as the sanctions and responsibilities applied. According to Marcus Haward and Joana Vince, they are interested in developing new tools and approaches to managing marine areas, such as the development of ecosystem-based management methods and efforts to move towards integrated “sectoral” management.

Most marine management standards and principles have an environmental dimension and are innovative, such as sustainable development and the precautionary principle. Others concern the general principles of the 1982 United Nations Convention on the Law of the Sea, such as the principle of the duty of cooperation. Regarding the principles and rules, Donal Rothwell points out that they are difficult to list because they have different and divergent points of view, and although

they cannot change the rules of the United Nations Convention on the Law of the Sea—UNCLOS, they must be considered in the interpretation of the Hamburg Convention. Some of the principles that govern the issue are protecting and preserving the marine environment, the principle of cooperation, and the common heritage of humanity, for example. Councils and organizations are part of a complex multilateral structure at global, regional, national, and regional levels. **Figure 3** shows a summary of all these principles.



Source: Prepared by the authors themselves.

Figure 3. Main standards and principles of marine management.

At the international level, the most important elements are the UNCLOS (Commission on the Limits of the Continental Shelf, Seabed Authority, and Maritime Court) and the bodies created by the UN and its special agencies. At the regional, sub-regional, and national levels of marine management, UNCLOS encourages the creation of institutions and organizations primarily for the protection of the marine environment and the conservation of marine species because regional and national cooperation can be more effective, and cooperation between countries can happen more efficiently at the regional level than at the global level. Some of the most important regional, sub-regional, and national agencies and institutions are the United Nations Environment Programme, the Regional Marine Programme, the European Union, and the Asia-Pacific Economic Cooperation. **Figure 4** summarises the main elements that deal with the theme at the international level.

3.4. Opportunities for Decarbonization and Energy Transition

As already pointed out, the article aims to study the applications of VLFS in the national Pre-salt in the context of Decarbonization and Energy Transition from a regulatory perspective. After the economic damage caused by the COVID-19 pandemic and climate effects aggravated by global warming, decarbonization, promoted by the energy transition, is the main objective of public policies that centralize and guide significant investments (Bodansky, 2006).



Source: Prepared by the authors themselves.

Figure 4. Key international elements.

The Energy Reconversion Plan, initiated by developed countries to achieve neutrality in greenhouse gas (GHG) emissions by 2050, aims to boost economic growth towards a sustainable economy. As a result, the main objective of this Plan is to encourage the energy transition of the leading global value chains that depend on the use of natural gas, coal, and oil for the generation of electricity from the generation of energy through hydraulic, wind, and solar matrices, which are considered environmentally friendly, renewable and sustainable (Bodansky, 2006).

In this sense, the Paris Agreement brought together more than 190 countries that individually committed to maintaining progressive efforts to reduce greenhouse gas emissions in the atmosphere through targets known as Nationally Determined Contributions (NDCs), aiming to limit global warming to less than 2°C and with efforts to stay below 1.5°C compared to pre-industrial levels (UN, 2014).

In this sense, the use of VLFS structures to compose HUBS and/or offshore production clusters, as well as the decentralization of the energy sector, aim to create sustainable energy matrices, which significantly increase Brazil's sustainable energy generation capacity and meet the provisions of the Paris Agreement (Pardo et al., 2015).

In addition, the use of VLFS is also part of an even broader discussion that focuses on the optimal and sustainable use of natural maritime resources, expanding the maritime economic frontier for humanity. In this broad legal perspective of the project, the objective is to explore development dynamics aligned with the more significant objective of building a low-carbon civilization focused on reducing global climate problems (Pardo et al., 2015).

These hubs aim to create structures and processes that minimize the carbon footprint, promoting greener and more efficient practices in long-stay maritime environments. Therefore, VLFS is responsible for the materialization of these hubs, offering support for the implementation of sustainable technologies and the crea-

tion of a versatile infrastructure in remote areas of the oceans, serving various activities, such as renewable energy production, industrial processing, offshore logistics, and even habitable areas (Scaranello, 2021).

4. Results and Discussion

Regarding the national regulatory legal aspects of long-term offshore systems based on large floating structures, more precisely those existing legal institutes applicable to Brazil, it is possible to observe that large floating structures represent a remarkable innovation in the field of maritime constructions, being an essential component of the “Greener Offshore HUBs” (GOH). Such structures represent an innovative approach to the design of offshore activity hubs, aiming at an integrated and sustainable exploitation of maritime resources (Arlota & Cardoso, 2013).

To begin with, the great importance of the international law of the sea for the theme addressed, not only because it encompasses the United Nations Convention on the Law of the Sea of 1982, but also other international treaties and agreements, state practices of governance and maintenance of international waters, determining limits and control of maritime spaces, the issue of sovereignty and jurisdiction of states in the interest of the international community, marine environmental protection, issues involving the exploitation of living and non-living natural resources, among many other related topics (Rothwell & Stephens, 2010).

Well, as for the legislation relevant to Brazil, it is first necessary to identify the normative framework of the platforms, whether it is a vessel, ship, or artificial island, whether the structure is fixed or mobile, or floating platforms of the Floating Production Storage and Offloading (FPSO) type, and then enter into the regulatory legal implications of each of these. The terminological distinctions of Brazilian vessels and floating structures bring important aspects of the Declaration of Conformity for Operation in Brazilian Jurisdictional Waters and normative issues of the Brazilian Maritime Authority to the case (Scaranello, 2021).

From Law No. 9.537/97 came the concept of the vessel, which in turn brought floating platforms as “Vessel—any construction, including floating platforms and, when towed, fixed ones, subject to registration with the maritime authority and susceptible of moving on the water, by its means or not, transporting people or cargo” (Brazil, 1997).

Also, according to Law No. 9.537/97, the authority responsible for registration—the Navy—is also responsible for defining which constructions capable of moving on water must be registered and are then considered vessels. In this sense, through Maritime Authority Standard No. 201 (Former Normam-01), the Brazilian Navy defines which vessels are subject to registration, expressly recognizing that platforms should be considered in this category. In this sense, the vessel concept, as admitted by Brazilian legislation, is broad enough to include maritime platforms. There are countless examples of equating a platform—regardless of its fixed or mobile nature—with a vessel in Brazil and abroad.

In Brazil, several types of vessels and floating structures have specific charac-

teristics and legislation depending on the end activity. For example, the Brazilian Navy—maritime authority in Brazil established a series of NORMAM (Maritime Authority Standards) specific to vessels, Series 200—Vessels (EM). The Navy segregates each Standard for a type of vessel, for example, standards for vessels for commercial use classified for the open sea or inland (NORMAM-201/DPC and NORMAM-202/DPC, respectively), for operation or traffic/permanence of foreign vessels in Brazilian jurisdictional waters (NORMAM-203/DPC and NORMAM-204/DPC., respectively), or even for sports and recreational vessels (NORMAM-211/DPC).

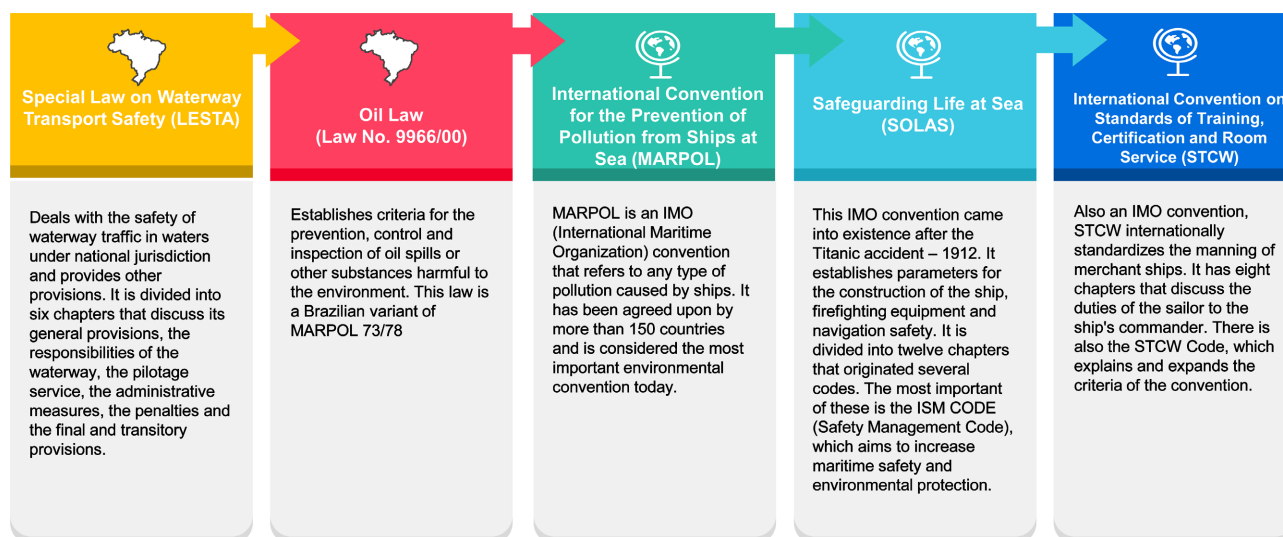
In addition to NORMAM, the Navy has several standards and legislation to regulate the activities inherent to vessels in national territory.

Still in the regulatory aspect, ANTAQ—National Waterway Transport Agency is responsible for regulating, supervising, and inspecting activities related to waterway transport services and the exploitation of waterway and port infrastructure. It covers the port, maritime, support navigation, and inland navigation subsectors (Antaq, 2020). Within the scope of this work, ANTAQ would be responsible for:

- maritime support, port support, cabotage, and long-distance navigation
- organized ports and port facilities located there
- terminals for private use
- cargo transfer stations

Therefore, within the scope of this work, only vessels and floating structures dedicated to hydrocarbon exploration and production activities will be explored.

According to Bolonini, due to the strong growth of this activity, it became necessary to develop national and international legislation to guarantee more excellent safety for human life at sea, preserve the environment, and prevent accidents. There are many laws related to maritime support activities, but the laws applicable to Brazil will be listed in **Figure 5**.



Source: Created by the authors themselves.

Figure 5. The main laws in the segment applied to Brazil.

Within the scope of the Brazilian Executive Branch, the regulations and guidelines arising from the ANP—National Agency of Petroleum, Natural Gas and Biofuels stand out, whose responsibilities were established by Law No. 9.478/97 or even by the Ministry of Labor, such as NR-37, which aims to establish the requirements for safety, health and working conditions on board oil platforms operating in Brazilian Jurisdictional Waters—AJB.

The Brazilian Navy differentiates the regulations applicable to Brazilian and foreign floating mobile platforms through the Maritime Authority Standards (NORMAM-01) and (NORMAM-04). NORMAM-01 included floating platforms in the concept of the vessel, precisely in line with the provisions of Law 9.537/1997, and are subject to registration with Port Captaincies (CP), Police Stations (DL), or Agencies (AG), whose data will be obtained through the Vessel Registration Title (TIE) issued (Brazil, 1997).

The registration and registration procedures of a Brazilian vessel must be done within fifteen days, counting from the “date (i) of the term of delivery by the builder, when built in Brazil; (ii) acquisition of the vessel or of the right and action, in the case of a promise of purchase and sale; or (iii) of its arrival at the port where it will be registered when acquired or built abroad” (Brazil, 1997).

About foreign platforms, the applicable regulation must be registered in the country of applicable nationality so that in order to operate in the waters of Brazilian territory, it must comply with the maritime rules provided for in NORMAM-04, which results in obtaining a Temporary Registration Certificate issued by the Navy, which will allow that vessel to operate on a regular basis (Brazil, 1997).

There is a need to comply with Brazilian legislation and international conventions ratified by the Brazilian government for large floating structures. In the case of foreign structures in Brazilian territory, the need for the validity of the temporary registration linked to the term of the concession ordinance of the National Agency of Petroleum, Natural Gas and Biofuels of Brazil (ANP) was also verified.

It is worth noting that, regarding floating platforms and their classifications and nature, there is, however, national and international legal uncertainty since there is no discussion before the Brazilian Navy regarding the classification of floating platforms as a vessel for regulatory purposes, in line with the current legislation on waterway traffic safety (Law No. 9.537/97).

Thus, an international order of cooperation made up only of states is too limited for the complexity of the twenty-first century, which makes it necessary to resort to new international actors, such as the International Maritime Organization (IMO). This statement is confirmed by the United Nations Convention on the Law of the Sea (UNCLOS), a treaty of the highest authority in the area of Maritime Law, which legally guarantees the participation of new actors in the International Maritime Regime. Thus, a scenario of opportunities is created for these actors, who are free to promote scientific and technological research and strengthen global cooperation. It results in greater efficiency in achieving the objectives of the Sea Regime through the firm maintenance of a rich and complex regulatory system based on

technical-scientific knowledge (Trindade et al., 2016).

Another important point observed with the advent of Maritime Law is the discussion of the balance between restrictions and freedoms in the use of maritime space. As a result, the dichotomy *mare clausum*, the principle of dominion over the entire sea, against *mare liberum*, the principle of freedom of the seas, became relevant so that countries wanted to benefit the most from the exploitation of marine resources (De Souza et al., 2020).

In this way, we can say that countries defend the *mare clausum* to guarantee the sovereignty of exploration without competition while simultaneously defending the *mare liberum* to exploit the maximum marine territory without another country having sovereignty over it, which results in very conflicting interests that prioritize their own benefit over the collective. Thus, UNCLOS became responsible for ensuring this balance to avoid international conflicts about the incessant search for raw materials in the maritime space (De Souza et al., 2020).

Finally, the gap in the marine environmental protection jurisdiction reveals itself as one of the most important points of Modern International Law. Even with the imminence of climate change, the exploitation of marine resources continued in the global plans to take advantage of the opportunities of the maritime territory, which led UNCLOS to decree the responsibility of States in the conservation of marine living resources, protection, and preservation of the marine environment and research in case any of these measures are not complied with. However, these measures are inefficient, poorly regulated, or still not very detailed, and they have gaps in practice so as not to conflict with the interest of maximum exploitation of the marine raw material of the States (De Souza et al., 2020).

Thus, we can also raise three other relevant points that frequently appear in the bibliographies: 1) Global cooperation to ensure a rich and complex system of rules of Modern Maritime Law, combining States and Organizations; 2) Balance between freedom and restriction, in order to avoid conflicts and ensure justice and equality in activities related to the marine environment; and 3) Gaps in Maritime Environmental Law, which is very inefficient in practice and ineffective in the fight against climate change.

5. Conclusion

The article dealt with the topic of the climate issue, as well as the optimized exploitation of maritime natural resources and the necessary promotion of innovation in low-carbon technologies, all through new concepts of naval engineering and ocean infrastructures for the in-situ monetization of natural gas in offshore activities in deep and ultra-deep waters, with the use of large floating structures.

It addressed the leading national and international laws and regulations regulating the installation of VLFS in deep and ultra-deep seas and the integration based on natural gas and industrial production in the deepwater maritime environment. With this question as a guideline, the Methodological Framework and the Planned Activities established presented a greater understanding of the legal

and regulatory dimensions that must be addressed in developing an onboard gas VLFS.

Preliminary studies have shown important opportunities for implementation in Brazil. Due to the country's port conditions and limitations, as well as the efforts to develop cabotage activities, the Offshore Port concept has also proven viable for the country, with important benefits for Offshore Hubs. Applications of VLFS were also identified in the scope of scientific research, defense, power generation, and installation of industrial units or floating electricity generation.

Comparative law is an appropriate methodological approach, and the selected articles contributed to identifying and approaching the issues associated with large-scale engineering constructions. Given this investigation's complexity and exploratory nature, it was necessary to gain a deeper understanding through a flexible design strategy, which is highly recommended for specific studies such as this one, where even data collection requires an innovative approach.

In this way, we can see that through the bibliography consumed, several important points were evidenced for the feasibility of the implementation of these VLFS; there are several nuances within this theme where the main ones are the regulatory issues and the risks of their implementation and operation, requiring studies that ensure safe operation and that can bring more sustainable hubs, that aim at platforms that can perform in the offshore scenario in a prudent way and in a global perspective, conventions and norms that pay attention to the meticulous relations involved between nations and the use of these shared spaces.

The bibliographic summary played a vital role in the survey of maritime legislation, especially those focused on the offshore region, where the focus of the research is located: the Large Floating Structures (VLFS). In this sense, the selection of themes concerned addressing Modern Maritime Law in a diversified and complete way in all its aspects, considering the beginning of its development to its main challenges and current conflicts. With this, a repertoire conducive to studying VLFS is guaranteed. It is a field with little exploration but enormous potential for integrated and sustainable exploration.

Thus, given the regulatory aspects and gaps identified, it would be possible to affirm that there are conditions for Brazil to use VLFS, where one of the main opportunities for Brazil would be the creation of HUBS and/or offshore production clusters. These large floating structures can then be designed for future integrated offshore natural gas processing, CO₂ conversion, LNG liquefaction, or offshore electricity generation projects, as well as for the offshore storage of fuels and as a hub for CO₂ injection in offshore CCS systems.

Based on legal and normative mappings, a rereading of instruments that must be conceived in Brazil is proposed so the country can house VLFS-type structures in the future. The results also show important opportunities for implementing VLFS in Brazil and possible paths for implementing regulation at the national level on the subject.

Acknowledgements

The authors are grateful for the support of CNOOC Petroleum Brazil Ltd. and the strategic importance of the support of the ANP (National Agency of Petroleum, Natural Gas and Biofuels) through the regulation of the R&DI rate (ANP Resolution No. 918/2023).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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