

Pollution of the Marine Environment by Spaceflights

Alla Pozdnakova^{*}

6.1 INTRODUCTION

Like other industrial activities, launches and returns of man-made space objects inevitably take a toll on the Earth's environment. For example, emissions from space launches may result in atmospheric pollution, ozone layer depletion, impact on wildlife and biodiversity, and pollution of land and water by emissions of carbon soot, alumina or water vapour, as well as by jettisoned parts (worked-off lower stages) of the launch vehicle. The impact from launching involves multiple explosive emissions of combustion products and thermal energy, as well as strong acoustic oscillation on the launch pad.¹ At the same time, developments in the space sector suggest that space launches will continue to grow as new commercial satellite launch facilities emerge in coastal areas around the world. Deposition into the sea of materials jettisoned during the launch of space vehicles is an activity expected to rise sharply in frequency in the coming years.²

Although environmental concerns in the space sector were raised decades ago, legal aspects of protection of the Earth's environment from pollution by spaceflights have received relatively little international attention. International treaty-based space law only indirectly addresses this problem through provisions on state liability for

^{*} I would like to thank Steven Freeland, Henrik Ringbom, Froukje Maria Platjouw and Jenni Tapio for their valuable comments on earlier versions of this chapter.

¹ Tatyana V. Koroleva, Pavel P. Krechetov, Ivan N. Semenov et al., 'The environmental impact of space transport (2018) 58 *Transportation Research Part D* 54–69; World Meteorological Organization Global Ozone Research and Monitoring Project–Report No. 58 (2018) *Scientific Assessment of Ozone Depletion* ES.50, available at <https://public.wmo.int/en/resources>

² Report of the Scientific Group of the London Convention and the 13th meeting of the Scientific Group of the London Protocol LC/SG 42/16, *Progress of the Correspondence Group on the Marine Environmental Effects of Jettisoned Waste from Commercial Spaceflight Activities* (LC/SG 42/8/1), available at www.unoosa.org

damage caused by space objects on another State's territory or aircraft.³ To tackle the challenges pertaining to the use of nuclear power sources in outer space, including protection of the Earth's biosphere, the United Nations (UN) has adopted non-binding instruments.⁴ However, contamination of the environment resulting from normal operation of launches and other spaceflight-related activities has largely remained within the national domain of States.⁵

Several reasons may explain scarce international development on this issue. The total impact of space activities on the Earth's environment has been viewed as insignificant, short-term and local, whereas the focus of international environmental law has traditionally been placed on serious transboundary pollution. However, the environmental impact of spaceflight may indeed be transboundary, affecting maritime areas both within and outside national jurisdiction of States. Even launches from inland-located spaceports may produce a long-range and transboundary environmental impact on maritime areas located far away from the launching site.⁶ The use of highly toxic fuels or nuclear power for propulsion of spacecraft could multiply environmental harm in the case of a launch accident, or of radioactively contaminated space objects returning to Earth.

- ³ Convention on International Liability for Damage Caused by Space Objects, London/Moscow/Washington, 29 March 1972, in force 1 September 1972, 961 UNTS 187 (Liability Convention). On the Cosmos 954 accident, see, e.g., Francis Lyall and Paul B. Larsen, *Space Law: A Treatise*, 2nd edition (London: Routledge 2018) 106. It is arguable whether pure environmental damage is included in the liability regime: see, e.g., He Qizhi, Environmental impact of space activities and measures for international protection (1988) 16 *Journal of Space Law* 117–127, at 124.
- ⁴ The Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space and the International Atomic Energy Agency, *Safety Framework for Nuclear Power Source Applications in Outer Space*, 19 May 2009, A/AC.105/934, available at www.un-ilibrary.org; UN Resolution 47/68, *Principles Relevant to the Use of Nuclear Power Sources in Outer Space* (NPS Principles), A/47/20, available at www.unoosa.org. See also Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future* (Leiden: Martinus Nijhoff Publishers 2008).
- ⁵ On UN concerns with the impact of increasing space launch activities on the Earth environment and the ozone layer: see The 1982 Report of the 2nd United Nations Conference on the exploration and peaceful use of outer space (A/CONF.101/10), paras. 290–291, available at www.digitallibrary.un.org, and The 1999 Recommendation on the protection of the Earth environment (A/CONF.184/6), 7 point 1(a)(v), available at <https://undocs.org/A/CONF.184/6>. Another step forward was taken by the initiative of the International Astronomical Union (IAU) on Dark and Quiet Skies, Recommendations, COPUOS (2021), A/AC.105/C.1/2021/CRP.17, available at www.unoosa.org, highlighting the issue of the environmental protection of the Earth from light pollution created by space activities.
- ⁶ The Rocket incident is described in Michael Byers and Cameron Byers, Toxic splash: Russian rocket stages dropped in Arctic waters raise health, environmental and legal concerns (2017) 53 (6) *Polar Record* 580–591; see also He Qizhi (n 3); Vito de Lucia and Viviana Iavicoli, From outer space to ocean depths: The 'Spacecraft Cemetery' and the protection of the marine environment in areas beyond national jurisdiction (2018) 49(2) *California Western International Law Journal* Art. 4, 346–389.

As the contemporary space sector is characterized by active participation of commercial, non-state actors, appropriate regulations at the national level are indispensable to ensure environmentally responsible conduct by private actors in the space sector.⁷ At the same time, the question arises whether an approach based on unilateral environmental regulations and standards of individual States is sufficient to tackle environmental pressures from spaceflight, especially pressures on maritime areas.

A feasible explanation for the lack of international legal measures to tackle spaceflight pollution lies in a weak environmental rule of law in the space sector. In principle, protection of the marine environment from pollution by spaceflights is governed by general international environmental law,⁸ and by two treaty-based regimes: space law and the law of the sea. General environmental law suffers from inherent weaknesses, notably vague environmental obligations of States, uncertain legal status of principles (e.g., the precautionary principle) and absence of an adequate institutional framework allowing for inter-state dialogue and cooperation.⁹ These issues remain largely unresolved in the special regimes of space law and the law of the sea. Neither space law nor the law of the sea expressly addresses protection of the Earth's environment from pollution by space-related activities. In the absence of specific provisions, the applicable obligations have to be derived from generally applicable environmental provisions and principles, resulting in a vague and fragmented legal framework. This is insufficient to address complex issues of environmental protection effectively and comprehensively in the space sector.¹⁰

This chapter argues that further development of international regulation of the environmental dimension of spaceflights is imperative in order to tackle existing and future pressures that such activities may cause the Earth's environment. The focus of the discussion in this chapter is international legal solutions for tackling spaceflight pollution of the marine environment, resulting from normal (operational) discharges during launch activities. It is pointed out that international cooperation needs to clarify and strengthen the relationship between the space

⁷ See Annette Froehlich and Vincent Seffinga (eds.), *National Space Legislation: A Comparative and Evaluative Analysis*, Studies in Space Policy 15 (Cham: Springer International Publishing AG 2018), https://doi.org/10.1007/978-3-319-70431-9_3

⁸ See Viikari (n 4); Lyall and Larsen (n 3), 254 et seq.

⁹ See, e.g., James R. May and J. Patrick Kelly, The environment and international society: Issues, concepts and context, in Shawkat Alam, Md Jahid Hossain Bhuiyan, Tareq M. R. Chowdhury and Erika J. Techera (eds.), *Routledge Handbook of International Environmental Law* (London: Routledge 2013) 16–17.

¹⁰ Claudia Cinelli and Katarzyna Pogorzelska, The current international legal setting for the protection of the outer space environment: The precautionary principle *avant la lettre* (2013) 22 (2) *RECIEL* 186–201, at 187; Steven Freeland and Donna Lawler, Whose mess is it anyway? Regulating the environmental consequences of commercial launch activities, *Proceedings of the International Institute of Space Law 2011*, The Hague: Eleven International Publishing, 3.

law and law-of-the sea regimes through developing a more effective normative and institutional framework.

Further discussion starts in Section 6.2 by assessing international space law and the law of the sea as normative frameworks for the marine environmental dimension of spaceflight, with focus on the Outer Space Treaty and United Nations Convention on the Law of the Sea (UNCLOS)¹¹ Part XII. Then in Section 6.3 the discussion turns to the question of how the environmental rule of law should be strengthened and developed to tackle marine pollution in the space sector more effectively. Section 6.4 concludes.

6.2 THE INTERNATIONAL ENVIRONMENTAL FRAMEWORK GOVERNING SPACEFLIGHT POLLUTION

6.2.1 *International Space Law*

The Outer Space Treaty is a universal treaty establishing a legal regime for state activities in the exploration and use of outer space.¹² Importantly, the Outer Space Treaty places responsibility on State Parties for their national governmental and non-governmental activities in outer space, and for assuring that national activities are carried out in conformity with the Treaty provisions. It further provides that the ‘activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty’.¹³ The State of registration of a space object ‘shall retain jurisdiction and control over such object’, and over any personnel thereof, while in outer space or on a celestial body.¹⁴

General obligations of States in the space sector should be interpreted in light of applicable international environmental law provisions.¹⁵ The Treaty contains relevant principles of law such as the principle of cooperation and mutual assistance, and the duty to report on potentially hazardous activities.¹⁶ Such fundamental rules of international environmental law as the duty to prevent transboundary environmental harm and the duty to notify of imminent danger had already been articulated

¹¹ Montego Bay, 10 December 1982, in force 16 November 1994, 1833 UNTS 397.

¹² Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other celestial bodies (the Outer Space Treaty) London/Moscow/Washington, 19 December 1966, in force 10 October 1967, 610 UNTS 205. The Outer Space Treaty is ratified by over 100 States and signed by around twenty States. Outer Space Treaty, *ibid.*, Art. IX.

¹³ Art. VI Outer Space Treaty (n 12).

¹⁴ Art. VIII.

¹⁵ Art. III Outer Space Treaty (n 12). See also Viikari, (n 4) 190; Ian H. Rowlands, Atmosphere and outer space, in Daniel Bodansky, Jutta Brunnée and Ellen Hey (eds.), *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University Press 2008) 332.

¹⁶ Arts. IX and XI Outer Space Treaty (n 12).

in international environmental law at the time when the space treaties were developed.¹⁷ With regard to nuclear safety, the UN Principles Relevant to the Use of Nuclear Power in Outer Space (NPS Principles) are accepted as part of customary international law.¹⁸

Further, the contours of the principle of prevention are arguably detectable in international space law instruments, including the Outer Space Treaty and the Liability Convention. In 1999, the UN recognized that ‘action should be taken to ensure, to the extent possible, that all space activities, in particular those which may have harmful effects on the local and global environment, are carried out in a manner that limits such effects and to take appropriate measures to achieve that objective’.¹⁹ This confirms the existence of a state obligation to take relevant measures to prevent and combat environmental degradation by spaceflights. However, the specific aspects of this obligation, including the criteria for determining environmental ‘harm’ triggering the duty to take measures are unclear.²⁰

Other questions that also remain are what kind of state measures would be required to achieve this objective, and whether existing international space law is adequate for this purpose. The ambiguity of state obligations laid down in space law instruments and the absence of expressly formulated provisions on protection of the Earth’s environment – other than Article IX of the Outer Space Treaty addressing protection of the Earth’s environment from pollution by extraterrestrial matter – results in challenges for the effectiveness of the environmental rule of law in the space sector. For example, international space law is silent on the duty to conduct an environmental impact assessment before starting a space activity. There are also no jointly developed standards of environmental safety and emission levels.

The legal relevance of the precautionary approach in the face of scientific uncertainty with regard to the environmental effect of spaceflights, including their terrestrial dimension, is not articulated explicitly in outer space law instruments, with the exception of the NPS Principles. These Principles require States to conduct safety assessments and take other relevant measures, indicating the importance of the precautionary approach (if not the precautionary principle) in the nuclear sector of outer space activities.²¹ The overall legal status of the precautionary principle – or at least the relevance of the precautionary approach – in outer space law is not yet

¹⁷ Trail Smelter Arbitration (1941), RIAA, vol. III, 1905–82.

¹⁸ See Rowlands (n 15).

¹⁹ Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), Recommendation on the protection of the Earth environment (A/CONF.184/6) point 1(a)(v), available at www.unoosa.org.

²⁰ See, e.g., Martha Mejía-Kaiser, Space law and hazardous space debris, planetary science, 30 January 2020, <https://doi.org/10.1093/acrefore/9780190647926.013.70>.

²¹ Principles Relevant to the Use of Nuclear Power Sources in Outer Space (NPS Principles) (n 4).

commonly agreed.²² This may be partly explained by the continuing uncertainty of the precautionary principle and its legal status in international environmental law generally.²³

An important condition for effective environmental rule of law in the space sector is the existence of an adequate international institutional framework. International governance of outer space, including its environmental dimension, takes place at several levels. The global space governance institution, the UN Committee on the Peaceful Uses of Outer Space (COPUOS),²⁴ has contributed significantly to development of policy on the long-term sustainability of outer space and mitigation of space debris.²⁵ Other international and regional organizations have also played an increasingly significant role in space governance. Importantly, the European Space Agency (ESA)²⁶ contributes to the formation of space law as it develops its own internal procedures, negotiates international agreements in the space sector and implements international space practices.²⁷ The ESA has been working on a green fuel project to replace toxic space propellants such as hydrazine.²⁸ However, COPUOS and other international space institutions do not have a specific environmental law-making mandate, nor are they explicitly given competence to monitor and supervise member States' measures regulating the terrestrial dimension of environmental protection in the space sector.

6.2.2 *Law of the Sea as a Normative Basis for Regulating Marine Pollution by Spaceflights*

UNCLOS provides a comprehensive legal framework on marine environmental protection.²⁹ A general obligation of States to protect the marine environment from

²² Viikari (n 4) 172.

²³ See, however, Nicolas de Sadeleer, *Environmental Principles: From Political Slogans to Legal Rules* (Oxford: Oxford University Press 2020) 139, arguing that the precautionary principle is a general principle of international law and a general principle of environmental (or even administrative) national law.

²⁴ Established by UN General Assembly (UNGA) Res. 1348 (XIII), Question of the peaceful use of outer space, 13 December 1948. See also Lyall and Larsen (n 3), 14.

²⁵ E.g., COPUOS Space Debris Mitigation Guidelines and Guidelines for long-term sustainability of space activities, 16 June 2016, A/AC.105/2016/CRP.17, available at www.unoosa.org. See also Jenni Tapio and Alexander Soucek, National implementation of non-legally binding instruments: Managing uncertainty in space law? (2019) 44(6) *Air & Space Law* 565–582.

²⁶ Convention for the Establishment of a European Space Agency, Paris, adopted 30 May 1975, in force 30 October 1980, 1297 UNTS 161.

²⁷ Lyall and Larsen (n 3), 21.

²⁸ ESA, 'Green' Satellite Fuel designed to make space safer 16 March 2010, available at www.esa.int/Our_Activities/Space_Engineering_Technology/Green_satellite_fuel_designed_to_make_space_safer

²⁹ On UNCLOS and third States see, e.g., J. Ashley Roach, Today's customary international law of the sea (2014) 45 *Ocean Development & International Law* 239–259, at 250–251.

the harmful impact of space activities follows from Article 192 UNCLOS. Crucially, UNCLOS requires States to exercise due diligence in environmental matters by adopting appropriate measures and showing adequate levels of vigilance in their enforcement and control.³⁰

Article 192 also encompasses potential impacts on the marine environment, transboundary and non-transboundary alike,³¹ the duty to protect the oceans from future threats and to take positive action with a view to maintaining and improving their present condition.³² The obligation to protect the marine environment from pollution is set out in Article 194 UNCLOS and detailed in several further provisions of Part XII. Although UNCLOS does not expressly include spaceflight pollution in its scope, it seeks to address ‘all issues relating to the law of the sea’ and requires States to protect and preserve the marine environment from all sources of pollution.

In general, the definition of pollution envisages actual or likely ‘deleterious effects’ on the marine environment such as harm to living resources or hazards to human health.³³ While the general threshold for harm is relatively low, some effect (even if only potential) on the marine environment is required. The focus appears to be not on changes in the marine environment in general but on harm to some more or less specific interests or resources.³⁴ Article 194 also envisages a nuanced approach, by requiring more stringent control of activities that may harm ‘rare or fragile ecosystems’.³⁵

Effective application of Article 194 is thus conditioned on the availability of knowledge about the effects of spaceflights on the marine environment, allowing State(s) to rely on some scientific outputs in order to determine whether and what ‘adequate’ and ‘necessary’ measures are to be adopted to tackle such pollution.³⁶ Still, existing research on the marine environmental effects of spaceflight appears rather piecemeal. These information gaps result in significant uncertainty about the risks and extent of environmental degradation that accelerating spaceflights may bring about, calling for use of the precautionary approach to protection of the marine environment from spaceflight-source pollution. In this author’s view, the hazardous character of spaceflight activities calls for application of the precautionary

³⁰ Request for Advisory Opinion submitted by the Sub-Regional Fisheries Commission (Advisory Opinion) ITLOS Reports (2 April 2015), para. 131; South China Sea Arbitration (*The Philippines v. China*) PCA Case No 2013-19 (12 July 2016), para. 944.

³¹ James Harrison, *Making the Law of the Sea: A Study in the Development of International Law* (Cambridge: Cambridge University Press 2011) 24–25.

³² South China Sea Arbitration (n 30), para. 941; Harrison (n 31).

³³ See De Lucia and Iavicoli (n 6).

³⁴ See also Allen L. Springer, Towards a meaningful concept of pollution in international law (1977) 26 *The International & Comparative Law Quarterly*. 531.

³⁵ Art. 194(5); South China Sea Arbitration (n 30), para. 945.

³⁶ On the precautionary approach in the law of the sea, see, e.g., Rosemary Rayfuse, Precaution and the protection of marine biodiversity in areas beyond national jurisdiction (2012) 27 *The International Journal of Marine and Coastal Law* 773–781.

approach as part of the duty of due diligence. However, while precaution is envisaged in several multilateral environmental agreements and has also been accepted by international courts with regard to specific activities and sectors, the general relevance of the precautionary approach in the law of the sea remains unclear.³⁷

Significant information gaps on the marine environmental impact of spaceflight highlight the particular importance of provisions addressing research cooperation (Article 200), establishment of scientific criteria (Article 201), monitoring the risks or effects of pollution and publishing reports (Articles 204 and 205) and assessing the potential effects of activities on the environment (Article 206). By comparison, no corresponding provisions with regard to environmental research are included in space treaties and other space law instruments developed at the international level.

Furthermore, UNCLOS also contains an overview of types of measures to be applied by States to prevent or minimize marine pollution.³⁸ However, UNCLOS grants States a considerable degree of discretion in their choice of appropriate measures. In particular, it does not require that environmental protection measures must always be adopted by States at the international level: States may adopt 'individual or joint measures as appropriate' to address marine pollution.³⁹ Further, international measures do not need take the shape of binding regulations or agreements: 'soft law' measures such as rules, standards or recommendations are also acceptable (if 'appropriate') and may indeed be preferable for States for a number of reasons. However, to meet its duty of due diligence, a State must actually consider what regulation, and at what level – individual, joint, global or regional, binding or not – will be adequate to address spaceflight pollution.

Article 194 clarifies that responsibility for taking measures is vested in the State holding 'jurisdiction or control' over activities that may cause damage to the marine environment of other States.⁴⁰ The State in whose territory the spaceport is located would clearly hold 'jurisdiction or control' over spaceflight activities within the meaning of Article 194. This would also be consistent with Article VI of the Outer Space Treaty, which assigns central responsibilities to the 'appropriate' State, which must authorize and properly supervise space activities by non-governmental entities in outer space.⁴¹

The notion of 'jurisdiction or control' may also include spaceflights conducted extraterritorially, that is, from launch sites located in other States or from the high

³⁷ The International Tribunal for the Law of the Sea has implicitly applied the precautionary principle but still has not endorsed the principle in general. See, e.g., Annecoos Wiersema, 'The precautionary principle in environmental governance', in Douglas Fisher (ed.), *Research Handbook on Fundamental Concepts of Environmental Law* (Cheltenham: Edward Elgar Publishing 2016) 464–466.

³⁸ UNCLOS Art. 194.

³⁹ UNCLOS Art. 194(1).

⁴⁰ UNCLOS Art. 194(2).

⁴¹ See Section 6.2.1.

seas. This is in line with the Outer Space Treaty.⁴² The duty to take appropriate measures to protect the marine environment thus also applies to spaceflight activities conducted from another State's territory or from the high seas. Article 192 also requires a State (or States) to take measures with regard to marine pollution by space debris re-entering the Earth, including pollution of the high seas. However, identifying the State(s) holding 'jurisdiction or control' over an extraterritorially located object or activity resulting in marine pollution may be difficult. It is questionable whether Article 194 UNCLOS should be interpreted in light of the relevant space law provisions, at least where such interpretation may result in narrowing down the application of Part XII UNCLOS.

Further, it is problematic that UNCLOS does not clarify the competences and responsibilities of other States whose EEZs may be affected by spaceflights. As the *Rockot* case illustrates, a coastal State in whose EEZ spaceflight produces environmental impacts may find itself in a vulnerable and unclear legal position.⁴³ In this author's view, the provisions of UNCLOS Part V entitle a coastal State to regulate or ban the use of its EEZ for jettisoning spaceflight residues by a foreign State, by virtue of coastal State jurisdiction over the EEZ.⁴⁴ Moreover, in light of the Part XII obligations described earlier, both the coastal State and the launching State(s) are under a positive obligation to take measures to prevent environmental harm to the EEZ.

Nevertheless, UNCLOS Part V does not provide for an obvious allocation of jurisdiction in such cases, challenging the coastal State's jurisdiction to regulate pollution resulting from spaceflight of foreign origin. A relevant legal basis for resolving conflicts arising from lack of clear allocation of rights and jurisdiction in UNCLOS may be found in Article 59 UNCLOS. This provision addresses cases where UNCLOS does not expressly attribute rights or jurisdiction by requiring resolution of a problem 'on the basis of equity and in the light of all the relevant circumstances, taking into account the respective importance of the interests involved to the parties as well as to the international community as a whole'. Protection of the marine environment from jettisoned space waste may, in principle, be one of the relevant interests under Article 59 (both of the coastal State and the international community). However, effective application of this provision is, in this author's view, conditional on cooperation to facilitate interaction and conflict resolution between the States concerned and to include the interests of the 'international community as a whole' in this work.

⁴² Bin Cheng, Article VI of the 1967 Space Treaty revisited: 'International responsibility', 'national activities' and 'the appropriate state' (1998) 26 *Journal of Space Law* 7.

⁴³ Byers and Byers (n 6), 585.

⁴⁴ Alla Pozdnakova, Oceans as spaceports: State jurisdiction and responsibility for space launch projects at sea (2020) 26 *Journal of International Maritime Law* 267.

6.2.3 *Relevance of the Dumping Regime to Tackling Marine Pollution in the Space Sector*

Section 5 of Part XII UNCLOS addresses specific sources of marine pollution and details the general rules of Article 194. Arguably, some of these provisions may provide a relevant normative basis to strengthen marine environmental protection from spaceflight pollution. This part examines Article 210, which requires States to take measures to prevent, reduce and control pollution of the marine environment by dumping. Importantly, according to this provision, States must ensure that national laws, regulations and measures prevent dumping from being carried out without permission from the competent authorities.

States are required to adopt relevant national rules and measures to prevent marine pollution by dumping that are no less effective in preventing, reducing and controlling such pollution than global rules and standards.⁴⁵ These international rules are laid down in the London Convention on Dumping (the London Convention)⁴⁶ as amended by the 1996 Protocol. The latter instrument extends the Convention provisions to include aircraft and imposes a prohibition on marine dumping, with a narrow exception.⁴⁷ The provisions of Article 210 UNCLOS are further detailed and strengthened in the London Convention with the 1996 Protocol, which transforms a 'right' into an 'obligation'. In addition, dumping is regulated at the regional level, for example, by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention).⁴⁸

International rules on protection of the marine environment from pollution by dumping are potentially relevant for spaceflight-source pollution. First, provisions on marine dumping may be relevant to governing de-orbiting of end-of-life space objects and regulating pollution caused by jettisoned space residues on the high seas.⁴⁹ Second, the marine dumping regime may also be useful for regulation of spaceflight-source pollution within maritime zones under jurisdiction of a coastal State, including situations when spaceflight residues generated by launches of space objects from another State's territory fall into maritime areas under national jurisdiction of a coastal State.⁵⁰

Thus, Article 210(5) UNCLOS precludes dumping within the territorial sea and the exclusive economic zone or onto the continental shelf without the express prior

⁴⁵ Art. 120(1) and (6) UNCLOS.

⁴⁶ Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Washington/Moscow/London/Mexico City, adopted 29 December 1972, in force 30 August 1975, 1046 UNTS 120.

⁴⁷ 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (as amended in 2006).

⁴⁸ Paris, 22 September 1992, in force 25 March 1998, 2354 UNTS 67, www.ospar.org/convention.

⁴⁹ See also De Lucia and Iavicoli (n 6), 379 et seq.

⁵⁰ Cf. Rocket case (n 6).

approval of the coastal State. The coastal State also has a right to regulate dumping within its maritime zones through a system of permits, regulations and controls. The wording of this provision may allow a coastal State to prohibit third States from using its EEZ for jettisoning spaceflight residues. It also specifies that a coastal State's right to issue permits and regulate and control such dumping is subject to the duty to bring the matter up for 'due consideration' by those States that, by reason of their geographical situation, may be adversely affected by dumping.⁵¹ These may arguably be neighbouring States and States dependent on navigation or other activities in the waters where jettisoning is taking place.⁵²

The question is whether a coastal State within the meaning of the dumping regime may also be viewed as the 'appropriate' State for the purposes of Article VI of the Outer Space Treaty. The latter requires that the appropriate State must authorize and supervise space activities by its non-governmental entities.⁵³ This question is relevant for situations when a coastal State is acting as a launching State (from whose territory the launch is taking place), or as a State whose maritime zones are used by another State for jettisoning spaceflight residues. As pointed out earlier, the coastal State's rights and obligations in the latter situation are not fully clear under general UNCLOS provisions and the Outer Space Treaty. If applicable, provisions on marine dumping laid down in Article 210 and the London Convention with Protocol would spell out a coastal State's competences to regulate such cases more clearly.

Regrettably, spaceflight-source pollution is not included in the definition of dumping in UNCLOS and the London Convention.⁵⁴ The regime only regulates dumping from vessels, platforms and other man-made structures, or from aircraft at sea. While Article 4.2 of the 1996 Protocol also includes 'any deliberate disposal at sea of vessels, aircraft, platforms or other man-made structures *at sea*' (author's italics), it is arguable whether jettisoned parts of space rockets and other space objects, including end-of-mission/de-orbited spacecraft, may be viewed as 'aircraft'.⁵⁵ In any case, the definition of dumping expressly excludes disposal of wastes or other matter 'incidental to, or derived from the normal operations' of vessels, aircraft, platforms or other man-made structures at sea and their equipment.⁵⁶ Spaceflight-source pollution in the shape of jettisoned launch waste is part of a normal launch

⁵¹ Art. VIII London Convention (n 46).

⁵² Compare, however, with Art. 59 UNCLOS, which encompasses the international community as a whole, not just geographically relevant States.

⁵³ UNCLOS Art. 210(3). The latter requirement is more far-reaching than Arts. 207, 211 and 212, which do not envisage a requirement to regulate polluting activities through permits. Art. 210 UNCLOS does not distinguish between governmental and non-governmental entities.

⁵⁴ Art. 1(5) UNCLOS.

⁵⁵ International law does not, however, contain a generally accepted definition of an aircraft: Lisa Tomas, 'Air Law', in Anne Peters (ed.), *Max Planck Encyclopedia of Public International Law* (Oxford Public International Law), available at opil.oxplaw.com.

⁵⁶ Art. 1(5) UNCLOS.

operation,⁵⁷ much like so-called operational discharges from ships. The marine dumping rules also differentiate between ‘deliberate’ and ‘incidental’ pollution, albeit without detailing what constitutes either type of pollution. Pollution resulting from an accident such as a space rocket explosion following a launch is likely not to be viewed as ‘dumping’ within the meaning of these regulations.

6.3 ASSESSMENT AND PATHWAYS TO MORE EFFECTIVE INTERNATIONAL REGULATION OF SPACEFLIGHT-SOURCE MARINE POLLUTION

6.3.1 *Overview*

The discussion in the previous section shows that the international environmental regime governing the space sector is fragmented and does not adequately regulate state responsibility for environmental measures in the spaceflight sector. Admittedly, UNCLOS establishes more far-reaching environmental obligations on States engaged with space activities than does the Outer Space Treaty, which only imposes a duty on States to conduct international consultations before starting activities with potentially harmful interference with activities by other States in outer space.⁵⁸ UNCLOS clarifies that States are responsible for protection of maritime areas, including the high seas, from any pollution, which would include spaceflight-source pollution.

However, the normative relevance and effectiveness of UNCLOS for spaceflight-source pollution is challenged by several factors. It often remains unclear which State should be responsible for taking appropriate measures to protect the marine environment from spaceflight-source pollution. It is also not clear what provisions would be feasible to develop, in what kind of instrument and what issues require international, rather than national, regulation. This may be partly explained by the absence of spaceflight-specific environmental provisions in UNCLOS and other international instruments, and the inherent ambiguity and normative weakness of general international environmental law, which is unable to fill the gaps in the space law and law of the sea regimes.

In this author’s view, the first step is to clarify and strengthen the relationship between international space law and the law of the sea. Currently, adequate interaction between the space law and law of the sea regimes is lacking at the normative and institutional level, which in turn stands in the way of developing environmental regulation in the space sector. Further, with regard to development of substantive environmental provisions in the spaceflight sector, unilateral

⁵⁷ Report of the Scientific Group (n 2), pkt 1.

⁵⁸ Art. IX Outer Space Treaty (n 12).

(national) measures should arguably be supplemented by joint (international) state measures. To enable progress in this area, it is necessary to obtain sufficient knowledge about the environmental effects of spaceflight and to develop an adequate institutional framework to back up the normative and procedural dimension of environmental protection in the space sector.

6.3.2 *Strengthening Knowledge about the Marine Environmental Impact of Spaceflight*

UNCLOS Part XII Sections 2–3, which lay down provisions on inter-state cooperation on gathering and exchange of knowledge about spaceflight pollution, should be used actively by States responsible for spaceflights as well as by States affected by spaceflight pollution. The necessity for measures to protect the marine environment is normally determined by means of establishing appropriate scientific criteria for the formulation of rules (Article 201 UNCLOS), by advice from international bodies such as the International Council for the Exploration of the Sea (ICES), and by monitoring and assessing the environmental impact of spaceflights (Articles 204–206).

As pointed out earlier, an important impediment is the absence of sufficient knowledge on the environmental impact of the spaceflight sector, as available research on the marine environmental effects of space activities is rather scarce and appears unsatisfactory.⁵⁹ States should more actively apply UNCLOS provisions requiring them to gather and exchange knowledge on spaceflight pollution of the marine environment. This may ensure the necessary scientific basis for assessment of space launch effects on the marine environment and enable development of a systematic international approach to problems revealed.

Arguably, the present under-utilization by States of UNCLOS provisions on scientific research on the environmental impact of spaceflight may even lead to infringement of the due diligence obligation with regard to protection of the marine environment. It is generally recognized that the duty to conduct an environmental impact assessment (EIA) follows from general international environmental law as part of a State's due diligence obligation, and is necessary for fulfilment of the international environmental law principle of prevention.⁶⁰ As EIA is an important – although not in itself sufficient – step towards collection and sharing of knowledge

⁵⁹ Greenpeace International submitted to the Scientific group of the London Convention that a gap exists in assessment and control of launch activities, de facto disposals of wastes at sea is taking place and access is limited to publicly available information and assessments: see Greenpeace, 'Concerns relating to de facto disposal at sea of jettisoned space vehicle components', available at www.greenpeace.to/greenpeace/wp-content/uploads/2018/09/LC-SG-41-8-2.pdf.

⁶⁰ Responsibilities and obligations of states with respect to activities in the area (Advisory Opinion, 11 February 2011) ITLOS case no. 17, ITLOS Reports (2011), para. 145.

on the cumulative environmental effects of spaceflight, it is hence essential for the future development of environmental standards and requirements in the space sector.⁶¹

With regard to the marine environment, the duty to assess the potential effects of planned space activities would follow from Article 206 UNCLOS. The duty to conduct EIA also applies to activities with an impact on the environment in areas beyond the limits of national jurisdiction.⁶² UNCLOS also requires States to publish reports with the results of such assessment or communicate the results to a competent international organization.⁶³

However, UNCLOS leaves it to the responsible State to evaluate whether there are 'reasonable grounds for believing' that the threshold for EIA – 'substantial pollution of or significant and harmful changes to the marine environment' – is reached.⁶⁴ Thus, States enjoy wide discretion to determine whether an EIA should be required for spaceflight, and what activities more specifically form part of such assessment. For example, some States require an EIA for launch activities; however, there exists no consistent and uniform international approach to the scope of this requirement.⁶⁵

It is arguably necessary to harmonize approaches to EIA among spaceflight-active States by expressly including spaceflight pollution in the scope of relevant activities and by detailing the conditions and requirements for EIAs. In this respect, it would be more effective to address the issue through a global, rather than a regional, measure such as the forthcoming legally binding instrument on biodiversity in areas beyond national jurisdiction.

The Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)⁶⁶ also sets out more detailed rules for EIA, including rules on the duty to notify and consult each other and important procedural provisions. Regrettably, the Espoo Convention does not expressly include spaceflight and, in any case, does not have global reach in terms of its ratification status. Amendment of the Espoo Convention would be an important step forward. In the EU context, a corresponding change could arguably be achieved by amending existing secondary legislation.⁶⁷

⁶¹ See also the IAU report to the 64th session of COPUOS (n 5), including statement by astronomers on the need to mitigate the adverse impacts of mega-constellations.

⁶² Responsibilities and obligations of States with respect to activities in the area (n 60) para. 148.

⁶³ Art. 205.

⁶⁴ Cf. Art. 2(3) Espoo Convention (n 66).

⁶⁵ On the scope of EIAs in national jurisdictions (US example), see also Joosung Lee, *Legal analysis of Sea Launch license: National security and environmental concerns* (2008) 24 *Space Policy* 104–112, at 107, who points out that the long-term effects on the environment remain undetermined.

⁶⁶ Espoo, 25 February 1991, in force 10 September 1997, available at <https://unece.org>.

⁶⁷ Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, OJ L 26, 28 January 2012, 1.

6.3.3 *Developing the Institutional Framework in the Space Sector to Include Environmental Matters*

To meet their due diligence obligations to protect the environment from spaceflight-source pollution, it is also crucial for States to establish environmental cooperation in the spaceflight sector. Outer space law is based on the premise of 'broad international cooperation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes'.⁶⁸ UNCLOS explicitly requires States to cooperate directly or through 'competent international organizations' on matters of the law of the sea. Cooperation through an organization or an institution, in addition to direct bilateral or multilateral cooperation on an ad hoc basis, has a number of advantages for regulating issues of global concern. For example, in the shipping sector, States acting through the International Maritime Organisation (IMO) have over time developed international safety and environmental standards, obligations and procedures. In the space sector, development of international emission and other environmental safety standards comparable to those adopted under the auspices of IMO (e.g., MARPOL) would be far too premature.⁶⁹ It would be feasible to begin by tackling the lack of an adequate institutional framework necessary to facilitate inter-state dialogue and to support cooperation on research, harmonization and monitoring of environmental legal standards in the space sector.⁷⁰ Presently, there are no international institutions that hold a clear mandate to address pollution of the marine environment by spaceflights. Better interaction between space law and the law of the sea may be achieved by stronger institutions with clearer competence for protection of the marine environment from pollution caused by spaceflight. This could also preclude unnecessary fragmentation of the environmental legal framework in the spaceflight sector, ensuring that international legal solutions consider protection of the Earth's environment as a whole.

An internationally coordinated approach through an institution responsible for international legal development in the space sector such as COPUOS, supplemented by inter-institutional cooperation with other competent international organizations, is indispensable to pave the way for prospective harmonization steps. It may also be feasible to adjust and strengthen the existing regulatory and institutional framework for spaceflight pollution, for example, by expanding the marine dumping

⁶⁸ Outer Space Treaty (n 12), Preamble.

⁶⁹ However, ESA is working on the project of 'greening' space launches, notably through developing more environmentally friendly types of fuel. See ESA, 'Green' Satellite Fuel designed to make space safer, available at www.esa.int/Our_Activities/Space_Engineering_Technology/Green_satellite_fuel_designed_to_make_space_safer

⁷⁰ See Samuel Barrows, *Racing to the top ... at last: The regulation of safety in shipping*, in Walter Mattli and Ngaire Woods (eds.), *The Politics of Global Regulation* (Princeton: Princeton University Press 2009) 196, who points out that the institutional context at the supranational level has been crucial in facilitating regulatory change in international shipping.

regime. As pointed out earlier, the London Convention and related instruments contain important regulatory tools that are not present in the space treaties or UNCLOS. Expanding the marine dumping regime to include ‘operational’ (normal) pollution by jettisoned components of space objects and by de-orbited end-of-mission spacecraft may contribute to strengthening legal protection of the marine environment from spaceflight pollution. The relevance of the dumping regime for the spaceflight sector has been under examination via the auspices of the IMO since 2016, but this work has not yet been concluded.⁷¹ It is advisable to continue the work initiated by the IMO and UN COPUOS to evaluate expansion of the London Convention to the spaceflight sector and accordingly to amend the 1996 Protocol in order to include disposal of jettisoned space objects into the maritime environment.

6.4 CONCLUSIONS

Spaceflight-source pollution of the marine environment is not yet perceived by States as a problem that requires immediate international measures. A likely explanation is lack of sufficient knowledge about cumulative, long-term and transboundary effects on the oceans of space launches and other spaceflight-related activities. This may partly be explained by a lack of clear environmental competences of international outer space governance institutions. Although some marginal steps have been taken in the right direction, namely, to assess application of the international dumping regime to jettisoned space launch waste, the issue is not a priority for interstate cooperation and the competent institutions in the maritime and space sector. Thus, international environmental rule of law remains at an embryotic stage of development in the space sector. There is a clear need for development of a more comprehensive, international framework to tackle the environmental impact of spaceflights.

International environmental law requires States to exercise due diligence in taking adequate measures to protect the environment from pollution by all kinds of industrial activities. However, an unclear and fragmented international legal context may hardly help States meet their obligations to protect the marine environment from spaceflight pollution. A more pro-active approach is nevertheless required from States at the individual and international level. Here, initial steps should be aimed at gathering and sharing knowledge about the marine environmental effects of spaceflight. To enable development of environmental rule of law in the space sector, including its maritime dimension, it is also crucial to build up an adequate institutional framework at the international level that can support the

⁷¹ Report of the Scientific Groups (n 2). See also Andrew Birchenough and Fredrik Haag, *The London convention and London protocol and their expanding mandate (2020)* 34 *Ocean Yearbook* 255–278, 274.

development of harmonized substantive provisions and facilitate cooperation on environmental matters. Such an institutional framework should be anchored in the existing international institutions – importantly, COPUOS and the IMO – but their responsibility for environmental matters needs to be clarified and, if necessary, strengthened. Last but not least, cross-institutional cooperation is indispensable to ensure that legal solutions are holistic, protecting the ocean environment, marine ecosystems and the Earth’s environment as a whole.