Submission to the Senate Enquiry on: 'The Threat of Marine Plastic Pollution in Australia'

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Author Credentials: Assoc. Prof. Osborn is a microbiologist and environmental scientist. Since moving to RMIT University in Dec. 2013, he has been building a research team focusing on the fate and impact of plastic and microplastic pollution within freshwater, marine and terrestrial environments around Port Phillip and its catchments and more broadly around the Australian coastline. This research includes consideration of the ecological interactions of polluting plastics with associated co-pollutants and also of the microbial biofilms that form on plastic surfaces. It builds on his earlier research that has demonstrated rapid microbial colonization of plastic surfaces in both sediments and open marine waters, and that the resulting microbial communities contain diverse algal and bacterial species. He has published over 75 research publications, cited >5,400 times, and his research on plastic pollution has featured on U.K. BBC Radio 4 and more recently on local radio and in local media in Melbourne.

SUBMISSION

1. Summary

In this submission, I briefly review some of the key environmental, societal and economic drivers and considerations relating to the problem of plastic pollution that now threatens our marine environments. More widely, I highlight the importance of considering the holistic linkages between terrestrial, freshwater and marine systems, as the marine system can not be considered in isolation of the source and transport routes for plastic pollution. The submission also briefly discusses the biological impacts of plastic pollution (physical and chemical), together with the emerging potential importance of the role of plastic-associated microbial biofilms. The latter part of the submission highlights some of the opportunities for harnessing the considerable Australia-wide expertise and interest in plastic pollution and I conclude by providing a short list of some of the knowledge gaps and challenges that require both further research and evaluation.

2. Living in the 'Plastic Age'.

We, alongside all other organisms, now live in the 'Plastic Age', with plastic infrastructure and industrial and consumer products now prevalent and playing a critically important role across every aspect of our lives **[1]**. However, the essential qualities of plastics, namely, resilience, durability, light weight, flexibility and resistance to degradation that have driven the adoption of plastics as materials of choice has also lead to the cosmopolitan distribution of plastic waste across the planet, and especially within marine environments. Globally, thousands of tons of plastic now enter our rivers, seas and oceans each year, with ocean surface waters alone containing over 5 trillion plastic pieces weighing over 0.25 million tons **[2]**. The vast majority of this plastic is present as microplastics, which are small (< 5mm) plastic pieces derived from the physical breakdown of larger plastics, together with plastic production pellets (nurdles; used as precursors in manufacturing), microbeads (from cosmetics) and microfibres (from clothing). The small size of microplastics makes them bioavailable to the majority of marine life.

Initially, environmental plastic litter was considered primarily as an aesthetic issue, but plastic pollution is now recognised as a major threat to aquatic organisms, due to the twin dangers associated with plastic entanglement or ingestion and especially because plastics can act as sponges adsorbing other co-pollutants and transport chemical pollution into aquatic foodwebs. The United Nations Environment Programme (UNEP) has now identified plastic pollution as a global environmental threat **[3]** with a proposal that plastic be designated as a hazardous waste product **[4]**. Since the 1950s, plastic infrastructure and industrial and consumer products have played an ever-increasing and significant role across every aspect of our lives. Global plastic production increased from 1.7 million tonnes in 1950 to 288 million tons in 2012 **[5]**, representing an 8.7% year-on-year increase **[6]**.

In Australia, annual plastic consumption in Australia exceeded 1.5 million tons in 2013/14 **[7]**, equating to ~65 kg of plastic each year for every single man, woman and child. Plastic products have led to substantive improvements in society and health **[1]**, including safer more resilient utility pipelines, medical implants, improved transport and numerous durable consumer products. Moreover, society has increasingly adopted convenient, but disposable, single-use plastics (e.g. beverage bottles, coffee lids, food packaging). In Australia in 2014, approximately 44% of plastic packaging (~0.23 million tons) was recycled **[7]** leaving the majority of packaging (~0.29 million tons) going primarily to landfill, incineration or released into the environment via littering.

Case Study: Plastic Packaging Consumption, Recycling and Litter in Victoria. In Victoria in 2013-14, plastic packaging consumption exceeded 0.13 million tons (~25 kg per capita), although Victoria led the way in Australia, recycling an estimated 86.8% of this packaging **[7]**. Despite this success, over 17,000 tons of plastic packaging in Victoria alone remained unaccounted for, with landfill and our natural environments as the key destinations. Across Melbourne, stormwater systems (comprising ~1,400 km of drains around Melbourne, including over 300 stormwater drains emptying directly into the bay) transport rainwater runoff and flush our litter into creeks, rivers and ultimately into Port Phillip. The extent of this litter transport is evidenced by the need for frequent, sometimes daily emptying of Parks Victoria litter traps on the Yarra River and that the Victorian government spent $80 million in 2012/13 alone on removing litter, including the removal of over 7,800 tons of litter and debris (including plastics) from Melbourne waterways.

3. The Problem(s) with Plastic.

The very qualities that make plastic so attractive (i.e. low weight, durability, resistance to degradation) are also the cause of their rapid prolific spread across our urban and natural environments. Once discarded, buoyant plastics such as polyethylene (PE, e.g. bags) and polypropylene (PP, e.g. bottle tops) can be readily transported via water into our bays, seas and oceans, so that plastic (mostly microplastic) is now ubiquitous in our ocean surface waters.

The United Nations Environment Program estimates over 10 million tons of plastic enter our oceans annually at an annual cost of US$13 billion dollars in environmental damage **[6]**. Around Australian surface waters, a CSIRO/UWA circumnavigation survey **[8]** has revealed plastic loads in excess of over 4,000 pieces km^{-2}, with highest incidences off Sydney and Brisbane (>15,000 pieces km^{-2}). It is noted that no data currently exists for the waters of Port Phillip receiving substantial plastic litter from Greater Melbourne. Plastic pollution will have long residence times (>270 days) in the shallow waters of Port Phillip due to the slow exchange of water and any associated pollution, due to the narrow inlet at the mouth of Port Phillip. Similar challenges will be faced in the waters of Sydney Harbour and other key Australian aquatic systems.

Some non-buoyant plastic including polyethylene terephthalate (PET), used in soft-drink bottles, (and also bioplastics) will sink, whilst microbial formation of biofilms may also cause reductions in PE and PP buoyant density driving sinking of these plastics to sediments. Internationally, studies of plastics in sediments have received less attention (than ocean waters), but marine and especially coastal sediments, including intertidal zones are now recognized as important sinks for plastic pollution **[9]**. I highlight that there is a scarcity of data describing plastic pollution abundance in sediments in Australian waters that consequently compromises our ability to predict the impact of these pollutants upon benthic systems. The University of New South Wales are currently undertaking studies of sediment plastic loads in Sydney Harbour (ARC-funded; CI: Prof. Johnston), but data is lacking for other major systems, including Port Phillip and also major rivers such as the Murray-Darling.

Typically, we are most aware of the aesthetic problems associated with (plastic) litter. However, we increasingly see the physical dangers for animals of plastic entanglement and suffocation (larger plastics, e.g. nylon ropes, plastic bags) and ingestion-caused starvation (e.g. dead marine birds have been found with over 250 pieces of plastic in their guts) **[10]**, whilst a very recent publication from CSIRO (Hobart) suggests that 99% of marine bird species will contain plastic within their guts by 2050 **[11].** We are far less aware of the dangers of plastic-additives such as phthalates or indeed of plastics acting as ‘sponges’ that accumulate and then transport persistent organic pollutants (POPs) and heavy metals into aquatic animals. These toxic chemicals can then be released into the gut and tissues of aquatic animals with pollution bioaccumulation up the food chain **[12]**. Microplastics (and also microbeads) are of particular concern as their small size means they can be ingested by the very smallest animals within the food chain, facilitating wider bioaccumulation. Most recently, researchers, (including in my research team) have begun to also investigate the potential importance of microorganisms upon the fate and impact of plastic and microplastic pollution in aquatic systems. These early studies demonstrate that plastic pollutants represent a surface for colonization by microbes, which form multi-species ‘biofilms’ **[13-16]**.

4. Opportunities.

Since arriving in Australia, it has become clear to me that there is considerable expertise in marine and aquatic plastic pollution. These include research teams in CSIRO, UNSW, UWA and at RMIT University, in addition to state-level organisations e.g. EPA Victoria and Parks Victoria and the expertise of the numerous City and Shire Councils that are managing litter and pollution as part of their remit.

More broadly there is tremendous community interest in plastic pollution, ranging from groups such as Tangaroa Blue, the TwoHandsProject and Beach Patrol to the many local community groups caring for their own local environments and habitats. In Melbourne, I highlight the excellent work of the Port Phillip EcoCentre, and the development of their excellent BayKeepers documentary (https://www.facebook.com/baykeepers).

Harnessing their energy but also their local expertise, in coordination with state and council groupings, and in conjunction with research institutions and environmental agencies, this offers a powerful route to promote improved education of the wider population. There is also the potential to develop a more coordinated Citizen-Science led program to quantify plastic loads and to collectively provide the regional-, state- and national- evidence base to inform the development of how best to reduce plastic pollution entering our aquatic systems.

Finally, any development of an effective plastic pollution strategy must consider actively involving the plastics and retail industry. Around Melbourne (and elsewhere), the plastics industry (including the developing bioplastics industry) is an important employer, and a constructive strategy should seek to work in partnership with plastic producers and also major retail, especially supermarkets. Additionally, development of plastic pollution reduction strategies should be conducted in partnership with the waste management and recycling industries.

5. Knowledge Gaps and Future Challenges

Firstly, it is noted that the scope of this enquiry is on the threat of plastic pollution within **marine** waters. However, as plastic pollution is derived from terrestrial systems and transported via stormwater and other freshwater systems, including creeks and rivers, I would strongly advocate that the enquiry should also consider these terrestrial and freshwater inputs and transport systems. Here, I take the opportunity to outline a number of key knowledge gaps and future challenges that relate to the threat of plastic pollutants to Australian marine (and other aquatic) environments:

1. What are the loads of plastic in our freshwater, stormwater, estuarine and marine systems, including loads in sediments and riparian zones? At which locations, could we implement more effective trapping of plastics entering aquatic systems?
2. What are the impacts of plastic-associated co-pollutants upon marine (and other aquatic) species, in particular, those species that are additionally vulnerable to other environmental stresses, including climate change and ocean acidification?
3. What are the roles of microorganisms in plastic pollution, with respect to the potential for microbial degradation of plastics and/or co-pollutants or conversely their potential to drive accumulation of pollutants into plastic surface biofilms and/or transport of plastics to sediments?
4. What are the fates and effects of bioplastics within aquatic systems? Current regulation requires evaluation of bioplastic degradation in composting and soil systems. However, in aquatic environments, the persistence of bioplastics is prolonged due to lower numbers of degrading microorganisms, and/or nutrient limitation.
5. What are the current and near-term strategies and products available that we can use to replace oil-based plastic packaging in the supply chain?
6. What are the key 'shovel-ready' strategies that could be deployed to immediately reduce plastic pollution? Cost-benefit analysis should be undertaken in relation to a raft of topics, including:
   - ❒ Beverage bottle deposits (e.g. as already employed in Northern Territory and South Australia) and/or drinking water bottle bans. If implemented, the latter would require further roll-out of drinking water fountains e.g. as seen in TapSydney: http://www.tapsydney.com.au or in Melbourne: https://www.melbourne.vic.gov.au/CommunityServices/CommunitySafety/Documents/drinking_fountain_map.pdf
   - ❒ Plastic bag bans and/or compulsory charging for plastic bags.
   - ❒ Improved recycling; for example, several states do not permit plastic bags to be

included in recycling bins.

❒ Improved transport of plastic production pellets (e.g. more secure packaging and containment) to minimize spillage and subsequent dispersal via wind and into water.

❒ Bans of microbeads in cosmetic products

❒ Education campaigns promoting recycling (including of plastics)

6. Supporting References

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