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The Plastic–Climate Nexus

Linking Science, Policy, and Justice

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Introduction

Among the plethora of marine ecosystem challenges of this century, two have received increasing attention in recent years. One of these challenges, the primary subject of this book, is climate change. Another challenge is that of plastic. Marine plastic pollution can be subdivided into three basic categories: (1) *macroplastics*, including debris such as fishing nets, large pieces of Styrofoam, and parcels that have been lost or discarded from cargo ships; (2) *microplastics*, which comprise particles under 5 mm in diameter that remain when plastic objects, including plastic nurdles (which are used in various production processes), enter the sea and phytodegrade; and (3) *nanoplastics*, the end state of microplastic degradation, which are invisible to the naked eye and, because they are so small (1,000 times smaller than an algal cell)), are more likely than microplastics to pass through biological membranes. All of these categories of plastics are regrettable intrusions on natural ecosystems, but the latter are particularly worrisome for those concerned with environmental change.

In this chapter, we argue that all types of plastic pollution are also troublesome irritants for those concerned specifically with climate governance. The links between plastic debris, which is reshaping ocean ecology, and the broader threat of climate change are rarely explored. Our analysis suggests that there are several interlinked variables and relevant ethical and policy-related considerations. In particular, the climate change and the microplastics narratives – discovery, scientific advances, technological and policy innovations – need to come together if we are to make solid progress in response to both of these wicked problems.

We develop three primary ideas in this chapter. First, there are clear links between the oceans and climate change agenda and the marine debris agenda. Microplastics especially are contributing to the climate change problem and vice versa (Royer et al., 2018). Second, there are intriguing governance parallels between the two problems, such as existential threat responses, shared but differentiated responsibilities, and common heritage issues. The most pronounced intersection is at the level of ecological justice. Third, we argue that climate change governance should take the microplastics plague into account. Similarly, those dealing with plastic debris have no choice but to take climate change into serious consideration.

In the remainder of this chapter we discuss why plastic debris should be a topic of grave concern to the climate change mitigation and adaptation community, and we show why it is a vital issue for environmental governance and ecological justice. We explore similarities between these two mega-issues from policy and justice perspectives, looking especially at human impacts and concerns about shared governance. We examine international legal principles that can be applied to both issues, including common heritage, shared but differentiated responsibilities, and the precautionary principle. Finally, we take a pragmatic look at what can be done to integrate these twin issues as part of wider efforts to achieve effective ocean governance amidst climate change.

The Emergence of Plastic Pollution

Synthetic polymers can be manufactured from fossil fuels or biomass. The complete biodegradation of plastic occurs when none of the original polymer remains, a result of microbial action breaking plastic down into carbon dioxide, methane, and water. Most plastic in circulation today is a petroleum and natural gas by-product. It does not biodegrade fully. Instead, it photodegrades into tiny particles that can both release toxic chemicals and absorb persistent organic pollutants and hydrophobic chemicals. Easily mistaken for food, this material then enters the marine food chain (Provencher, 2014). It has even been found in organisms living in the deep sea (Taylor et al., 2016). Plastic has also been found in the most remote ocean areas and identified in every type of marine habitat (Ivar do Sul and Costa, 2014). For example, a French team studying plankton found remarkably high plastic levels in the Southern Ocean in 2012. Remote Arctic sea ice has been found to contain high concentrations of microplastics, and the extent to which melting ice will release various anthropogenic particulates back into the ocean is not yet fully known (Obbard et al., 2014). Plastic debris acts as a transport system for invasive alien species and diminishes sunlight and oxygen levels, contributing to dead zones.

The positive correlation between loss of marine biodiversity and reductions in marine ecosystem services has been known for quite some time (Worm et al., 2006). However, although plastic pollution has been observed for decades, awareness of microplastics is relatively new, dating back to the late 1990s. There was solid scientific evidence that plastic debris, even at the micro-level, was an emerging problem in the Atlantic Ocean in the early 1970s (Carpenter et al., 1972; Colton, Knapp, and Burns, 1974), but it was not until the 1990s and early 2000s that a flood of research emerged finding microplastic abundance in the oceans and, still later, in freshwater systems. An alarming European Commission report suggested that approximately 10 percent of the global plastic manufactured each year, about 265 million tons, ends up in the oceans or other water systems (EC, 2011). In some areas, densities have been recorded at 100,000 particles per square meter of water (Wright, Thompson, and Galloway, 2013).

That the entire life cycle of plastic is vast and global should not surprise us. An industry producing over 260 million tons of product annually, and using roughly 8 percent of global oil production in the process, leaves a tremendous ecological footprint (Redclift, 1996; Thompson, 2009; Clapp, 2012). The world's shorelines are the most obvious repository of plastic debris, from fishing material to degraded plastic bottles. The discovery of five so-called "garbage patches" in the oceanic gyres, first in the Pacific and then elsewhere, rang loud alarm bells (Moore et al., 2001, Kaiser, 2010, Titmus and Hyrenbach, 2011). The five gyres serve as conductor belts for masses of immeasurable subsurface microplastic. Early pelagic studies even indicated a higher abundance of microplastics than zooplankton (the building block of the marine food chain) in some areas (Moore et al., 2001). This is especially troubling, given the important role zooplankton play in regulating climate. Plastic debris also has a direct impact on wildlife health and contributes to positive feedback loops: for example, plastic bags look very similar to jellyfish in the marine environment, leading sea turtles to ingest the plastic and suffocate or starve as a consequence. The reduction in the number of sea turtles, in turn, exacerbates the growing problem of invasive jellyfish abundance (see Schuyler et al., 2014; Wilcox et al., 2015). One author sums up the wildlife impact of plastic marine debris as "entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions" (Gregory, 2009; see also Desforges et al., 2014). There is no evidence that even biodegradable plastics break down once consumed by mammals such as sea turtles or seabirds (Muller et al., 2012).

Plastic debris originates from many sources. Nurdles used as preproduction pellets escape the product cycle at various stages and end up in oceans (Ogata et al., 2009; Hammer et al., 2012). Microbeads used in cosmetic cleansers and other personal products, including toothpaste, are flushed into water systems and are too small to be stopped by wastewater filtration systems. Three-quarters or more of litter in the ocean comes from land-based sources (Derraik, 2002; Hardesty et al., 2014; Jambeck et al., 2015). Consequently, microplastic pollution, whether through nurdles and pellets, microfibers in clothing released through washing processes, or personal cosmetic products, needs to be managed before it reaches the ocean. Regulation of the use of microbeads in cosmetic products has been timely; however, enforcement and implementation are slow. Resilient plastic bags are ubiquitous across continents and have joined bottle caps, six-pack rings, straws, cigarette butts, and other plastic products in waterways considered pristine before the 1970s. Increasing evidence suggests polyester, released through the washing of clothes, is one of the most abundant microplastics found on shorelines (Browne et al., 2011). Even the synthetic rubber in car tires results in microplastic debris.

As societies move toward an aquaculture-based global protein regime, many observers have concluded that it is already a major source of plastic pollution (Austin, 2014; Mathalon and Hill, 2014). One study found that aquaculture was a major contributor of marine litter off the coasts of Chile, South Korea, Japan, and other areas (Hinojosa and Thiel, 2009). Another area of future concern will be the rise of 3D printing, "using plastic 'ink' [which] will guarantee expanded use of polymeric feedstocks" (Moore, 2015: vii). Even the recycling industry, which is vital for reducing plastic pollution, comes with its own pollution and climate change issues, although exciting ideas for secondary uses of plastics, such as the construction of roads and sidewalks in the Netherlands, are appearing (Valentine, 2015).

Meanwhile, new evidence suggests that the deep sea is harboring much more plastic than was previously imagined. A 2014 study found that microplastic fibers were "up to four orders of magnitude more abundant (per unit volume) in deep sea sediments from the Atlantic Ocean, Mediterranean Sea and Indian Ocean than in contaminated sea-surface waters" (Woodall et al., 2014; see also Van Cauwenberghe et al., 2013). Extricating this plastic is not feasible. And scientists are now investigating "life in the plastisphere," where entirely new microbial communities are evolving (Zettler, Mincer, and Amaral-Zettler, 2013).

For both plastic pollution and climate change, technological solutions exhibit serious limitations. We believe that they should not form the basis of an action strategy in the future. Robotic or captained pelagic vacuum cleaners (such as the crowd-sourced SeaVax) or trailing suction hopper dredging ships (such as the *Queen of the Netherlands*) can no doubt make a substantive impact. However, it would take a virtual navy of such ships to affect significant change, given the mass of plastic in our oceans, lakes, and rivers. That said, this is not a reason to consider plastic retrieval to be futile, and governments with exclusive economic zones surely have an obligation, when possible, to undertake surface cleanup programs. Given their difficult location in areas beyond national jurisdiction, a multilateral fund such as that suggested by the Global Oceans Commission could be utilized to finance retrieval operations in the oceanic gyres. The Ocean Cleanup Project proposed conducting retrieval operations in the North Pacific Garbage Patch, while another study indicates that more beneficial outcomes would be attained by focusing retrieval areas off the coast of East Asia, from where a majority of plastic litter now originates. Such operations could include capture closer to coasts to prevent marine litter being swept into the open ocean. This would reduce the amount of plastic that degrades into microplastic, and it could also reduce the amount of microplastic and plankton overlap (Sherman and van Sebille, 2016).

As with climate change, larger-scale geoengineering designs are more problematic. Stimulating phytoplankton presence and activity by increasing nutrient availability in areas swamped by plastic waste is one such proposal which would, theoretically, also increase carbon dioxide (CO_2) uptake (see Chapter 26). Unfortunately, introducing iron or nitrogen into areas with especially high plastic density may cause as many problems as it solves. Stimulating plastic-bound bacteria to increase their nitrogen-fixing capacity is another idea that seems rather far-fetched to most scientists. In general, stimulating phytoplankton can lead to eutrophication and "dead zones" with low oxygen content in which anaerobic bacteria thrive; their respiration produces nitrous oxide, a greenhouse gas about 265 times more potent than CO_2. Biodegradable plastics, meanwhile, do not offer a solution to the aquatic plastics problem. Most biodegradable plastic products do not decompose unless a temperature of 50°C is reached, which is (to put it mildly) highly undesirable in any aquatic context.

Microplastic Pollution and Climate Change

Climate-Related Impacts of Plastic Pollution in Oceans

The production of plastic products and the deluge of aquatic plastics is contributing to problems associated with climate change. The plastics industry itself has been estimated to produce a 10 percent contribution to total "global warming potential" if its relative contribution to other material groups is included (STAP, 2011). This is probably a low estimate that does not include the climate implications of the global recycling industry. Beyond this, microplastics and nanoplastics can be ingested by zooplankton and microzooplankton (Cole et al., 2013), which negatively affects algal feeding, potentially increasing algal blooms and disrupting zooplankton growth and fecundity. Phytoplankton use sunlight to bind water and carbon dioxide, creating oxygen and organic matter for other organisms to eat. If organisms are ingesting microplastic, or their permeable membranes are absorbing nanoplastic, they are ingesting less organic carbon-based matter, and thus the carbon cycling function of ocean ecosystems may be compromised. Research in this area is just beginning. Membrane permeability is a core concern when we link nanoplastic pollution with the climate-regulating functions of the oceans (see Koelmans et al., 2015). This is admittedly speculative at this juncture, but the implications could be severe for the global carbon cycle because oceans act as sinks for at least half of anthropocentric carbon emissions. This is a potential "tipping point" or positive feedback loop that we cannot afford to ignore.

In addition, there is emerging evidence that plastic ingestion by coral reefs adds to the threat climate change and ocean acidification (see Chapter 22) pose to these precious biodiverse resources (Hall et al., 2015). In general, increased water temperatures and acidification can accelerate the breakdown of macroplastic into micro- and nanoplastic. Increased carbon levels in the oceans are already contributing to ocean acidification and other problems, but microzooplankton and zooplankton form the basis of the marine food chain, and their collapse would spell biological disaster. Ocean currents may shift due to climate change, delivering plastic to (increasingly rare) untainted areas, and sea-level rise will claim more litter from shorelines with tidal activity and extreme weather events such as hurricanes and cyclones. A combination of shifting temperature zones and the use of plastic debris as vectors will exacerbate the problem of invasive species, including that of travelling microbes (Derraik, 2002). Warming waters will also release plastic and related toxic material (and potential pathogens) captured in marine ice (CBD, 2012). In short, climate change and heavy microplastic pollution are working in tandem to lower marine ecosystem resilience.

Plastic Pollution and Climate Justice

Where the plastic–climate nexus is most clear, however, is in the normative sphere. Climate change and plastic pollution are both social justice issues where deleterious impacts are suffered by those who have typically contributed the least to the problems and are least able to escape them. The overlap between plastic pollution and climate change is just beginning to receive serious scientific investigation, but the political similarities are already quite striking. For example, in both cases common but differentiated responsibilities are involved. This is well known in the case of greenhouse gas emissions, where a minority of countries are effectively responsible for the majority of pollution. In the plastic context, according to one estimate, "20 countries, out of a total of 192 coastlines, are responsible for 83% of the plastic debris put into the world's oceans" (Tibbetts, 2015: A91). Another study concluded that reducing waste by 50 percent in the top 20 countries would result in a nearly 40 percent decline in inputs of plastics to the oceans (Leonard, 2015). More pollution (carbon, methane, plastic) now comes from the Asian region than others, but historically both industrial emissions and plastic were largely European and American innovations. It would be a constructive exercise to begin discussing the historical and contemporary plastic footprint of countries and even of individuals.

Most visibly, perhaps, small-island states are as disproportionately affected by aquatic microplastics as they are by extreme weather events and sea-level rise (see the chapters in Part II). They have contributed relatively little to these problems (see Costa and Barletta, 2015). This was acknowledged in the landmark 2011 Honolulu Commitment, whereby parties "recognized the need to address the special requirements of developing countries, in particular the Least Developed Countries and Small Island Developing States, and their need for financial and technical assistance, technology transfer, training and scientific cooperation to enhance their ability to prevent, reduce and manage marine debris as well as to implement this commitment and the Honolulu Strategy" (see later). Even with financial and technological assistance, implementing such policies can be difficult, as has been the case in the Pacific (see Chasek, 2010; Vince et al., 2017). These environmental justice concerns permeate both the plastic and climate change adaptation discourses for good reason.

Both climate change and microplastic pollution are severe threats to human health (on climate see Machalaba, Romanelli, and Stoett, 2017; on plastics see van Cauwenberghe and Janssen, 2014). Similarly, both climate and plastic pollution threaten the very existence of ecosystems on which humans and especially riparian and coastal communities are dependent. This makes both issues subject to the heritage-of-mankind concept, which asserts common responsibilities for conserving resources for future generations. The scientific uncertainty about the long-term impact of micro- and nanoplastic abundance on climate change – not only climate change impacts in the oceans but also on a global scale (because of the oceans' regulatory role in climate) – gives rise to the relevance of the precautionary principle in this regard. According to this principle, avoiding pollution is required to avoid potentially harmful consequences. Intergenerational justice is also a significant concept in both contexts, because lack of action today will certainly exacerbate hardship in the future.

Shared Governance of Climate Change and Marine Plastic Pollution

The governance arrangements involved in managing both climate change and marine plastic pollution are multifaceted and complex. Climate change has been labelled a "wicked" and "super wicked problem" (Lazarus, 2008; Levin et al., 2012), and marine plastic pollution is also categorized in a similar vein (Hastings and Potts, 2013). As with climate change policy, the complexity with regulatory approaches lies with the transboundary and cross-jurisdictional nature of the problem. The vast quantities of marine plastic waste can be localized, or it can travel via ocean currents to the most remote parts of the globe (STAP, 2011), highlighting the difficulties of attributing responsibility to any state, government, or organization for its removal. Microplastics make this even more challenging. The sources are so varied and widespread that technological advances to filter plastic waste from the ocean surface are too small in scale to have an impact.

Regulation is only one approach to managing macroplastic and microplastic marine debris. Economic/market and community-based efforts are also an integral part of the management, prevention, and mitigation of plastic pollution. Similar to climate change, this mixture of governance approaches is developed and implemented at the local, national, regional, and global levels, all at varying scales and degrees of success (Vince and Hardesty, 2016). Importantly, regulating, ceasing, or altering land-sourced microplastic pollution is the responsibility of national governments, and each jurisdiction will have different methods for doing this. In the United States in 2015, the California Assembly voted to prohibit the sale of microbeads in personal care products from 2020. California's actions with regard to marine debris are significant, and already the impact of the "California effect" (Fredriksson et al., 2002; Perkins and Neumayer, 2012) is being seen elsewhere. Other jurisdictions around the world are following suit by introducing microbead bans (see Rochman et al., 2015). However, by the time they are fully implemented, tons of microplastics will have entered the ocean. In Australia, microbead legislation has not been enacted, and state and federal governments have only agreed to voluntary approaches. Rwanda's outright ban on plastic bags and France's recent plastic utensil bans are examples, but resistance to such bans is also fierce in the United States and elsewhere.

Bottom-up, community governance solutions to marine pollution cannot be underestimated. Many of the positive changes to reducing plastic marine pollution have occurred through community action (Ghostnets Australia, 2015; Vince and Hardesty, 2016). Education (Derriak 2002; Duckett and Repaci, 2015) and the use of "citizen science" (Science Communication Unit, 2013; Hidalgo-Ruz and Thiel, 2015; Jambeck and Johnsen, 2015) increase engagement with the community and change the behavior of those involved with the use and removal of plastics from the marine environment. Local communities and nonstate actors are using social license to bring about change where regulation is lagging (Vince and Hardesty, 2016). While the larger nongovernmental organizations (NGOs), such as Greenpeace, Worldwide Fund for Nature, and the International Union for Conservation of Nature, usually take a holistic approach to the problem of plastic debris, other NGOs are issue specific. *Beat the Microbead* is an organization that distributes data on which products do or do not have microbeads, and it is accessible through their website or smartphone app (Beat the Microbead, 2015). Consequently, the consumer has the power through social license to drive changes to corporate policies and products (Morrison, 2014; Cullen-Knox, 2016; Vince and Haward, 2017).

The polarizing effects of politics surrounding plastic pollution are particularly noticeable in the microbead debate. The legislative changes and the voluntarily driven consumer demand have had a number of positive impacts on industries and the use of microbeads. Legislative loopholes remain for those companies that may not necessarily want to change from plastic to natural alternatives. Major retailers Coles and Woolworths in Australia have introduced bans across their stores as a response to consumer demand (Browne, 2016). Johnson & Johnson, and Procter & Gamble have all agreed to remove gradually polyethylene microbeads from their products (Abrams, 2015). However, it is unclear whether the microplastics will be replaced with bioplastics or natural alternatives. Corporations are varied in their responses to this issue and in the general use and life cycle of plastics. Changes to their corporate social responsibility (CSR) policies may have an impact. However, in the meantime the wider community and consumer demand exercised through social license will be a driver of change within the market.

According to a report by the secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel (GEF, 2012), "many companies now see packaging and plastics sustainability as part of broader corporate social responsibility, and negative brand image is becoming a major driving force which is being harnessed in the interests of improving packaging materials and technologies." In 2011, industry plastics associations came together and developed a global Declaration for Solutions on Marine Litter. Sixty-nine plastics organizations from 35 countries have signed this Declaration (Marine Litter Solutions, 2017). Market and economic governance approaches encourage industry to engage in corporate social responsibility and actively participate in reducing or removing plastic marine debris from the environment. UNEP's *Guidelines on the Use of Market-Based Instruments to Address the Problem of Marine Litter* (2009) identify market-based instruments as taxes, charges, fees, fines, penalties, liability and compensation schemes, subsidies and incentives, and tradable permit schemes. There are several basic principles behind these instruments: the polluter pays principle, the user/beneficiary pays principle, and the principle of full cost recovery. While market-based instruments have been used successfully to reduce macroplastic pollution (for example, Cho, 2009; Hardesty, 2014), little progress has occurred with their application in the management of microplastics, just as their ultimate impact on climate change mitigation remains contested.

Globally, the need to address the plastic problem is increasingly recognized, with discussions on marine plastic pollution occurring at international assemblies such as the World Ocean Summit and G7 (2015) and G20 meetings. Calls for a new legally binding international agreement have been made by a number of scholars (Stoett, 2010; Gold et al., 2013; Chen 2015; Vince and Hardesty, 2016; Raubenheimer and McIlgorm, 2017), demonstrating the large gap in international law for specifically dealing with land-based plastic marine pollution. The United Nations Law of the Sea Convention (UNCLOS) Part XII (Articles 192–237) is dedicated to the protection and preservation of the marine environment (see Chapter 2) and requires states to take all measures "that are necessary to prevent, reduce and control pollution of the marine environment from any source, using for this purpose the best practicable means at their disposal and in accordance with their capabilities, and they shall endeavor to harmonize their policies in this connection" (art. 194). Although UNCLOS sets out the responsibilities of states and necessary measures they need to undertake to minimize pollution, there are doubts that UNCLOS on its own can solve the plastics problem. While UNCLOS recognizes that there are six different sources of marine pollution, including land-based pollution, it does not go into detail about the type of pollutants and technical rules (Palassis, 2011). States are directed to adopt their own laws and regulations dealing with marine pollution and to work with relevant international organizations.

Soft law dominates global efforts to deal with plastic marine debris. While soft law is nonbinding, there is a strong expectation that it will be adhered to (Birnie and Boyle, 1992), and it maintains "a considerable practical significance" (Lyster, 1985). Joyner (2000) argues that soft law facilitates the process that gives rise to customary law and that it encourages compliance. With regard to plastic marine debris, soft law is an essential part of a nascent regime on ocean plastic. There are many examples of this, including:

- The UN Conference on the Environment and Development's Rio Declaration encouraged integrated, precautionary, and anticipatory marine environmental protection (United Nations, 1992). It set out an approach to addressing damaging impacts from air, land, and water; recycling; sewage treatment; and the prevention, reduction, and control of ship-sourced pollution. Plastic marine debris can certainly be added to this list.
- The Conference of the Parties to the CBD (COP CBD) and the Scientific and Technical Advisory Panel of the Global Environment Facility released a report on the impacts of marine debris on marine and coastal biodiversity in 2012. A decision to address the impacts of marine debris on marine and coastal biodiversity was adopted through Decision XI/18 at the 11th Meeting of COP CBD.
- The United Nations Environment Programme (UNEP) released several guidelines for dealing with marine pollution: *Guidelines on Survey and Monitoring of Marine*

Litter (2009), *Guidelines on the Use of Market-Based and Economic Instruments* (2009), and *Marine Litter: A Global Challenge* (2009). The latter report has a number of recommendations for the 13 participating Regional Seas Programs, including, *inter alia,* the development of a Regional Action Plan or strategy to deal with marine pollution; mitigation delivered globally but coordinated at the regional level and implemented at the national level; National Plans of Action that draw on existing legislation; and the coordination of UN organizations working on the marine litter problem.
- The *Honolulu Strategy* was formed with UNEP collaboration in 2012 as a global strategy to reduce marine debris.
- The UNEP Global Partnership on Marine Litter (GPML) was announced in 2012. It is a coordinating forum for stakeholders at all levels working on marine debris prevention and management.
- In 2014 the Global Ocean Commission Report recognized that the majority of marine debris is land sourced and called for a more coordinated effort by governments, the private sector, and civil society to stop plastic pollution before it enters the ocean.
- The parties of the United Nations Sustainable Development Summit (2015) agreed upon the goal to *Conserve and Sustainably Use the Oceans, Seas and Marine Resources*, including to "[b]y 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution."
- The G7 group released an *Action Plan to Combat Marine Litter* in June 2015, which included land-based and sea-based priorities to reduce marine debris.

The diffuse nature of the origin of plastic pollution in the oceans, and the abstract nature of the oceans crisis generally – it is far removed from most citizens' daily lives, or at least their daily consciousness – might make plastic pollution a difficult subject for proponents of global governance to sell to governments. The new discovery of microplastics in freshwater systems, which have an immediate impact on water supplies, fisheries, and other variables essential to human health, will prompt more policy action. The abstract nature of the problem is reshaped by the increased proximity to citizens and politicians.

Recommendations

It would betray any serious effort to integrate ocean governance issues to omit the plastic pollution issue. Its links to climate change demand an even more precise response. Toward this end, we have a number of recommendations:

a) The Honolulu Strategy should be reinvigorated by the adoption of a global accord to curb the purposeful and incidental dispersion of plastic waste into the marine environment (Gold et al., 2013; Chen, 2015; Raubenheimer, 2017). There is a global ethical imperative to establish such an accord, but it will be a long-term project demanding multilevel, adaptive governance. The accord should refer to the plastic–climate nexus to give it greater legitimacy and expand its scope.

b) The potential links between climate change and plastics pollution should receive ample research funding, as well as political consideration. Governments should integrate pollution limitation agendas with their climate change mitigation and adaptation plans. The Transboundary Waters Assessment Program (n.d., 2014) can be helpful in this regard as well.
c) Linked to the earlier point, marine plastic pollution should be seen as a justice issue. Plastic pollution is a fundamental challenge to the UN Sustainable Development Goals' "development-with-dignity agenda." Indeed, climate justice and the risks of plastic abundance in waterways are inseparable concerns and thus should be linked by activists accordingly.
d) More research is needed on the behavioral economics of marine litter (Wyles, 2014). Incentive structures need to be constructed for both governmental policy making and for consumer and producer behavior to reduce plastic consumption, as well as greenhouse gas emissions.
e) The Global Oceans Commission's suggestion to establish a Global Marine Responsibility Fund to help finance related retrieval and research efforts should be explored. Heavy investment in technological advancement for plastics retrieval is critical and should be partially funded by the plastics and fossil fuel industries, part of a broader regime of extended producer responsibility. This can be linked with climate initiatives where possible, and such efforts should take climate impact into consideration.
f) Though the extent of plastic in the oceans is a major problem, and industries such as aquaculture must be regulated, the main problem for future generations is the increase in land-based sources of plastic pollution, including microfibers released into water supplies with clothes washing and through other invisible forms of pollution. Tackling this issue demands fiscal and taxation strategies to reduce waste, updates in water treatment facilities, and harsh penalties for serious violations of dumping regulations. Many of these regulatory measures can also be applied to climate policy and will face similar problems regarding transparency, surveillance, and other monitoring challenges.
g) Governments and NGOs must continue to encourage the active involvement of "citizen science" in both climate and pollution monitoring. We can learn from previous positive experiences with invasive species identification and wastewater management.
h) Clear indicators are necessary for tracking progress. For example, the Convention for the Protection of the Marine Environment of the North-East Atlantic employs three indicators of marine plastic: seabed litter, beach litter, and ingestion by Northern fulmar seabirds. Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection and others are working on operational indicators. Such measurements should be integrated with climate models and assessments.

Conclusion

The aquatic plastic pollution problem can be linked to climate change. Emerging science suggests that ocean acidification, the potential breakdown of the ocean ecosystem food chain, rises in sea levels, invasive species, and plastic marine debris are interlinked variables. Thus, there is a global imperative, based on the four most widely accepted tenets of international environmental law – the precautionary principle, common but differentiated responsibilities, intergenerational equity, and the common heritage of mankind – to prevent further macroplastic, microplastic, and nanoplastic waste from entering rivers, lakes, and oceans. Since those who contribute least to both problems are the most heavily affected, environmental injustice is a common theme.

Climate governance efforts need to take the plastic plague seriously because plastic debris can disrupt the food chain, and by implication the ocean ecosystem's ability to regulate climate. This adds further fuel to arguments that serious tipping points on climate are approaching. Climate governance models assume that ecosystem resilience is a positive factor, necessary for the success of both long- and short-term efforts to mitigate and adapt to climate change. Indeed, the ecosystem-based adaptation approach hinges on this assumption. Plastic debris is a major threat to this resilience and could render many climate governance efforts fruitless if it is not addressed.

Converging international legal principles, actors, and governance mechanisms are involved in the plastic–climate nexus. Plastic production contributes directly to greenhouse gas emissions, and changes to the product cycle can have a positive impact on mitigation efforts. The shipping (see Chapter 23), oil and natural gas (Chapter 24), and tourism industries (Chapter 3) are all key sectors in both marine debris and climate change mitigation. Responses such as beach maintenance and coastal ecosystem conservation will involve many government agencies and clients. The evolving legal framework for plastic waste reduction may provide helpful models for the climate regime, and vice versa: the Paris Agreement, with its limited and self-defined legal obligations, may be the best model for plastic pollution reduction. Though it is also a limited device, UNCLOS will undoubtedly play an organizational role in both of these policy objectives, and it could place emphasis on their continued convergence.

There is no doubt that ocean governance needs to grapple with both climate change and marine plastic pollution as two of the major issues of our time. There is merit in considering the interlinkages between the two issues. It will be valuable to consider common, and perhaps even linked, policy responses to them.

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