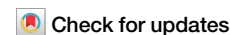


<https://doi.org/10.1038/s44454-025-00026-w>

Marine plastic pollution governance: the role and challenges of international law

Yuanhong Shi¹ ✉ & Yanxu Zhang²

Marine plastic debris poses a serious threat to the global marine ecosystem and has become a pressing international concern. Given the connectivity and mobility of the oceans, the fragmented international governance further underscores the urgent need for a holistic approach. To address this fragmentation, we review the evolution of international legal frameworks for marine plastic pollution, identify prevailing challenges, and propose concrete pathways for establishing a life-cycle-based international legal regime.

Plastics have been integral to modern life since the 1950s, but their proliferation has resulted in severe marine pollution, jeopardizing the health of ocean ecosystems¹. According to related research, roughly 80% of marine plastic debris are land-based, a consequence of inadequate waste management and recycling systems incapable of keeping pace with the rapid growth of plastic production and consumption². Although the international community has worked on curbing marine plastic pollution, the problem continues to escalate; however, national and regional policy responses remain largely fragmented and insufficient. Against this backdrop, this paper examines marine plastic pollution governance from the background, focusing particularly on the validity of international law. It highlights the principal challenges confronting current governance frameworks and advances a life-cycle-based approach as a pathway for strengthening international legal responses.

Background

Marine plastic pollution is inherently transboundary, which not only heightens the complexity of governance but also poses new challenges to the international legal framework, including the United Nations Convention on the Law of the Sea (UNCLOS)³. Studies show growing attention to this issue, yet current global governance mechanisms remain fragmented⁴. Accordingly, scholars advocate a life-cycle approach by expanding the Extended Producer Responsibility (EPR) to overcome the limitations of traditional plastic pollution management^{5–7}.

From the perspective of marine plastic pollution governance, plastic debris poses severe ecological threats to marine organisms through multiple pathways^{8,9}. However, the international community still lacks a comprehensive risk assessment system¹⁰. Research has revealed systemic flaws in plastic pollution governance mechanisms across the entire life cycle^{11,12}. It has also been argued that regional cooperation platforms, such as the Pacific Alliance, should adopt a circular economy and life-cycle approach, coordinating national and regional policies to deliver regional solutions¹³. From the perspective of international law, emerging global governance initiatives

should align with international environmental law and operate within a complementary and mutually supportive legal framework¹⁴. Nevertheless, significant limitations persist in existing international legal and policy frameworks concerning the regulation of plastic life cycles and cooperation in governance¹⁵. Numerous studies note that traditional marine law instruments such as UNCLOS and the International Convention for the Prevention of Pollution from Ships (MARPOL) are increasingly inadequate for addressing the diverse and expanding sources of plastic pollution, and the enforcement of their relevant rules remains limited^{16–18}. Furthermore, there are still debates over the effectiveness of international legislation aimed at addressing marine pollution¹⁹. For these reasons, scholars broadly advocate for a legally binding global plastics treaty, which would help address many challenges in governing marine plastic pollution^{20–23}.

Overall, existing studies on marine plastic pollution adopt diverse perspectives, but research focusing exclusively on its governance from an international law standpoint remains limited. It is important to examine the role of international law, its challenges, and potential strategies in establishing an effective governance system for marine plastic pollution.

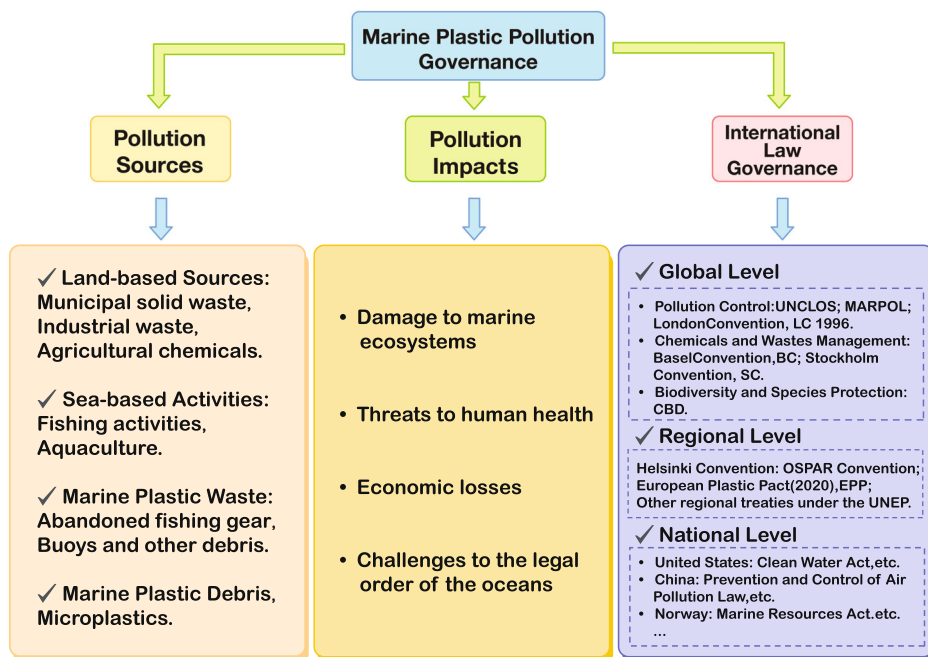
The international law process of governing marine plastic pollution

International legal regulation of marine plastic pollution governance covers the entire life cycle of plastic, rather than a few isolated norms. In this progress, international law has gradually formed a systematic framework through both “hard law” and “soft law” instruments at global, regional, and national levels (see Fig. 1).

According to Fig. 1, the international legal framework centers on key conventions. At the global level, the key conventions and agreements including the UNCLOS, the MARPOL Convention, and the London Convention (LC) focus on pollution control. The UNCLOS provides the fundamental legal framework for the protection of marine environment. In particular, Articles 192–194 establish that, while States enjoy sovereign rights to exploit marine resources, they also bear a general obligation to protect

¹International Law School, China University of Political Science and Law, Beijing, China. ²Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, USA. ✉e-mail: cu214018@cupl.edu.cn

Fig. 1 | Sources, impacts, and international law governance of marine plastic pollution.



marine environment and must take all necessary measures to prevent, reduce, and control pollution from any source. The MARPOL Convention is a major international agreement addressing pollution caused by ships. Notably, its Annex V offers the core regime for regulating ship-based plastic pollution through its strict ban on discharging plastic waste at sea. The 1972 LC, the first global treaty regulating ocean dumping, bans the disposal of hazardous waste at sea. Its 1996 Protocol tightens these controls and adopts a more precautionary “reverse list” approach to managing the disposal of waste containing plastic materials. Then, the Basel Convention (BC, 1989) and the Stockholm Convention (SC, 2001) concentrate on the management of chemicals and waste. The BC aims to regulate the export of hazardous waste from developed to developing countries. The SC seeks to indirectly regulate harmful additives in plastics and their long-term marine impacts by restricting and eliminating persistent organic pollutants (POPs). In addition, the Convention on Biological Diversity (CBD) agreement, etc. seek to protect biodiversity and species.

At the regional level, legal instruments of the Helsinki Convention, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention), the European Plastic Pact (EPP), as well as various regional treaties under the United Nations Environment Programme (UNEP)’s Regional Seas Program, provide a legal basis for controlling marine plastic pollution. At the national level, a lot of countries have enacted laws such as the United States’ Clean Water Act and Microbead-Free Waters Act, China’s Laws on solid wastes and air pollution, and Norway’s Marine Resources Act, among others.

Nevertheless, above international legal frameworks are confronted with certain limitations against the complex marine environment, dynamic international relations, and unique challenges posed by plastic pollution management²⁴. For this reason, the United Nations has increasingly focused on how to deal well with the issue of international legal regulation in marine plastic pollution governance. Between 2022 and 2025, negotiations on a Global Plastics Treaty were launched to boost international collaborative actions. Although the talks have been slow and characterized by considerable divergence, they nonetheless represent a significant step forward. The draft treaty envisions a more holistic approach to dealing with marine plastic pollution by encompassing the entire life cycle of plastics, introducing stricter enforcement and supervision systems, and emphasizing global cooperation. Once finalized, it may vitally help combat marine plastic pollution²⁵. Scholars have argued that, given the presence of increasingly

more scientific studies validating the plastic pollution severity, the absence of a robust plastics treaty would inevitably exacerbate the problem²⁶. Nevertheless, the most recent round of global negotiations, held under the auspices of the UN in Geneva on August 15, 2025, did not achieve a legally binding international agreement. This outcome highlights the arduousness of the endeavor to achieve effective global governance of plastic pollution.

The role of international law in the marine plastic pollution governance

International law serves as a fundamental instrument for structuring international relations in global ocean governance. It is widely recognized as both pragmatic and rational, embodying the pursuit of fairness and justice in international affairs²⁷. States function simultaneously as creators, enforcers, and adherents of international law, enjoying equal sovereignty while remaining beyond each other’s jurisdiction²⁸. In governing marine plastic pollution, global ocean management holds an overarching objective of safeguarding the ocean environment and the common interests of humanity. Protecting the marine governance rights of sovereign states forms the foundation for their engagement in global governance. Within this framework, international law provides mechanisms to allocate rights and obligations among states, delineates the scope of these rights and responsibilities, stabilizes the legal environment, and establishes a robust foundation for global plastic pollution governance and marine environmental protection.

International conventions and agreements serve as the foundation and guarantee for marine plastic pollution governance. As legally binding instruments, they constitute both a fundamental source and a principal expression of international law, while also providing the basis and support for global governance. During the management process, the interconnected and fluid nature of the oceans increases the difficulty of management, making it essentially a global issue requiring collective efforts and responses from the international community. Under the current international legal framework, there is already a relatively rich body of international conventions and regional agreements making specific provisions to address marine plastic pollution governance. These conventions and agreements provide fundamental guidance for the normal conduct of marine activities by states and regions, and their dispute resolution mechanisms in ocean governance help mitigate conflicts between states, thereby offering legal assurance for effective cooperation and marine environmental management.

International soft law well drives the global governance of marine plastic pollution. International soft law primarily takes the form of initiatives, declarations, and action plans. It is often reflected in post-conference documents issued by international organizations or major international conferences²⁹. Despite being not legally binding, these soft law instruments still have nonetheless significant on governing marine plastic pollution. For example, soft law instruments and international initiatives of the Honolulu Strategy, the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, and relevant United Nations General Assembly resolutions, provide guiding frameworks for pollution prevention actions. These documents, with no legal binding, can still exert practical influence. At the national level, they serve as incentives and may reflect potential directions for the future development of international law³⁰. In conclusion, soft law instruments have made significant contributions to marine plastic pollution governance, while also generating political commitments that stimulate progress in global plastic pollution governance. States should make active and effective use of international soft law as a tool to address the marine plastic pollution issues.

International legal challenges in the marine plastic pollution governance

The international legal and policy framework is not perfect. It has not sufficiently regulated the transboundary movement of plastics in a unified manner in the context of their global life cycle. The deteriorated marine plastic pollution highlights widespread shortcomings in managing the land-to-sea transfer of materials, challenging the effectiveness of existing international mechanisms for governing marine plastic pollution. The transboundary nature of marine plastic pollution shall be well concerned globally. However, global action has fallen short of expectations. As early as 2006, the UNEP reported that marine litter was becoming increasingly severe, with insufficient legislation identified as a primary cause³¹. Furthermore, plastic products typically cross multiple countries throughout their design, production, consumption, and disposal stages; yet, currently no legally binding international agreement is capable of comprehensively addressing the potential impact on environment and human during the plastic life cycle.

The governance mechanisms for marine plastic pollution are fragmented. The current marine plastic pollution governance suffers from a lack of dedicated plastic treaties, resulting in fragmented governance mechanisms. First, although numerous international rules govern marine plastic pollution at varying levels, they lack coordination and systematic integration. The standards they set are inconsistent, making it challenging to generate a synergistic effect in governance. Second, the fragmented framework of international law restricts plastic pollution from being well addressed, as it overlaps with various legal domains such as maritime law, waste management and environmental protection, resulting in a lack of uniformity and coherence in governance efforts³². Third, while international conventions of UNCLOS and the 1974 Paris Convention, etc. provide some guiding principles for the land-based marine pollution governance, they are usually short of binding obligations or all-sided enforcement systems³³.

The treaty enforcement mechanisms are inadequate. Within the existing international legal framework, the execution and enforcement of treaties face numerous challenges, significantly impeding marine plastic pollution governance. On the one hand, the fragmentation of treaties has resulted in inconsistent implementation standards, and uniform standards for treaty implementation are therefore lacking. For example, MARPOL regulates waste discharge from ships, including oil pollution, whereas the Basel Convention focuses on hazardous materials' transboundary movement. These differing regulatory targets lead to divergent implementation standards, thereby influencing the overall efficacy of treaty enforcement. On the other hand, dedicated treaty implementation bodies are also absent. A systematic review of the international legal framework reveals that many international treaties and agreements lack specific enforcement institutions. The Helsinki Convention has only made some progress at the regional level, providing for the establishment of a dedicated convention committee to supervise and ensure the process the convention being implemented and

enforced. Most treaties neither establish dedicated enforcement bodies to coordinate implementation nor specify mechanisms for dispute resolution. Consequently, in the event of disputes, states lack a reliable forum for seeking adjudication or redress.

The oversight mechanisms of marine plastic pollution are weak. Existing conventions addressing marine plastic pollution lack specificity in regulating plastics, e.g., they do not cover the entire plastics life cycle, nor do they implement comprehensive circular economy measures. Scholars have argued that preventing marine plastic pollution lies in the effective oversight mechanisms³⁴. In addition, international governance for marine plastic pollution is fragmented, which exacerbates challenges to addressing multilateral investment policies. Jurisdiction overlapping alongside regulatory gaps present resulting from diverse international agreements and organization being weakly coordinated. Ultimately, whether marine plastic pollution is effectively prevented and controlled depends on whether states can establish functional regulatory governance mechanisms to reduce unnecessary plastic use, minimize waste generation, and increase reuse and recycling through proactive governance measures. Under international law, all states are required to take action to address these problems by establishing effective mechanisms for managing plastic waste.

Pathways for international legal governance of marine plastic pollution based on the entire life cycle

(1) Enhancing the effectiveness of international legal governance of marine plastic pollution. To effectively manage plastic waste, robust regulations that cover the entire plastic life cycle shall be well formulated. As previously noted, the fragmented nature of international law on marine plastic pollution and the absence of a multi-level policy frameworks involving international, regional, and national stakeholders undermine effective of timely responses. Within the international law framework, a comprehensive and effective legal framework shall be developed to address this issue. Several measures should be adopted. The International Maritime Organization (IMO) should be designated as the primary international body responsible for proposing regulations or standards to address this issue. The IMO should also strengthen cooperation and communication with other international organizations, such as UNEP, to develop detailed implementation rules and guidelines that ensure compliance with relevant international regulations and standards. Besides, information exchange and monitoring mechanisms should be established to track the marine pollution status alongside its influence on the marine environment. Such mechanisms would facilitate constructive discussions among all parties, the sharing of up-to-date information, and the identification of potential solutions.

(2) Strengthening life-cycle-based cooperation in marine plastic pollution governance. Marine plastic pollution is a representative consequence of land-based issues; therefore, protecting human and ecosystem health is equally crucial alongside marine environmental protection. Adopting a life-cycle approach to governance prevents plastic waste from being generated, meanwhile mitigating the harmful impacts of plastic products⁷. Furthermore, applying a complete life-cycle approach is particularly significant because plastic pollution is transboundary in nature and has substantial impacts on ecosystems. This paper argues that further strengthening life-cycle-based governance of marine plastic pollution should involve several measures. At the international level, there is an urgent need to reach legally binding agreements targeting marine plastic pollution and to call on all states and relevant international organizations of the IMO, UNEP, and the Food and Agriculture Organization, to establish cooperative frameworks. At the national level, laws and policies alone are insufficient for fully addressing plastic waste pollution. It is also necessary to enhance inter-agency cooperation within governments, foster collaboration and communication between government bodies and enterprises, and encourage companies to seek alternative materials with lower environmental impacts.

(3) Focusing on regional-level governance of marine plastic pollution. Beyond global cooperation, regional governance of marine plastic pollution remains crucial. Regional frameworks often include concrete measures such as monitoring, pollution control, and action plans, supported by technical standards and data sharing. For example, the EU's Marine Strategy Framework Directive sets marine litter reduction as a core goal, requiring unified monitoring and programs for coastal cleanup and fishing-gear recovery. The Pacific Marine Litter Action Plan under Secretariat of the Pacific Regional Environment Programme similarly promotes data sharing, port-reception facilities, and capacity building for small island states. Such regional practices provide replicable experiences and support the future Global Plastics Treaty, enhancing cooperation and building a resilient, multi-level governance system.

(4) Improving the enforcement and oversight mechanisms for marine plastic pollution governance. In terms of treaty implementation, international treaties and agreements on marine plastic pollution depend on States Parties' compliance and domestic enforcement. As international law carries inherent legal force and binding effect, it must be taken seriously and strictly observed. Strengthening compliance obligations is essential for enhancing the enforceability of marine pollution rules and for promoting joint implementation mechanisms among countries and regions under relevant conventions. In terms of regulation, it is necessary to establish and refine oversight systems capable of effectively controlling marine plastic pollution. This can be achieved by reinforcing coordinated supervision among international organizations, regional seas conventions, and coastal States, thereby fostering a dynamic and sustainable model of regulatory governance. Overall, only through the combined strengthening of treaty implementation and regulatory mechanisms can enable international governance of marine plastic pollution to achieve its full effectiveness.

Marine plastic pollution, as a big global environmental concern, potentially threatens marine ecosystem and even human health. Global ocean governance has driven a shift in legal mechanisms from fragmented and dispersed arrangements toward more integrated and holistic approaches. This governance is an ongoing process that cannot be achieved overnight. Against the backdrop of the Global Plastics Treaty still under negotiation, the existing international legal framework remains insufficient for comprehensively addressing pollution throughout the full life cycle of plastics. We should effectively leverage international law in governing marine plastic pollution, consolidating and strengthening the authority of international legal mechanisms. In addition, effective international legal regulation depends on coordinated action, with countries actively participating and enhancing the global legal system targeting marine plastic pollution through sustained cooperation.

Data availability

No datasets were generated or analyzed during the current study.

Received: 8 October 2025; Accepted: 30 December 2025;

Published online: 02 February 2026

References

- United Nations Environment Assembly of the United Nations Environment Programme (UNEP). Combating marine plastic litter and microplastics: an assessment of the effectiveness of relevant international, regional and subregional governance strategies and approaches (UN, 2018; <https://digitallibrary.un.org/record/3976248?v=pdf>).
- Jambeck, J. R. et al. Plastic waste inputs from land into the ocean. *Science* **347**, 768–771 (2015).
- Carratta, G. & Jaeckel, L. Global plastics governance: opportunities and challenges for its improvement from a life cycle perspective. *Eur. J. Leg. Stud.* **15**, 29–64 (2023).
- Carlini, G. & Kleine, K. Advancing the international regulation of plastic pollution beyond the United Nations Environment Assembly resolution on marine litter and microplastics. *Rev. Eur. Comp. Int. Environ. Law* **27**, 234–244 (2018).
- Zhou, J. & Luo, D. The global governance of marine plastic pollution: rethinking the extended producer responsibility system. *Front. Mar. Sci.* **11**, 1363269 (2024).
- Zhou, X. & Xu, B. The SWOT analysis of China's strategy for addressing marine plastic pollution in the context of global plastic treaty negotiations. *Mar. Pollut. Bull.* **213**, 117653 (2025).
- Raubenheimer, K. & McIlgorm, A. Can the Basel and Stockholm Conventions provide a global framework to reduce the impact of marine plastic litter?. *Mar. Policy* **96**, 285–290 (2018).
- Zhang, Y. et al. Plastic waste discharge to the global ocean constrained by seawater observations. *Nat. Commun.* **14**, 1372 (2023).
- Lebreton, L. C. M. River plastic emissions to the world's oceans. *Nat. Commun.* **8**, 15611 (2017).
- Zhang, Z. et al. Ecological risk assessment of marine plastic pollution. *Nat. Sustain.* **9**, 1143–1153 (2025).
- Wysocki, I. T. & Billon, P. L. Plastic at sea: treaty design for a global solution to marine plastic pollution. *Environ. Sci. Policy* **100**, 94–104 (2019).
- Wu, H.-H. A study on transnational regulatory governance for marine plastic debris: Trends, challenges, and prospect. *Mar. Policy* **136**, 103988 (2022).
- Ortiz, A. A. et al. A regional response to a global problem: single use plastics regulation in the countries of the Pacific Alliance. *Sustainability* **12**, 8093 (2020).
- Barrowclough, D. & Birkbeck, C. D. Transforming the global plastics economy: the role of economic policies in the global governance of plastic pollution. *Soc. Sci.* **11**, 26 (2022).
- Chang, Y.-C. & Saqib, M. International legal systems in tackling the marine plastic pollution: a critical analysis of UNCLOS and MARPOL. *Water* **17**, 1547 (2025).
- Zhang, L. *Legal Guidelines on Marine Pollution and Their New Developments* (Law Press, 2019).
- Widagdo, S. & Anggoro, S. A. Combating ocean debris: marine plastic pollution and waste regulation in Indonesia. *Int. J. Mar. Coast. Law* **37**, 458–492 (2022).
- Ma, M. & Liu, X. The Control of microplastic pollution in semi-closed seas: good-faith cooperation and regional practice. *Sustainability* **15**, 12412 (2023).
- Mukherjee, P. K., Mejia, M. Q. & Xu, J. *Maritime Law in Motion* (Springer International Publishing, 2020).
- Zhou, X. & Xu, B. The SWOT analysis of China's strategy for addressing marine plastic pollution in the context of global plastic treaty negotiations. *Mar. Pollut. Bull.* **213**, 117653 (2025).
- Van der Marel, E. R. & Stofen-O'Brien, A. Accommodating a future plastics treaty: the 'plasticity' of the UN Convention on the law of the sea. *Int. J. Mar. Coast. Law* **39**, 322–344 (2024).
- Carratta, G. & Jaeckel, L. Global plastics governance: opportunities and challenges for its improvement from a life cycle Perspective. *European. J. Leg. Stud.* **15**, 29–64 (2023).
- O'Meara, N. Human rights and the Global Plastics Treaty to protect health, ocean ecosystems and our climate. *Int. J. Mar. Coast. Law* **38**, 480–515 (2023).
- Klerk, B. E., Heinrich, K. & Primicerio, R. Beyond equilibrium thinking: dynamic area-based management tools in a changing ocean. *Front. Mar. Sci.* **11**, 1418435 (2024).
- Sodik, D. M. Marine pollution in Indonesia and the regulatory framework. *Int. J. Mar. Coast. Law* **36**, 114–135 (2021).
- Sonke, J. E., Segur, T. & Bucci, S. Plastic Ponzi scheme. *npj Emerg. Contam.* **1**, 4 (2025).

27. He, Z. A correct understanding of the fundamental characteristics and functions of international law. *Glob. Gov.* **15**, 49–54 (2025).
28. Liao, F. The contribution of Chinese modernization to international law. *Jilin Univ. J. Humanit. Soc. Sci.* **65**, 49–63 (2025).
29. Li, Z. & Kou, Y. Advancement in the international legal regulation on the marine plastic pollution and China's participation. *J. Hainan Univ. (Humanit. Soc. Sci.)* **42**, 33–43 (2024).
30. He, Z. Normative rationality of the universal declaration of human rights as soft law. *Mod. Law Science* **40**, 12–21 (2018).
31. Mendenhall, E. Making the most of what we already have: activating UNCLOS to combat marine plastic pollution. *Mar. Policy* **155**, 105786 (2023).
32. Ferraro, G. & Failler, P. Governing plastic pollution in the oceans: Institutional challenges and areas for action. *Environ. Sci. Policy* **112**, 453–460 (2020).
33. Wang, S. International law-making process of combating plastic pollution: Status Quo, debates and prospects. *Mar. Policy* **147**, 105376 (2023).
34. McIntyre, O. International water law's role in addressing the problem of marine plastic pollution: a vital piece in a complex puzzle!. *Chin. J. Environ. Law* **6**, 218–252 (2023).

Acknowledgements

The authors thank Mark Davis (from Tulane Center for Environmental Law) for the discussion. This work is funded by the China Postdoctoral Science Foundation (No.2024T171046).

Author contributions

Y.S. wrote the main manuscript text, and Y.Z. revised the manuscript and supervised this work. Both authors have read and approved the final manuscript.

Competing interests

Author Y.Z. is Editor-in-Chief of npj Emerging Contaminants. Y.Z. was not involved in the journal's review of, or decisions related to, this manuscript. The authors declare no other competing interests.

Additional information

Correspondence and requests for materials should be addressed to Yuanhong Shi.

Reprints and permissions information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2026