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International Law and Regulation of Marine Microplastics: Current Situation, Problems, and Development

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Abstract: The severe global hazards posed by marine microplastics must be given attention. This study evaluated the current international legal framework, and offers forward-looking recommendations for enhancing international law. The analysis began by examining the unique characteristics and profound impacts of marine microplastics, underscoring the necessity of a corresponding international regulatory regime. Through a thorough review of the existing global and regional legal instruments—both soft and hard laws—we identified key issues and challenges in the international legal response to marine microplastics, particularly in terms of legislation and enforcement mechanisms. The study emphasizes the urgent need for strengthened international legislation, including the potential development of a specialized international treaty, and calls for the enhancement of compliance mechanisms to effectively combat marine microplastic pollution and support the broader goal of sustainable development.

Keywords: marine microplastics; international law; pollution control

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1. Introduction

1.1. The Concepts and Types of Marine Microplastic Pollution

The concept of microplastics was first introduced by British researchers in 2004 [1]. Today, microplastics are typically defined as plastic particles measuring less than 5 mm in diameter [2]. According to the United Nations Environment Programmer (UNEP), marine litter is described as "any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment" [3]. By their nature, marine microplastics fall within this category of marine litter. However, they are distinguished by five unique characteristics: a solid state, less than 5 mm in diameter, insolubility, resistance to degradation, and plasticity. These features set marine microplastics apart from other types of marine litter, marking them a novel and significant pollutant within the marine environment.

Marine microplastics can be classified into two categories: primary and secondary microplastic particles. Primary microplastics are micron-sized particles that are intentionally produced during industrial processes. These primary microplastics often enter marine environments, contributing to marine microplastic pollution [4]. In contrast, secondary microplastics do not originate as small particles but are instead formed through the degradation or fragmentation of larger plastic materials. These secondary particles result from the breakdown of various plastic products and waste, primarily due to environmental exposure [5]. The most significant sources of secondary microplastics are related to plastic waste generated by human activities. Plastics used in agriculture, industry, and tourism frequently enter marine environments through various pathways. Intentionally or unintentionally discarded plastic waste in human life also causes a large amount of microplastic

pollution [6]. Over time, these plastics undergo physical, chemical, and biological degradation, resulting in particles smaller than 5 mm in diameter, which contribute to marine microplastic pollution.

1.2. Sources and Hazards of Marine Microplastics

The sources of marine microplastics are broadly categorized into land-based and sea-based origins [7]. Land-based marine microplastic pollution refers to microplastics that originated on land, whether as primary or secondary particles, that eventually arrived at the ocean. Research by the United Nations Environment Assembly (UNEA) confirmed that microplastics are not only generated through the fragmentation of larger plastics but also from other sources [8–11], including industrial discharges, sewage, and runoff from products containing microplastics. Sea-based sources of marine microplastics include activities related to fisheries, aquaculture, shipping, offshore operations, and marine tourism [12]. People's daily lives are also an important source of microplastics [4].

The hazards of microplastics have several characteristics. First, microplastics are characterized by vast spreading and significant mobility in terms of spatial distribution. This transboundary mobility presents a substantial challenge to the prevention and regulation of microplastic pollution, underscoring the necessity for international cooperation and coordinated governance efforts [13]. Secondly, microplastics are difficult to detect and monitor. The detection and control of marine microplastic pollution are heavily reliant on scientific progress, making the management and control particularly challenging [14,15]. Thirdly, the harm of microplastics could be long lasting and insidious. The process by which microplastics accumulate in living organisms and transfer through the food chain to humans is lengthy and complex, with significant intergenerational impacts [8–10,16]. The slow and hidden nature of this process makes it difficult to sustain long-term incentives for governance mechanisms, leading to a lack of motivation and practical effectiveness in pollution control efforts. Fourthly, the prevention and treatment of microplastics present significant challenges due to their complex nature. The lack of effective regulatory mechanisms at the international level has hindered the development of post-pollution management strategies. The governance of microplastics heavily relies on risk prevention, underscoring the critical importance of proactive regulation [17]. However, the international community has yet to achieve a consensus on the issue, nor has it established a global cooperation mechanism. This lack of agreement and coordinated action hampers the implementation of effective preventive measures.

Its distinct features necessitate a different approach to their governance and regulation compared to other types of marine pollution. Given the specific challenges posed by marine microplastics, there is a clear need for regulation at the international law level. This study aimed to address three key questions: First, what is the status of international law regarding the regulation of marine microplastics? Second, what are the primary issues within the existing international legal framework for controlling marine microplastics? Third, how could the international regulatory system for marine microplastics be effectively improved?

2. Materials and Methods

To comprehensively review the international regulation of marine microplastics, relevant findings from various sources have been collected, including public databases and academic research, with a particular focus on two key legal databases: HeinOnline and Westlaw Next. HeinOnline contains a vast collection of over 2500 global core law journals, including the top 500 core law journals and the leading 20 journals in each legal discipline. It also features more than 100 SCI-indexed law journals and over 400 peer-reviewed journals, covering literature from nearly 100 countries and regions, mainly including the United States, the United Kingdom, the Commonwealth, Europe, Asia, North America, Africa, etc. Westlaw Next, developed by Thomson Reuters, is a next-generation, all-in-one legal information retrieval platform designed for legal practitioners. The platform provides access to international treaties, regional agreements, case law, and statutory laws from

jurisdictions such as the U.K., U.S., France, Australia, Canada, South Korea, Hong Kong, and EU countries. It also includes more than 5000 law journals from the United States, the European Union, and other regions (more than 90% of which are core American law journals), along with nearly 4000 specialized legal monographs and up-to-date news in law, finance, and politics. More global legal updates can be obtained immediately through the WestLaw database. Using the resources from these two major databases, we conducted a thorough review of the international legal regime governing marine microplastics, drawing on both statutory law and international legal theory.

This study applied document analysis, comparative research, interdisciplinary research, and legal interpretation to examine the current status, challenges, and future development of the international legal regime on marine microplastics. The specific methods are as follows :

1. Literature Research Method.

Although there is some existing literature on the international law and regulation of marine microplastics, this study was guided by the topic of international legal regulation of marine microplastics, categorizing and summarizing the available research to provide a theoretical foundation and guidance for the study. By reviewing various sources of documents, the study examined the challenges faced by the current international legal framework in addressing marine microplastic pollution. Building on these research findings, this paper proposes targeted recommendations to enhance the capacity of international law to effectively respond to the issue of marine microplastic pollution.

2. Comparative Research Method.

This study conducted a comparative analysis of the applicability of existing international hard law and soft law on marine microplastics, identifying the strengths and weaknesses of the current international legal framework and how they complement each other in regulating marine microplastic pollution. On the other hand, by comparing and reviewing the legislation and practices related to marine microplastic pollution in regional conventions and regional marine programs, this study explored the issues in the current international legal regulation of marine microplastics at both the legislative and practical levels. The pollution control experiences derived from the comparative analysis were also evaluated.

3. Interdisciplinary Research Method.

The complex nature of marine microplastic pollution poses significant challenges for scientific research. This study drew on a range of literature from the field of marine environmental science to analyze the unique characteristics of marine microplastic pollution. This interdisciplinary approach provides a scientific foundation for proposing improvements to the international regulation of this pollution management issue.

4. Legal Interpretation Method.

This involved analyzing international conventions and regional agreements, particularly those defining marine microplastic pollutants, to demonstrate the necessity of enhancing regulations on microplastic pollution within the framework of international law.

3. Result

Building on the foundational concepts and theories discussed earlier, this section will analyze selected conventions, plans, and documents from two perspectives: global international law regulation and regional international law regulation.

3.1. International Law and Regulations

3.1.1. International Soft Law Regime

International soft law refers to a set of non-legally binding rules and guidelines that can have significant practical implications. This concept is extensively applied in international law and relations, encompassing a wide range of documents, agreements, declarations,

guidelines, and standards that, while not legally enforceable, can influence behavior and policy. Key examples include the Marine Litter and Microplastics Resolution, the Honolulu Strategy Global Framework for the Prevention and Management of Marine Debris, and the Draft Resolution on Ending Microplastic Pollution, all of which are examined in this analysis. The details of the case are shown in Table 1.

1. Marine Litter and Microplastics Resolution

In 2017, the UNEP brought the issue of marine litter and microplastics to the forefront during the third session of the UNEA. The Marine Litter and Microplastics Resolution emphasized the urgent need for the international community to address marine litter, with a particular focus on microplastics. The document recommended prioritizing waste minimization and preventive measures as key components of environmentally sound waste management. Additionally, it calls for the implementation of site-specific measures to effectively tackle marine litter, especially microplastics.

The Marine Litter and Microplastics Resolution outlines several mechanisms for addressing marine litter. First, it calls for a standardized definition of marine microplastics, along with harmonized methodologies and standards to enable the precise measurement and monitoring of microplastic quantity and density in the marine environment. The absence of such definitions and standards in current international law is common, and many countries have yet to incorporate marine microplastics into their local and national waste management and wastewater discharge plans. This lack of uniformity hinders global efforts to address the escalating issue of marine microplastics. Secondly, it advocates for the establishment of a Global Partnership on Marine Debris. The United Nations General Assembly has actively promoted the creation of global partnerships involving national governments, intergovernmental bodies, and non-governmental organizations. These partnerships aim to advance the implementation of the Honolulu Strategy and enhance access to online networks dedicated to managing marine microplastic debris.

In addition, the Marine Litter and Microplastics Resolution provides guidelines for research on marine microplastic waste, establishing a research foundation for countries to monitor marine litter and microplastics effectively. Among these guidelines, the most critical is the emphasis on strengthening research into the primary sources of microplastics. Understanding these sources is essential for effectively addressing marine litter and microplastics. Only when countries identify the specific sources of marine debris and microplastics in waters of their area can it implement tailored management strategies based on local conditions. This approach is crucial for reducing the influx of garbage, plastics, and microplastics into marine environments.

2. The Honolulu Strategy Global Framework for the Prevention and Management of Marine Debris

The Honolulu Strategy Global Framework for the Prevention and Management of Marine Debris has three main objectives: first, to reduce the amount of debris and solid litter in the marine environment from land-based sources; second, to reduce the amount of marine litter from ocean-based sources, including solid waste, lost cargoes, and abandoned ships; and third, to reduce the amount and impact of litter that accumulates on coastlines, in benthic environments, and in the oceans. The Honolulu Strategy not only provides direction on the global issue of marine microplastic pollution prevention and control, but also provides a framework for multi-party cooperation.

3. The Draft Resolution on Ending Microplastic Pollution

On 2 March 2022, the Fifth UNEA adopted the Draft Resolution on Ending Microplastic Pollution, which seeks to address the root causes of microplastic pollution on a global scale. The resolution outlines three key agreements: First, it calls for the establishment of an intergovernmental negotiating committee. Second, it emphasizes the importance of managing microplastics throughout their entire life cycle. Historically, efforts have primarily focused on the treatment and recycling of microplastic waste, overlooking the sig-

nificant impacts of microplastics during production and use. The end-of-pipe management approach addresses surface problems rather than root causes, and therefore fails to fully mitigate microplastic pollution. Third, the resolution advocates for enhanced international cooperation to promote technological advancement, capacity building, and scientific and technological exchange. These measures are intended to drive fundamental changes in production, consumption, and microplastic waste management, enabling a more effective global response to the challenge of microplastic pollution.

Table 1. International soft law norms for marine microplastic pollution.

Name	Establishment Date	Nature of Contracting Parties	Applicability
Marine Litter and Microplastics	2017	Country, international organization, non-governmental organization	Regulations on the research of marine microplastic waste
The Honolulu Strategy Global Framework for the Prevention and Management of Marine Debris	2012	Country, international organization, non-governmental organization	Provides direction for the prevention and control of microplastic pollution in the ocean
Draft Resolution on Ending Plastic Pollution	2022	Country	Targets the prevention and control of microplastic pollution in the ocean

All three of these documents aim to protect the marine environment and foster cooperation among nations. However, they differ in focus: the Marine Litter and Microplastics Resolution aims to provide a framework for disposal mechanisms for marine litter and microplastics; the Honolulu Strategy Global Framework for the Prevention and Management of Marine Debris centers on the management of marine litter; and the Draft Resolution on Ending Microplastic Pollution is dedicated to combating microplastic pollution. While these documents provide valuable guidance for the prevention and control of marine microplastic pollution, their lack of enforceability limits their effectiveness in addressing the current challenges in marine microplastic pollution prevention and control.

3.1.2. International Hard Law Regime

International hard law refers to legally binding rules that apply to international actors, such as states. It primarily encompasses international treaties and customary international law, which are typically enacted or recognized by legitimate legislative bodies and carry mandatory obligations. Examples of hard international law include the United Nations Convention on the Law of the Sea (UNCLOS), the International Convention for the Prevention of Pollution from Ships (MARPOL), and the London Convention along with its 1996 Protocol. These examples are analyzed in the following discussion. The details of the case are shown in Table 2.

1. UNCLOS

The 1982 UNCLOS is the most widely recognized and influential international treaty in maritime law. It addresses the protection of the marine environment in Part XII, where it establishes a general obligation for states to protect and preserve the marine environment [18]. Specifically, UNCLOS mandates that states must prevent, reduce, and control "all sources of pollution of the marine environment [19]". Although marine microplastics were not explicitly identified as pollutants when the Convention was drafted, they clearly fall within the Convention's definition of "pollution of the marine environment" and are covered the mandate to prevent, reduce, and control all sources of pollution. Therefore, even though UNCLOS does not specifically mention marine microplastics or outline precise measures for their management—largely due to the scientific limitations at the time of its drafting—the regulation and control of marine microplastics still fall under the treaty's scope. States are therefore obligated to comply with both the general and specific pro-

visions of UNCLOS regarding the protection of the marine environment, including the management of microplastic pollution.

Given that marine microplastics are a relatively recent discovery, the detection, monitoring, and management are closely tied to advancements in scientific research, making the creation of new international rules, standards, and recommendations particularly critical. Therefore, international cooperation should be strengthened to promote the development of international rules, standards, and recommendations. In terms of microplastic governance, states must comply with several procedural obligations under UNCLOS, including the duty to exchange information, communicate and notify, cooperate in scientific research, provide technical assistance to developing countries, and develop and promote pollution contingency plans.

Among the specific obligations under UNCLOS, several provisions are directly applicable to the management of marine microplastics. Firstly, states should employ recognized scientific methods to observe, measure, estimate, and analyze the risks and impacts on the marine environment [20]. This includes monitoring domestic production, activities, and discharges that are likely to contribute to marine microplastic pollution [21], as well as conducting environmental impact assessments for activities that could result in significant pollution or harmful changes. Secondly, they are obligated to minimize, to the greatest extent possible, the discharge of microplastics, given their persistence and difficulty in degrading. Thirdly, the control of microplastics pollution from dumping and from ships is essential.

However, the provisions of the UNCLOS are of a general nature and do not provide a detailed framework of obligations and measures necessary to address the production, transportation, consumption, trade, and end-of-life disposal of plastics and their additives, and do not eliminate the sources of marine microplastics [22].

2. MARPOL

Shipping is the primary source of microplastics originating from marine activities. Regulations on pollution from ships are primarily embodied in the MARPOL 73 and its 1978 Protocol (MARPOL 78). MARPOL 73/78 comprises six annexes, with Annex V being the most relevant to microplastic pollution [23]. Annex V provides comprehensive control measures for the prevention and management of garbage pollution from ships, covering five key aspects: area management, discharge standards, operational requirements, port reception facilities, and port state inspections. In particular, Annex V mandates that, with specific exceptions, the discharge of all plastic products— including but not limited to synthetic ropes, synthetic fishing nets, and plastic garbage bags—into the sea is strictly prohibited [24]. This provision is crucial for controlling microplastic pollution at its source.

At the 70th session of the Marine Environment Protection Committee of the International Maritime Organization (IMO), important amendments were made to MARPOL 73/78, Annex V. The definition of relevant concepts in MARPOL 73/78 Annex V, a more detailed way of classifying garbage, and clear discharge standards will help to better manage and handle ships' garbage and help to reduce the impacts of microplastics on the marine environment. The definition of the concepts in MARPOL 73/78 Annex V and the clear discharge criteria will help to better manage and handle shipboard garbage and help to reduce the potential threat of microplastics to the marine environment.

However, there are shortcomings in MARPOL 73/78 regarding the regulation of marine microplastics. Firstly, the scope of the regulation is limited to microplastics in the marine debris released into the sea during ship operation, but not to microplastics generated by ships in other states, nor to microplastics discharged from flag of convenience ships. Secondly, MARPOL 73/78 is more stringent in controlling the discharge of black water from ships, but very lax in controlling gray water, which is also an important source of microplastics.

3. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, commonly known as the London Convention, was adopted during the 1972

Dumping at Sea Conference. Its primary objective is to regulate sea dumping, promote the effective control of all marine pollution sources, and implement practical measures to prevent marine pollution from the dumping of waste and other materials. The London Convention categorizes dumped substances into "blacklists", "gray lists", and "whitelists" through three annexes. Marine microplastics are addressed in Annex I, which includes durable plastics and other synthetic materials on the "blacklist", thereby prohibiting their dumping.

In 1996, the Protocol to the London Convention was adopted to further strengthen the protection of the marine environment from all sources of pollution. Unlike the original convention, the Protocol does not specify prohibited substances but instead provides a "reverse list" of substances permitted for dumping. This approach makes the Protocol more restrictive regarding marine waste dumping. Microplastics are not included in the "reverse list", implying that their dumping is prohibited under the Protocol. While the Protocol addresses the source of secondary microplastics through its ban on plastic substances, it cannot eliminate the introduction of microplastics into the oceans due to the diverse sources, such as dredged materials on the "reverse list", which have been found to contain microplastics. Consequently, the London Convention and its Protocol cannot fully prevent the discharge of plastic debris into the sea and lack comprehensive regulation of primary microplastic sources from ships.

4. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention), adopted in 1989, aims to regulate the adverse effects of hazardous and other waste transboundary movements on human health and the environment. With over 100 member states, the Basel Convention has a broad impact. Under the Convention, "hazardous wastes" can be identified either through Annexes I, II, and III or by the domestic laws of the parties. This means that, in addition to the substances specified in the Convention, parties have the authority to classify other substances within their jurisdictions as hazardous wastes. In 2002, the Conference of the Parties to the Basel Convention adopted the Technical Guidelines for the Identification and Environmentally Sound Management of Plastic Wastes and their Disposal. These guidelines provide detailed advice and information on the composition, transportation, recovery, treatment, and recycling of plastics, aiming to reduce their contribution to microplastic formation and entry into the oceans [25]. The 2021 amendments to Annexes II, VIII, and IX of the Basel Convention further clarify the definition of "plastic waste" and how it should be managed. Although the term "microplastics" is not explicitly mentioned in these amendments, the concept of "plastic waste" should be understood to encompass microplastics due to their composition.

Table 2. International hard law norms for marine microplastic pollution.

Name	Establishment Date	Whether Effective	Effective Date	Nature of Contracting Parties	Applicability
United Nations Convention on the Law of the Sea (UNCOLOS)	10 December 1982	In operation	16 November 1994	Country	The treatment of marine microplastic pollution is mostly a general regulation
International Convention for the Prevention of Pollution from Ships (MARPOL Convention or MARPOL 73/78)	17 February 1973	In operation	2 October 1983	Country	The scope is limited to the scope of ships, and the ability to control microplastic pollution is restricted

Table 2. *Cont.*

Name	Establishment Date	Whether Effective	Effective Date	Nature of Contracting Parties	Applicability
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC)	29 December 1972	In operation	30 August 1975	Country	Lack of comprehensive regulation of the primary sources of microplastics in ships
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (BC)	22 March 1989	In operation	May 1992	Country	Regulates the cross-border transfer of marine microplastic pollution

3.2. Regional Regimes of International Law

The Regional Seas Programs of the UNEP provide a cooperative framework for countries to manage pollution in shared marine and coastal areas. Currently, 18 regions have been established globally, some of which operate directly under UNEP. These programs facilitate information exchange, awareness-raising, and the harmonization of national measures tailored to regional environmental challenges, including the control of land-based and marine sources of microplastic pollution. While regional conventions and programs can effectively target specific regional issues, they also lead to significant disparities in regulation across different regions.

3.2.1. Regional Conventions

1. Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

The OSPAR Convention, signed in 1992, seeks to protect marine ecosystems by preventing the discharge of pollutants from land-based and offshore sources, as well as pollution from ocean dumping. Its scope covers the North-East Atlantic, the North Sea, and adjacent Arctic waters. The Convention enforces strict regulations on the discharge of certain substances into the sea. For instance, substances listed in Annex I require special permits, which must be issued by the appropriate authority in accordance with Annex II. Permit applicants must demonstrate that they have conducted thorough assessments of waste minimization and prevention strategies, alternative disposal methods, proper waste identification, potential impacts, and detection techniques.

The Convention has strict provisions on the discharge of specific substances into the sea. For example, discharges into the sea of substances listed in Annex I require special permits to be granted by the competent authority in accordance with the provisions of Annex II. In applying for a permit, applicants need to demonstrate that they have carried out appropriate assessments of waste minimization and prevention approaches, alternative waste disposal methods, appropriate waste identification, selections of locations, possible impacts, and detection techniques. The Convention does not contain explicit provisions on microplastics. Its scope of "waste or other matter" takes an exclusionary approach, i.e., it excludes human remains, near-shore constructions, near-shore pipelines, untreated fish, and fish offal discarded from fishing vessels [26]. Microplastics are not excluded and should therefore fall within the scope of the dumping ban under the Convention.

Through the analysis of Annex I and Annex II above, it can be concluded that although microplastics are not explicitly stated in Annex I, it can be speculated that they are closely related to the annex to the Convention and require compliance with the minimum environmental hazard measures that must be taken to obtain the license, otherwise microplastics are not allowed to be discharged into the ocean.

2. Convention on the Protection of the Marine Environment of the Baltic Sea Area

The Convention on the Protection of the Marine Environment of the Baltic Sea Area, signed on 22 March 1974 by seven European countries including Denmark and Finland, is a significant transnational agreement aimed at promoting the protection and sustainable development of the Baltic Sea ecosystem. The Convention outlines the responsibilities and obligations of the participating states and sets forth a series of targeted protective measures and restrictions.

To prevent marine pollution from land-based sources, the Convention establishes objectives and measures, including the treatment of municipal sewage, improvement of production processes, and reduction of industrial waste discharged into the sea. For the prevention of ship-sourced pollution, the Helsinki Convention fully adopts the provisions and standards of MARPOL 73/78. Regarding ocean dumping, the Convention imposes a comprehensive ban on the dumping of any debris in the Baltic Sea region, except for dredging waste. Although microplastics are not explicitly mentioned in the Convention, its stringent controls on marine dumping contribute to mitigating microplastic pollution in the Baltic Sea.

Both regional conventions play a limited role in preventing and controlling marine microplastic pollution due to their narrow scope and the fact that enforcement largely depends on the commitment of the contracting parties.

3.2.2. Regional Seas Programme

The Regional Seas Programme, initiated by UNEP in 1974, is a global initiative aimed at addressing widespread marine environmental issues through regional action plans supported by legal instruments and technical assistance. The program's primary objective is the sustainable management and use of the world's oceans and coastal areas, providing a comprehensive framework for action by all Member States.

1. Mediterranean Action Plan (MAP)

The MAP, established in 1975 under the support of UNEP, led to the adoption of the Barcelona Convention in 1976, which entered into force in 1978. MAP addresses various aspects of environmental protection, including pollution control and biodiversity conservation. The Barcelona Convention serves as a key legal foundation for MAP, making it legally binding.

In 2013, MAP adopted its first legally binding regional framework specifically targeting marine litter management, and by 2021, this framework was expanded to cover plastic and microplastic pollution in the Mediterranean. MAP is known for its adaptive approach to marine environmental protection, allowing it to respond effectively to emerging issues. It was among the first legal frameworks to address marine microplastics explicitly. By establishing a model of "Convention + Additional Protocol", creating biodiversity conservation areas, and enforcing the responsibilities of regional parties, MAP has contributed significantly to reducing microplastic discharge and mitigating marine microplastic pollution.

2. Northwest Pacific Action Plan (NOWPAP)

The Northwest Pacific Action Plan (NOWPAP) is a crucial component of UNEP's Regional Seas Programme, aiming to enhance the protection, management, and sustainable development of the marine and coastal environment in the Northwest Pacific Ocean. The first NOWPAP meeting was held from 28 to 31 October 1991 in Vladivostok.

NOWPAP has three subsidiary objectives: to control, halt, and prevent the further degradation of marine and coastal environmental resources; to restore degraded environments with restoration potential; and to achieve long-term sustainable development of these resources for the benefit of present and future generations. In terms of pollution control, NOWPAP focuses on reducing pollutant discharge from land-based sources through a network of four Regional Activity Centers coordinated by the Regional Coordinating Unit

(RCU). These centers are involved in developing environmental assessment tools, monitoring the biological effects of pollutants, and advancing technologies such as remote sensing. These efforts enable more effective monitoring and assessment of marine microplastic pollution, thereby enhancing the region's response to this issue. Additionally, NOWPAP emphasizes monitoring and assessing biodiversity, harmful algal blooms, eutrophic zones, and land-based sources of litter (including microplastics) in marine and coastal areas. The program also continues to develop tools for detecting seagrass distribution and establishing regional remote sensing capabilities. These initiatives support the implementation of strategies to combat marine microplastic pollution and restore the marine environment.

The Mediterranean Action Plan and the Northwest Pacific Action Plan are both significant regional marine programs with flexible mechanisms and a strong focus on advanced technical tools. However, their impact is limited to specific regions, and they function primarily as soft law instruments, limiting the capacity to comprehensively address marine microplastic pollution. Nonetheless, several other regional seas programs have also undertaken regional actions to control microplastic pollution. For example, the Baltic States have implemented regional initiatives such as sharing best practices, improving stormwater management to reduce litter entering the ocean, and considering the need for legislation addressing microplastics [27]. Beyond regional conventions and seas programs, economic forums such as the Group of Seven (G7), the Group of Twenty (G20), APEC, ASEAN [28], and OECD have also focused significant attention on the issue of marine litter, including microplastics.

4. Discussion

Based on the analysis of the existing international soft and hard laws on the prevention and control of marine microplastic pollution, the problems of the existing international legal regime on marine microplastics were analyzed and summarized from the perspective of international legislation and the compliance mechanism.

4.1. Deficiencies in International Legislation

4.1.1. Fragmentation of International Rules on Marine Microplastic Pollution

The fragmentation of international rules is a significant deficiency at the legislative level in addressing marine microplastic pollution. This global environmental problem, with its far-reaching and complex impacts, demands a comprehensive and coordinated set of international legal regulations. However, the current international framework for preventing and controlling marine microplastic pollution is notably fragmented [22]. Regulations are dispersed across various conventions and non-binding documents related to marine pollution control, making it challenging for countries to identify a clear and unified legal basis for addressing marine microplastic litter. This fragmentation weakens the international community's effectiveness in managing this issue [29]. Marine microplastic pollution necessitates the harmonization of multiple parallel branches of international law, such as the law of the sea, international watercourse law, biodiversity law, chemical substances law, waste management law, and wastewater law. It also requires coordination across different levels of regulation, including multilateral, regional, and domestic laws [30].

The sources of marine microplastic pollution are diverse, including land-based and sea-based origins, and involve the entire lifecycle from production to consumption and recycling. These varied sources require targeted regulatory measures, and different multilateral organizations are attempting to address the issue, often resulting in overlapping or conflicting regulations. However, the existing international rules frequently focus on isolated aspects of the problem, leading to undesirable outcomes. The differences in focus and provisions across various treaties, and the potential contradictions between them, complicate the task of selecting the appropriate legal framework when microplastic pollution happens for countries.

4.1.2. Lack of Operability of International Rules on Marine Microplastic Pollution

The effectiveness of international legislation in preventing and controlling marine microplastic pollution must be evaluated not only in terms of its intended outcomes but also through the lens of its concrete implementation—specifically, the operability of international law.

Firstly, international soft law is poorly operationalized as it only provides framework and principle-based guidelines that are not mandatory or binding. Generally speaking, international soft law highlights the consensus reached by countries and embodies their common will but lacks specific provisions on rights and obligations. The realization of the objectives set forth in international soft law relies heavily on the voluntary commitment of countries, which often leads to inadequate enforcement. The three international soft law instruments referenced earlier suffer from limited binding force, hindering their effective implementation.

Secondly, existing international hard laws do not specifically address marine microplastic pollution; they tend to categorize it broadly as a form of marine debris or plastic waste. To address this issue pragmatically, it is essential to explore established legal frameworks for the prevention and control of plastic pollution. Marine microplastics exhibit distinct characteristics compared to traditional marine debris and plastics, complicating the applicability of current international legal norms. This discrepancy may result in significant gaps in the enforcement of measures aimed at mitigating marine microplastic pollution.

4.1.3. Absence of a Specialized International Convention on Marine Microplastic Pollution

In 2014, the UNEA adopted Resolution 1/6 on "Marine Plastic Debris and Microplastics". At the conference in 2017, UNEA established an Expert Group on Marine Debris and Microplastics to conduct research and write reports. The first resolution adopted at the 2019 conference focused on marine litter and microplastics [12], with 49 countries committing to "prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities including marine debris and nutrient pollution" by 2025. The agenda for the UNEA 2022 meeting again included microplastics, and there was a proposal to develop an international convention specifically addressing marine microplastic pollution. Despite this, no significant progress has been made towards establishing such a treaty, and the current UNEA resolutions on marine microplastics remain non-binding.

The existing legal framework is inadequate to meet the regulatory needs for marine microplastics [29], primarily due to the absence of an international convention specifically focused on this issue [30]. This gap has resulted in a lack of uniformity in the global response to marine microplastic pollution. Existing provisions are scattered across different conventions, and most of these only provide vague guidelines without specific implementation standards. This lack of coherence and precision has led to inconsistent standards and enforcement across different countries, creating disparities and contradictions in the management of marine microplastic pollution [31]. Marine microplastic pollution is a global problem that requires a coordinated response from all countries. However, in the absence of a specialized international convention, countries primarily rely on domestic laws to combat the issue, making it difficult to establish an effective global governance system. This situation is highly detrimental to the prevention and control of marine microplastic pollution and significantly undermines the overall effectiveness of global governance efforts.

4.2. Deficiencies in Compliance Mechanisms

4.2.1. Lack of Penalty Mechanisms for Non-Compliance

International law generally requires that states bear responsibility when they fail to fulfill their treaty obligations. However, a significant deficiency in most international legal frameworks addressing marine microplastic pollution is the absence of effective penalty mechanisms for non-compliance. This absence allows some states to evade their responsibilities, undermining the effectiveness of international regulations. For instance, Annex V of MARPOL 73/78 lacks formal implementation and compliance procedures, relying

instead on the "Annex V Implementation Guidelines", which merely provide non-binding recommendations. This lack of enforceability diminishes the impact of the Convention, creating an environment where compliance is weakly enforced. Additionally, the ambiguous language used in various conventions, such as "all possible steps" and "all appropriate measures", leads to differing interpretations among countries and dispute resolution bodies. This ambiguity further complicates the establishment of a uniform penalty mechanism for non-compliance, making it easier for states to neglect their obligations, particularly when the cost of compliance is high.

In some conventions, liability provisions are presented as optional appendices, giving countries the authority to accept or reject the obligations related to non-compliance. When faced with the substantial costs associated with coping with marine microplastic pollution, countries may opt to reject these provisions in favor of their national interests. This selective acceptance can lead to a ripple effect, where other states follow suit, ultimately undermining the overall compliance environment. This situation not only weakens the deterrent effect of international conventions but also exacerbates the problem of marine microplastic pollution by encouraging non-compliant behaviors.

4.2.2. Lack of Execution Agencies

The challenges in controlling marine microplastic pollution are not solely due to gaps in international law but also stem from the insufficient implementation of existing global and regional regulations [10,32]. A critical deficiency is the lack of a specialized agency dedicated to coordinating and harmonizing efforts to prevent and control marine microplastic pollution on a global scale. The effective management of this issue requires consensus and coordinated action among countries, yet significant differences persist in how states approach the problem [10]. In the absence of a specialized implementing agency, compliance with international conventions often depends on the willingness of individual countries. Without a clear and authoritative executive body, states may lack the motivation to fulfill their commitments under international agreements, leading to lax enforcement and a tendency to shirk responsibilities. This situation exacerbates the already serious issue of marine microplastic pollution.

Although some conventions have established executive bodies, their effectiveness has been limited. For example, while MARPOL 73/78 assigns the responsibility for addressing violations to the competent authority of the ship's flag state, enforcement relies heavily on the actions of the contracting parties themselves. This self-regulatory compliance mechanism lacks the necessary coercion and binding force, resulting in some countries choosing to ignore their obligations when confronted with the high costs of preventing and controlling marine microplastic pollution.

4.3. Countermeasures to Improve International Law on Marine Microplastic Pollution Prevention and Control

Building on the analysis of the deficiencies in existing international law regarding marine microplastic pollution, this section proposes specific measures for improvement. These measures aim to strengthen the legal framework and ensure more effective prevention and control of marine microplastic pollution. Additionally, this section draws lessons for improving China's approach to managing marine microplastic pollution. The UNEA has taken steps to address these issues, notably through the adoption of Resolution UNEA-1 on Marine Plastic Debris and Microplastics. This resolution supports the development of international agreements and regional programs, providing a foundation for the establishment of robust international rules on marine microplastic pollution at both global and regional levels.

4.3.1. Enhancing International Law on Marine Microplastic Pollution Prevention and Control

1. Revision of Existing International Law on the Prevention and Control of Marine Microplastic Pollution

To effectively prevent and control marine microplastic pollution, it is essential to develop more operational legal frameworks that address existing loopholes. This can be achieved through amendments that align with the intended purpose of the legislation.

To address the insufficient binding force of international soft law, a legislative consensus among countries should be established at the international level. This can be initiated through advocacy to create a supportive legal environment for international legislation. Once conducive conditions are met, the formulation of binding jus cogens should be considered through inter-country consultations and the convening of an international conference to facilitate the "hardening of soft law".

In view of the problems that exist in the international law, it should be revised through the following approach: Firstly, marine microplastics as a kind of pollutant should be clearly defined in the relevant treaties. A clear definition of marine microplastic pollution is the basis for accurate judgment of marine microplastic pollution and improvement of specific rules. Secondly, the rules for the management and control of marine microplastic pollution should be formulated in the light of all aspects of the pollution, including the sources and pathways of pollution. Effective prevention and control require a thorough understanding of the pollution chain, necessitating differentiated legal measures at each stage of microplastic development to maximize anti-pollution efforts. This holistic governance approach must encompass the production, consumption, and disposal of microplastics, involving a diverse range of stakeholders.

While international law includes numerous provisions addressing marine plastics, the regulatory framework for primary microplastics remains inadequate, despite the increasing prevalence of primary microplastic pollution due to refined production processes. Therefore, enhanced regulation of primary microplastics should be prioritized in treaty revisions as the technology evolves.

Strengthening scientific research on plastic particles is vital for underpinning legislation aimed at controlling marine microplastic pollution. Establishing internationally unified technical standards for the monitoring, analysis, and assessment of microplastic pollution will enhance data accuracy and comparability. The scientific standards developed should be promptly integrated into legislative frameworks. Consequently, a comprehensive international standard and monitoring system should be established, potentially as an annex to existing international treaties or through the improvement of current categorization and monitoring standards.

2. Promoting the Adoption of an International Convention on Marine Microplastic Pollution

Marine microplastic pollution has emerged as a significant global environmental challenge that demands urgent and coordinated action. While the existing international regulations and some domestic laws address microplastic pollution to varying degrees, they lack comprehensive strategies specifically targeting marine microplastics. Scholars have debated the best approach to regulation, with some advocating for strong, binding obligations on states [33], while others emphasize the role of soft law and framework conventions [34]. There is also a perspective that suggests combining both hard and soft law approaches [35]. Regardless of the approach, the development of an international convention dedicated to the prevention and control of marine microplastic pollution is crucial. Such a convention would provide clear guidelines and regulatory frameworks necessary to effectively tackle this global issue.

The core content of an international convention on marine microplastic pollution should underscore the seriousness and urgency of the problem while advocating for close international cooperation to address this environmental crisis. The convention should establish specific rights and obligations for states to combat marine microplastic pollution, incorporating measures that include penalties for non-compliance as well as incentives for adherence. Additionally, the convention should address pollution sources by implementing specific regulatory measures for both primary and secondary microplastic pollution. While current international law contains more regulations related to plastic pollution, which

contributes to secondary microplastic pollution, there is a notable lack of rules specifically addressing primary microplastic pollution. Therefore, the new convention should bridge this gap by focusing on the regulation of all major stages of the marine microplastic life cycle: production, consumption, waste management, and pollution [22]. Moreover, the convention should pay special attention to pollution source management, as this plays a crucial role in the prevention and control of marine plastic pollution. It should cover a broad range of pollution sources that contribute to marine microplastic pollution and establish clear, unified standards for the convention's application to ensure effective implementation and compliance by participating countries. The new convention must also address the relationship with existing international rules, aiming to complement and strengthen the current legal and policy framework without undermining the established governance structures.

3. Promoting the Conclusion of Regional Treaties

A multi-level regulatory approach is essential for effectively addressing the challenge of marine microplastic pollution. While multilateral international treaties are critical, the promotion and conclusion of regional treaties are equally important in tackling this issue [30]. Addressing marine microplastic pollution requires robust cooperation among countries, and regional treaties offer an effective mechanism for uniting nations within a specific region to collaboratively develop and implement preventive and control measures. Recognizing the significance of regional programs, the UNEP is actively involved in assisting the development of marine litter action plans in regions such as Southeast Asia, South Asia, the South Pacific, and the Northeast Pacific. UNEP also supports the establishment of the greater Caribbean, Mediterranean and the North-West Pacific regions as regional nodes of the Global Partnership on Marine Litter [36]. These initiatives, which include a focus on microplastics [29], are crucial for the effective implementation of the existing action plans.

Countries within the same region often face similar challenges in combating marine microplastic pollution. Through collective discussion, countries can develop region-specific agreements tailored to address the unique circumstances and needs of the region. The European Union serves as a leading example of advanced regional legislation on marine microplastics [37]. Within the framework of regional treaties, countries can establish information-sharing platforms, exchange best practices in pollution prevention and control, and collaborate on research and innovation in marine microplastic pollution technologies. The signing of regional treaties facilitates the coordination of policies among countries in the region, helping to avoid conflicts in the implementation of regulations and fostering regional synergies. This coordinated approach is vital for effectively addressing the challenge of marine microplastic pollution. Furthermore, treaties, protocols, and action plans adopted under regional seas programs must be strengthened and harmonized to ensure their efficacy in combating this pervasive issue. The mandates of existing international institutions need to be expanded to coordinate efforts to achieve common goals, and these regional institutions should also expand their coordinating role to promote the harmonization of standards and commitments.

4.3.2. Enhancing the Compliance Mechanism for International Law on Marine Microplastic Pollution Prevention and Control

1. Strengthening Disciplinary Mechanisms and Measures for Non-Compliance

The lack of effective disciplinary mechanisms and measures in most existing international laws and regulations on marine microplastic pollution significantly undermines their effectiveness. Establishing robust disciplinary mechanisms is essential not only as a deterrent but also to reduce the likelihood of non-compliance by states [38].

To improve these mechanisms, it is crucial to implement appropriate disciplinary measures that correspond to the severity of the breach. For less serious violations, measures such as warnings or reminders could be employed. These mild sanctions are designed to alert the non-compliant state to its misconduct without imposing an excessive burden, thereby encouraging corrective action. For more serious breaches, stronger measures such

as fines, suspension, or revocation of membership in relevant international organizations could be considered. These sanctions would increase the financial and reputational costs of non-compliance, motivating the offending state to adhere to the relevant agreements. In cases of particularly egregious violations, even more stringent measures such as long-term bans from participating in international cooperation, public condemnation, or specific forms of international sanctions could be applied. These severe disciplinary actions are intended to compel states to fulfill their obligations under international law.

2. Establishing Specialized Implementing Agencies

The prevention and control of marine microplastic pollution is a complex, transboundary issue that requires internationally coordinated efforts. Without a specialized implementing agency, it is challenging to effectively address it globally and regionally. A specialized agency would play a pivotal role in coordinating and standardizing global efforts to combat marine microplastic pollution, ensuring that international goals and standards—including various sustainable development objectives—are met. Additionally, such an agency would encourage other international entities to contribute to these efforts [22].

The establishment of a specialized implementing agency would necessitate a clear definition of its core functions and responsibilities. This could involve either strengthening the existing institutions or creating a new global body to serve as the secretariat, supported by a scientific committee dedicated to reporting, monitoring, and coordinating the activities related to marine microplastic pollution. The primary responsibility of this agency would be to coordinate actions among states, setting uniform standards for implementation and preventing significant conflicts between state parties regarding marine microplastic pollution prevention and control measures. The agency would also be responsible for monitoring compliance. A stable monitoring system should be established to periodically assess the implementation of control measures by states and the overall effectiveness of these measures. Through a transparent evaluation and feedback mechanism, the agency would oversee the adherence of parties to the agreement and take appropriate disciplinary actions upon non-compliance. The operational costs of this agency would be covered by the state parties and relevant regional administrations.

5. Conclusions

This study revealed that the current international regulatory framework for marine microplastic pollution is insufficient to address the threats posed to marine ecosystems and the sustainable development of the global community. The review on relevant global and regional treaties and agreements highlighted their limited applicability to marine microplastic pollution. Additionally, this paper discussed the role of soft law in the governance of marine microplastic pollution at both global and regional levels [30]. The findings underscore significant deficiencies in the international regulation of marine microplastics, including the fragmentation of international rules [22], the absence of a dedicated international treaty, and the lack of effective disciplinary mechanisms and specialized enforcement agencies. There is an urgent need to enhance the international regulation of marine microplastic pollution by improving both the substantive and procedural aspects of international law [38,39]. Specifically, this involves the formulation of a specialized international treaty on marine microplastic pollution [13], amendments to existing treaties within the international legal framework to promote coherence and harmonization, and the establishment of effective disciplinary mechanisms and specialized institutions to ensure compliance with international law [29]. These steps are crucial for fostering a more robust and effective global response to the growing challenge of marine microplastic pollution.

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