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Eliminating Plastic Pollution: How a Voluntary Contribution From Industry Will Drive the Circular Plastics Economy

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Marine plastic pollution is a symptom of an inherently wasteful linear plastic economy, costing us more than US$ 2.2 trillion per year. Of the 6.3 billion tonnes of fossil fuel-derived plastic (FFP) waste produced to date, only 9% has been recycled; the rest being incinerated (12%) or dumped into the environment (79%). FFPs take centuries to degrade, meaning five billion tonnes of increasingly fragmented and dangerous plastics have accumulated in our oceans, soil and air. Rates of FFP production and waste are growing rapidly, driven by increased demand and shifting strategies of oil and gas companies responding to slowing profit growth. Without effective recycling, the harm caused by FFP waste will keep increasing, jeopardizing first marine life and ultimately humankind. In this *Perspective* article, we review the global costs of plastic pollution and explain why solving this is imperative for humanity's well-being. We show that FFP pollution is far beyond a marine environmental issue: it now invades our bodies, causing disease and dysfunction, while millions of adults and children work in conditions akin to slavery, picking through our waste. We argue that an integrated economic and technical solution, catalyzed through a voluntary industry-led contribution from new FFP production, is central to arrest plastic waste flows by making used plastic a cashable commodity, incentivizing recovery and accelerating industrialization of polymer-to-polymer technologies. Without much-needed systematic transformation, driven by a contribution from FFP production, humanity and the oceans face a troubling future.

Keywords: oceans, plastics, circular economy, voluntary contribution, technology, waste, linear consumption model, Sea The Future initiative

INTRODUCTION

Plastics are a ubiquitous and persistent form of marine pollution (Gago et al., 2018; Angiolillo, 2019; Barboza et al., 2019a,b) with contamination levels rising drastically on beaches (Barnes, 2005; Kako et al., 2014; Lavers and Bond, 2017), the seafloor (Matsuguma et al., 2017) and coastal and oceanic waters (Lebreton et al., 2018; Ostle et al., 2019). While our knowledge of ocean plastics is far from complete, the best available predictions suggest that with increasing mismanagement of fossil fuel-derived plastics (FFP) (Lebreton and Andrady, 2019) there will be one tonne of ocean plastic for every three tonnes of fish by 2025 (Ellen MacArthur Foundation, 2017), the equivalent of 600 plastic bags for every ten-kilogram fish. The most visible impact of marine plastic pollution is its harm to marine megafauna (Galgani et al., 2019) including turtles (Lynch, 2018; Wilcox et al., 2018), mammals (Panti et al., 2019), birds (Wilcox et al., 2015) and sharks (Parton et al., 2019), which ingest and become entangled in FFP with fatal consequences (Stelfox et al., 2016; Provencher et al., 2017). Millions of marine animals of at least 260 species die annually due to interactions with FFP (Moore, 2008; Thompson et al., 2009; Claro et al., 2019). These numbers are likely to increase as smaller and more elusive organisms are examined (Jamieson et al., 2019). Additionally, plastics transport invasive species and pathogens between marine regions (Rech et al., 2016; Lamb et al., 2018), inhibit gas exchange between sea water and seafloor sediments (Goldberg, 1997), and smother fragile seafloor inhabitants (Gregory, 2009).

Marine plastic pollution not only comprises visible items, such as single-use packaging and fishing gear, but also microplastics, particles <5 mm (Hidalgo-Ruz et al., 2012), and nanoplastics, $<1\,\mu$m (Gigault et al., 2018), released directly into the environment or created by the fragmentation of larger items. The legacy and reach of FFP is strikingly demonstrated by its impact on the most remote and inaccessible marine ecosystems. Jamieson et al. (2019) recently detected synthetic particles in the hindguts of the majority of crustaceans sampled in deep ocean trenches around the Pacific Rim, at depths from 7,000 to 10,890 m, the latter being the deepest point of the ocean. Over 72% of specimens contained at least one synthetic item in their digestive systems. Concerningly, preliminary Fourier-transform infrared spectroscopy (FTIR) analyses suggest that most of these synthetic materials were produced before the 1970s (Jamieson, personal observation), implying that they have taken 50 years to reach their current resting place and that the far vaster quantity of plastic pollution generated since is still working its way through the marine ecosystem. Plastics' invasion of natural environments now appears complete, with contamination found from mountain tops and polar extremes (Bergmann et al., 2019) to the remote depths of our oceans.

Plastics' fragmentation and dispersal as micro-particles may be the most insidious property of marine plastic pollution. FFPs contain dyes, flame retardants and plasticizers, some of which are persistent, bio-accumulative toxins (Rani et al., 2015). These compounds, along with water-borne pollutants absorbed into micro- and nanoplastics (Engler, 2012), can be transferred to organisms upon ingestion (Cole et al., 2011; Neves et al., 2015), contaminating them, their predators and potentially accumulating up food chains to human consumers of seafood (Bouwmeester et al., 2015; Rochman et al., 2015b; Vethaak and Leslie, 2016; Lusher et al., 2017; Santillo et al., 2017; Revel et al., 2018; Rist et al., 2018). Nanoplastics, while understudied at present, may pose the greatest ecotoxicological risk (Koelmans et al., 2015; Haegerbaeumer et al., 2019) because their concentrations at sea are likely higher than for microplastics (Andrady, 2011), they have a proportionally larger surface area for the absorption of toxic chemicals (Koelmans et al., 2015; Mattsson et al., 2015) and, critically, they can penetrate living tissues (Kashiwada, 2006; Rossi et al., 2014; Mattsson et al., 2017) causing intracellular damage (Brown et al., 2001; Haegerbaeumer et al., 2019). Observed effects of micro- and nanoplastics on experimental organisms include increased mortality (e.g., Lee et al., 2013; Ziajahromi et al., 2018), disease (e.g., Vasseur and Cossu-Leguille, 2006; Chae et al., 2018), inflammation in digestive and respiratory systems (e.g., Murray and Cowie, 2011; Jin et al., 2018), increased oxidative stress (e.g., Bhattacharya et al., 2010; Gomiero et al., 2018), disturbed feeding behavior (e.g., Cedervall et al., 2012; Nasser and Lynch, 2016) and compromised fecundity and reproduction (e.g., Bergmann et al., 2015; Sussarellu et al., 2016).

In this *Perspective* article, we argue that ocean plastic pollution is a symptom of a far broader issue, rooted in the way we place little to no value on a versatile material made from a finite resource, whose environmental legacy lasts decades following its brief usefulness to us. The solution to plastic pollution cannot rely solely on more ocean research (Borja and Elliott, 2019), education (Uyarra and Borja, 2016) and clean-up technologies (Sherman and van Sebille, 2016), nor in phasing out or replacing all FFPs (Rochman et al., 2015a). It requires us to shift the economics of FFPs from a linear to a circular model. We first review the cost of the plastic pollution problem and then propose a pragmatic solution to fix it, which builds beyond current proposals.

THE PRICE OF PLASTIC

Plastic pollution results from our failure to account for the full economic cost of FFP's manufacture and disposal, and its impacts on ecosystem services and human health. While our knowledge is incomplete, best estimates suggest that plastic costs humanity over US$ 2.2 trillion per year in environmental and social damage (UNEP, 2014; Ricke et al., 2018; Beaumont et al., 2019; Zheng and Suh, 2019). This is a consequence of a linear economic model in which resources flow unidirectionally from fossil fuels, are cracked into monomers (the building blocks of plastic "resins"), extruded into a final product, used, often briefly, and then discarded (Geyer et al., 2017; Hundertmark et al., 2018; **Figure 1A**). It is estimated that nearly 60% of this plastic waste is dumped into landfill and the environment, with at least 10% entering the oceans (**Figure 1B**; **Supplementary Materials** section Plastic Leakage to Oceans).

Most of the costs of plastic pollution damage results from impacts on our oceans (**Figure 1C**; **Supplementary Materials** section Plastic Pollution Damage Costs). An estimated ∼US$ 1.5 trillion per year is lost through reductions in the oceans' capacity to provide seafood, genetic resources, oxygen, clean water and recreational and cultural value, as well as critical regulation of Earth's climate (Beaumont et al., 2019). An additional ∼US$ 730 billion per year in losses occurs during FFPs' upstream lifecycle (UNEP, 2014; Zheng and Suh, 2019), due to a model of plastic waste management that is more "burn, bury, befoul" than "reduce, reuse, recycle." These costs include ∼US$ 700 billion per year from the release of greenhouse gases during FFP production and waste incineration (Ricke et al., 2018; Zheng and Suh, 2019), the release of toxic chemicals from plastics buried in landfill to soils and water sources (∼US$ 25 billion per year); water usage during plastic production and manufacturing (∼US$ 4.5 billion per year); release of plastic-associated pollutants into the

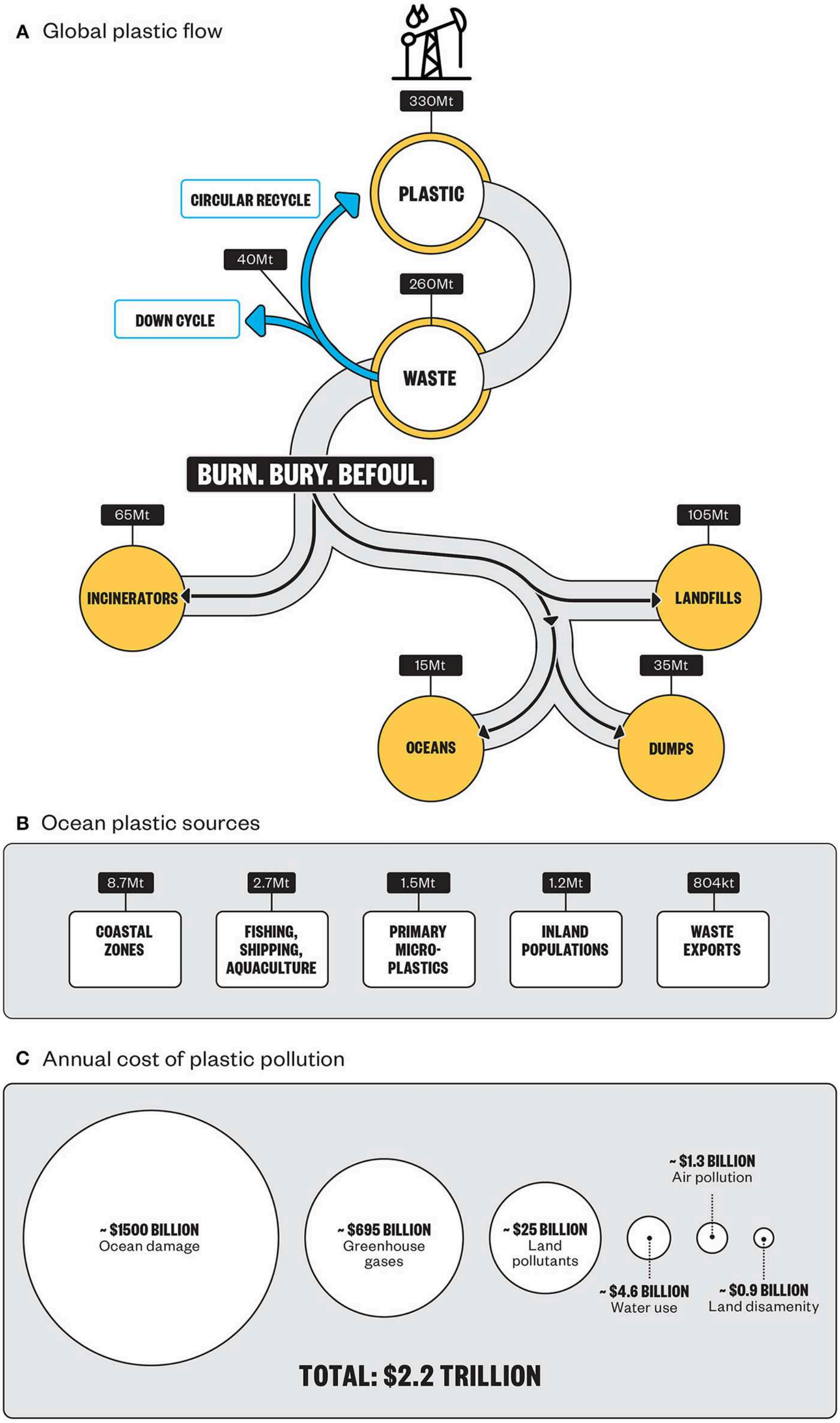

FIGURE 1 | The plastic problem. **(A)** Global plastic flow in 2016, as estimated by Hundertmark et al. (2018). Numbers within black boxes represent amounts (million tonnes per year) of plastics produced, wasted, recycled, incinerated, landfilled, dumped and leaked to oceans. **(B)** Break-down of the different sources of ocean plastics, in million tonnes per year: coastal zones (Jambeck et al., 2015), fishing (Watson et al., 2013; Bell et al., 2017; Lebreton et al., 2018), shipping (Halpern et al., 2008; Lebreton et al., 2018), aquaculture (FAO, 2016a; Lebreton et al., 2018), primary microplastics (Boucher and Friot, 2017), inland populations (Lebreton et al., 2017, 2018), and waste exports (UN Trade Statistics, 2018). **(C)** Break-down of the different costs associated with plastic pollution in US$ per year: ocean damage (Beaumont et al., 2019), greenhouse gases (Ricke et al., 2018; Zheng and Suh, 2019), land pollutants, water usage, air pollution, and land disamenity (UNEP, 2014). The data, limitations and assumptions used for the plastic mass flow and environmental economic analysis are described in **Supplementary Materials**.

air (~US$ 1.3 billion per year); and land value loss due to littering or proximity to waste disposal sites (~US$ 875 million per year; UNEP, 2014).

The estimated total cost of plastic pollution is likely conservative, as several important impacts are yet to be quantified, particularly those related to human health. Plastics can harm us both through the interaction of nanoplastics with human cells and our exposure to harmful additives in plastic products (Hermabessiere et al., 2017; Revel et al., 2018). Both nanoplastics and harmful additives occur in food packaging, household items and even medical equipment, entering the body via ingestion, inhalation and skin contact. Nanoplastics have been shown to cause damage and inflammation in human skin, lung and brain cells (Lehner et al., 2019) and may be linked to cancers (e.g., Pauly et al., 1998; Mastrangelo, 2003). Plastics also leach harmful endocrine-disrupting chemicals (Meeker et al., 2009; Talsness et al., 2009) which have been linked to:

- Cancer (Ohlson and Hardell, 2000; Brophy et al., 2012; DeMatteo et al., 2013)
- Obesity (Angel Nadal, 2012; Manikkam et al., 2013)
- Diabetes (Lang et al., 2008; Shankar and Teppala, 2011)
- Endocrine system disorders (Andra and Makris, 2012; Brophy et al., 2012)
- Thyroid disfunction (Ahmed, 2016)
- Reproductive impairment (Kabir et al., 2015).

Infants and children are the most vulnerable groups, due to their greater sensitivity and higher exposure to plastic-associated chemicals via baby food packaging (Fantoni and Simoneau, 2003), children's toys (Xie et al., 2015; Turner, 2018) and breast milk (Tanabe and Kunisue, 2007). Plastic contamination in humans has been detected globally (Koch and Calafat, 2009; Barboza et al., 2018), with the average US citizen consuming more than 74,000 microplastic particles annually (Cox et al., 2019) and an unknown but likely larger number of nanoplastics (Triebskorn et al., 2019). Further research is urgently required into the human health impacts and associated health-care costs of plastics and their ingredients.

A further unevaluated cost of plastic is the prevalence of acute labor issues in the waste management systems of many low and middle-income nations, where collection, recycling and disposal of domestic and imported waste are largely unregulated. The informal recycling sector employs an estimated 15–20 million workers globally (UNEP, 2015) and often creates abusive and hazardous conditions for a meager but crucial income (Wilson et al., 2006; Walk Free, 2018; GAIA, 2019). This highlights a moral dimension of plastic pollution: profits from fossil fuel extraction and plastic production typically accrue to a small number of companies headquartered in high-income nations, while waste disposal, burning and dumping, including of imported waste from wealthy countries, are usually shifted to low to middle-income nations (GAIA, 2019). This disconnect between production and disposal also weakens the impetus for consumers in rich, high consumption countries to shift behavior, since they are insulated from the consequences of their plastic habit (Torras and Boyce, 1998).

PRINCIPLES OF A SOLUTION

The US$ 2.2 trillion annual external cost of plastic pollution is not captured in the production costs of our linear plastics economy, representing a major market failure (Laffont, 2008). Whilst initiatives such as Extended Producer Responsibility (EPR) and plastics-related legislation have made some positive inroads to reduce plastic pollution, a system-wide change is needed to rectify this market flaw. A pragmatic solution is to apply an appropriate contribution to FFP at first production, whereby the supply chain passes on this price premium on raw FFP resin equitably through to the trillions of plastic items purchased each year by end consumers, converting plastic waste into a cashable commodity. This voluntary contribution, promoted publicly as the "Sea The Future" initiative, but referred to herein as "the Contribution", will also generate considerable funds to tackle the plastic issue, via investment in transformative technologies and by funding environmental remediation. Such a voluntary, industry-led contribution for FFP, applied at the resin production level, has the greatest potential to drive global manufacturing toward a circular economy (**Figure 2**; Schepel, 2005).

A circular plastics economy has remained elusive despite decades of concerted advocacy and public outcry. The key barrier to its realization has been the inability of circular recycling technologies to compete with the extremely low direct cost of producing FFPs. This perverse market price signal has meant that emerging technologies which can infinitely recycle most used plastic into high-purity polymers (e.g., Ragaert et al., 2017; Rahimi and García, 2017) have failed to achieve global-scale commercialization. A higher cost of FFPs, applied via the Contribution, levels the playing field and should drive plastic producers to rapidly seek out lower cost feedstocks. Demand for recycled polymers will ignite, transforming plastic waste from toxic and destructive into a cashable commodity, incentivizing recovery and recycling rates. This will have a transformative effect on the recycling industry as the next generation of polymer-to-polymer technologies are modularized, thereby enabling both an extremely low capital cost, compared with traditional large scale refineries and petrochemical plants (IHS Chemical, 2015), and placement at aggregation points of plastic waste (e.g., rivers, garbage depots, mine sites). This powerful competitive advantage, together with a level playing field, will energize new entrepreneurs and recycling businesses to contribute to the circular economy in both developed and developing markets (Baechler et al., 2013). Concurrently, mobile applications and artificial intelligence (AI) are set to remodel and decentralize waste collection services (Adams, 2018; Coelho et al., 2019). These peer-to-peer technologies have tremendous potential to connect billions of people currently not serviced by formal waste collection systems, increasing recovery rates without the need for expensive waste collection infrastructure. Access to this technology may also contribute to improving the livelihood of millions of disenfranchised waste-pickers through improved transparency, security and compensation (Walk Free, 2018).

The Contribution would also directly (via investment) and indirectly (via demand) support advances in

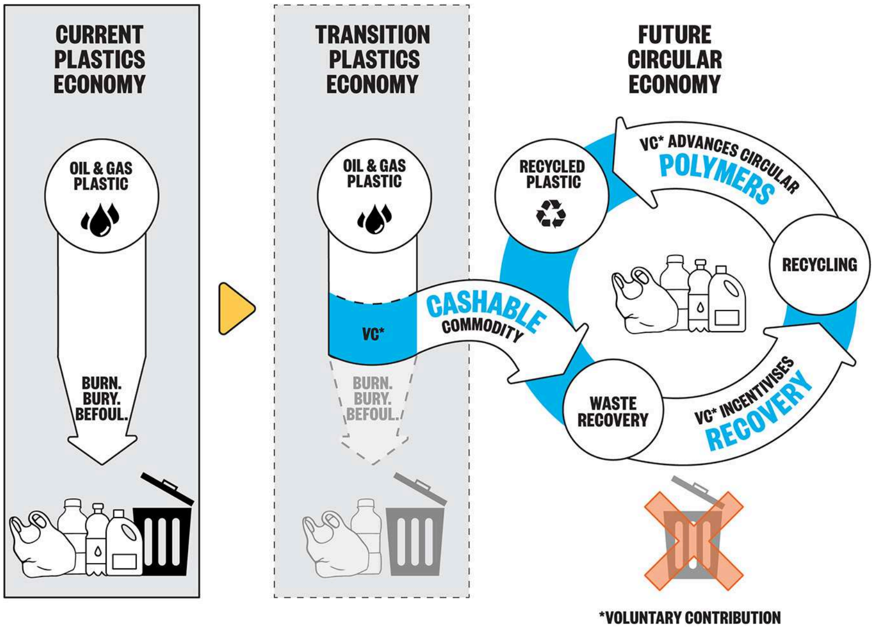

FIGURE 2 | Illustrations of the linear plastics economy (left), circular polymers economy (right), and transition plastic economy (center). Our proposed initiative will re-direct the flow of fossil fuel-derived plastics away from the environment and into the economy.

renewable, compostable biomaterials including "edibles" and polyhydroxyalkanoates (PHAs) (Shit and Shah, 2014; Dilkes-Hoffman et al., 2019a) derived from sustainable sources such as seaweed (Rajendran et al., 2012) and biomass residues (FAO, 2016b). These are ideal materials for problematic applications such as sachets and agricultural films (Dilkes-Hoffman et al., 2019b) as well as aquaculture and fishing gear likely to be lost at sea (Park et al., 2010; Bilkovic et al., 2012; Bugnicourt et al., 2014; Kim et al., 2016; UNEP, 2018).

In summary, the Contribution achieves the following:

- Transforms plastic waste into a cashable commodity, rewarding recovery and increasing recycling rates
- Incentivizes the plastic industry to reduce its use of fossil fuel feedstocks and seek out recycled and degradable alternatives
- Makes a material contribution to reducing climate change in the context of the global community's targeted temperature increase range, when considered on an accumulative basis to 2050 (Zheng and Suh, 2019)
- Halts the rising health impacts of plastics on both humans and other species and ensures viable ecosystem services
- Materially improves the profitability of polymer-to-polymer technologies and other supporting industries
- Is complementary to and supportive of the "Three Rs" philosophy, "Reduce, Reuse, Recycle," promoted by the circular economy community (Ellen MacArthur Foundation, 2019)
- Prioritizes technologies which keep plastics within the economy, e.g., purification, depolymerization and pyrolysis technologies (Sardon and Dove, 2018; The Center for the Circular Economy, 2019)
- Generates funds to develop waste management infrastructure, catalyze innovation and deal with legacy pollution issues, such as plastic waste accumulated in the oceans.

How Will the Contribution Be Implemented?

The most effective point to apply and collect the Contribution is at resin production, ensuring that it can be practically implemented and administered. This concentrated point in the supply chain, comprised of only a small group of producers (American Chemistry Council, 2013), facilitates the application of the Contribution on a simple, equitable and transparent per-weight basis, streamlining stakeholder participation and industry-wide application. As the cost of the Contribution is passed through intact from the base of the supply chain to the point of final consumption, it is divided out via manufacturing intermediaries, packaging companies and retailers (UNEP, 2014), to the end consumers, who each experience only a small price increase. To anticipate potential anti-trust concerns regarding the implementation of the Contribution, the lead author has engaged with global law firms to investigate the issue and believes that an initiative in the public good can comfortably operate within the law in countries across the world.

How Will the Contribution Be Governed?

Strict governance of the Contribution is paramount to avoid issues such as corruption and gaming of the system and to ensure that intra- and international value transfer is equitable and efficient, as the revenues from FFP production and the costs from its polluting effects often accrue in different regions (Abbott and Sumaila, 2019). Extended Producer Responsibility (EPR) policies (Hanisch, 2000; Spicer and Johnson, 2004; European Commission, 2019; Hilton et al., 2019) provide a template for a global scheme. EPRs often rely on a Producer Responsibility Organization (PRO) to act on behalf of the stakeholders and operate under clearly defined governance arrangements (Fleckinger and Glachant, 2010; Börner and Hegger, 2018; Park et al., 2018). Here, a global audit system will play a critical role and to circumvent concerns regarding governance costs the Minderoo Foundation has committed to underwrite up to 5 years of audit fees for a total cost of US$ 260 million, plus US$ 40 million in establishment costs, subject to appropriate conditions. As a further protection mechanism against fraud, a certification process would be implemented that could leverage blockchain technologies to track provenance (Kim and Laskowski, 2018), supported by technologies allowing identification of plastics via their chemical signatures (Primpke et al., 2018; Serranti et al., 2018). This potentially facilitates producer-specific labeling of plastics, informs consumer purchasing decisions and further drives industry adoption. A global PRO would allow funds raised from the Contribution to be aggregated and distributed according to a constitution that ensures efficient governance and management, timely allocation of funds and maximizes environmental, social and health benefits. Four constitutional pillars will be prioritized as follows:

1) Drive the global deployment and industrialization of polymer-to-polymer technologies and associated infrastructure as well as support the segments of the incumbent supply chain vulnerable to the impact of Contribution, during the transition from FFP to polymer-to-polymer production.
2) Provide pollution remediation where a market solution is not feasible, such as sedimentary build-up of plastics in rivers and landfills.
3) Recovery of oceanic plastics.
4) Other environmental policies as agreed, which may include mitigating climate change.

The first author has reached a preliminary agreement on these four pillars with a major consumer-facing organization. With respect to (1), the consensus reached was that the petrochemical businesses are the most vulnerable to the impact of the Contribution, but conversely have a key role to play in achieving a circular plastics economy (Hundertmark et al., 2018). It was agreed, under an initiative known as the Bridging Scheme for Industry (BSI), that part of the Contribution proceeds will be used to facilitate the industry-wide transition from fossil fuels to plastic waste, which eventually becomes its sole feedstock.

As the capital raised by the Contribution is estimated to reach at least US$ 20 billion per annum, these funds may eventually exceed the quanta required for priorities (1–3). While this excess could be fully refunded, it may instead be attractive to apply the balance to the mitigation of anthropogenic climate change, largely a by-product of the fossil fuel industry, under pillar (4). Given consumers have ultimately paid the cost of the Contribution, this would be an attractive outcome for the fossil fuel industry.

If Not a Voluntary, Industry-Led Contribution, Then What?

Should industry fail to act, then alternatives to the Contribution include government-led taxes, heightened industry regulation or joining international treaties with similar force. However, each of these interventions has drawbacks in the context of the complexity of plastics. Global treaties like the Montreal Protocol on Substances that Deplete the Ozone Layer, and the Stockholm Convention on Persistent Organic Pollutants, regulate the manufacture and application of specific chemicals with relatively narrow use cases, like chlorofluorocarbons and the pesticide dichlorodiphenyltrichloroethane. While both are supported by multilateral compensation funds and have successfully assisted countries to develop and promote safer alternatives to these niche chemicals, they do not address a problem as pervasive and embedded in every part of the consumer economy as plastics. Our most visible attempt to solve such a problem with an international treaty, the Kyoto Protocol and subsequent Paris Agreement, continues to attract criticism from environmental groups, academics and governments for the range of exemptions and trade-offs it offers to individual countries and industries, and its failure to achieve its central goal of reducing carbon emissions. Consequently, the US has yet to ratify the treaty and Canada has withdrawn from the protocol.

Compared with a global voluntary industry contribution, taxes and regulation in individual jurisdictions open the door for regulatory arbitrage and the requirement for border taxes on plastics imports. Trillions of plastics items are traded globally daily in varying different forms, from resin pellets to finished products, and often contain compositions of many different plastic types and other materials. As a result, the task for governments of administering taxes and regulations on goods, both domestically and across borders, is onerous and complicated, potentially compromising their effectiveness. Local governments may also invest tax revenue in programs unrelated to resolving the plastic problem, compromise on policies unpopular with voters, and be unwilling to redistribute proceeds to other countries, making it difficult to deal with the issues in many impoverished nations subject to exported waste.

The Contribution is a global solution with the potential to overcome many of these shortcomings by transcending the compliance issues related to a mosaic of national taxes, laws and treaties. Self-governed industry initiatives have also previously been applied successfully to challenges of cost recovery in the agriculture (OECD, 2017), fisheries (Townsend et al., 2008) and media industries (Leeds, 2006).

Ultimately, the Contribution and other interventions should not be seen as mutually exclusive and, in fact, will likely play complementary roles. For example, regulations can and should be used to tackle specific situations such as environmental leakage of nano- and microplastics and use of harmful additives in plastic products. In these cases, immediate alternatives are available, including compulsory filters on washing machines (McIlwraith et al., 2019), upgrades in wastewater treatment plants (Talvitie et al., 2017), regulatory frameworks to better prevent plastic pellet spills (Karlsson et al., 2018) and bans of both toxic plastic additives (Halden, 2010; Kole et al., 2017; Lahimer et al., 2017) and nano- and micro-plastics as ingredients in products (Rochman et al., 2015a; Hernandez et al., 2017).

What Should the Quantum of the Contribution Be?

An estimated contribution in the range of US$ 200 to US$ 5,000 per tonne is required to incentivize the collection and recycling of used FFP, with the quantum of the Contribution depending on the type of polymer. This equates to between ∼20% and 500% of the cost of FFP resin (The Plastics Exchange, 2019), translating into only a ∼US$ 1 to 3 cent increase in the cost of a take-away coffee, as an example. Assuming an average contribution of US$ 500 per tonne of FFP resin, the total cost of the Contribution is <10% of the US$ 2.2 trillion in damages currently caused by FFP pollution. Our suggested contribution range is based on anecdotal estimates collected during discussions with major stakeholders in the plastics supply chain, including oil and gas companies, resin producers, consumer goods brands, retailers and recycling businesses. As such this quantum is preliminary, with further economic modeling required to triangulate other factors, including the different incentive levels required to collect waste in different regions, capital market incentives and the price elasticity of plastics demand.

CONCLUSION

Plastic pollution damages societies, economies and natural environments, particularly the world's oceans. With plastic pollution's increasing visibility on land and at sea, pressure for action is mounting while an effective global solution to this "wicked problem" remains elusive. While removing plastic litter from oceans (Sherman and van Sebille, 2016) and replacing plastics with other materials (Song et al., 2009; Dilkes-Hoffman et al., 2019b) contribute to a solution, we suggest that a far broader economic and technical approach is needed to catalyze change. The proposed initiative, a voluntary contribution on new FFP production led by the global plastics industry, should jump-start the circular economy by transforming plastic waste into a cashable commodity. The new economics will help catalyze global-scale commercialization of polymer-to-polymer technologies capable of creating food grade polymers from plastic waste, while drawing plastic pollution from the environment back into the economy. If implemented successfully, the effects can be far-reaching: stopping the flow of plastics into oceans, giving economic opportunity to vulnerable people, funding remediation of contaminated ecosystems and protecting future generations from the toxicity of plastic waste.

DATA AVAILABILITY

All datasets for this study are included in the **Supplementary Material**.

AUTHOR CONTRIBUTIONS

AF conceived the idea. AF, JR, DT, and LG delineated the research and collated data from the literature. AF, LG, DT, JR, and JM wrote the manuscript. LG made the figures. All authors revised the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2019.00627/full#supplementary-material

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. Minderoo Foundation has committed to underwrite 5 years of audit fees for a total cost of US$ 260 million, plus US$ 40m in establishment costs, subject to appropriate conditions. The authors also declare that any existing and future investments that may form part of the FFP supply chain will be subject to the proposed initiative.