In a nutshell: Microplastics and fisheries

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An important and emerging issue for fisheries in the Pacific is the increasing prevalence of microplastics in ocean habitats. Recent evidence suggests they present increasing physical and toxicological risks to marine organisms (Law and Thompson 2014; Teuten et al. 2009) with the potential for compromising Pacific food security and trade initiatives. Furthermore, there is mounting evidence of their increasing abundance and global distribution (Cole et al. 2011; Law et al. 2010). This includes the coastal and oceanic habitats in the Pacific region.

What are microplastics and how do they get into our oceans?

Microplastics are microscopic particles of plastic typically smaller than 1 mm but also includes plastics that are less than 5 mm. The sources of this type of pollutant are diverse (Browne et al. 2011). Some are the direct result of small granules that are manufactured for industrial applications (e.g. microbeads, resin pellets) that enter marine ecosystems through accidental spillage (both at sea and on land), and failure to adequately contain waste from processing plants and their inappropriate use (Cole et al. 2011; Thompson et al. 2009a). Others are formed in the marine environment as a consequence of the breakdown of larger plastic material (Thompson et al. 2009a). More recently, studies have identified diffuse origins of microplastics such as the shedding of synthetic fibres from textiles by domestic clothes washing and from the use of microbeads in the cosmetics industry (Browne et al. 2011). In both of these cases the microplastics enter marine ecosystems through poor wastewater management (Browne et al. 2011).

Although the sources of microplastics may be localised, due to their buoyancy and longevity, they can become distributed throughout the marine environment through hydrodynamic processes (Law et al. 2010; Lebreton et al. 2012). Densities of microplastics are reported to be higher in regions that are nearer to the point source of the pollution, such as urban centres, harbours, and coastal habitats (Barnes et al. 2009; Claessens et al. 2011; Desforges et al. 2014; Todd et al. 2010); however, they are also reported in the coastal sediments of remote islands where there is little or no local plastic production (Baztan et al. 2014; Ivar do Sul et al 2009; Ivar do Sul et al. 2014; Pruter 1987) and in the open ocean, in particular, accumulations within subtropical gyres (Goldstein et al. 2012; Law et al. 2010; Lebreton et al. 2012; Martinez et al. 2009; Moore et al. 2001). Densities as high as 100,000 plastic particles per cubic meter of seawater have been reported in an area adjacent to a polyethylene production plant (Wright et al. 2013) and 33 particles per cubic meters in the north Pacific tropical gyre (Goldstein et al 2012).

The risk to marine fauna

Information of the ecological consequences of microplastic pollution is nascent; however, there is increasing evidence of direct and indirect effects associated with the ingestion by organisms and the toxic responses from inherent contaminants leaching from the microplastics and from extraneous pollutants that adhere to them (Cole et al. 2011; Teuten et al. 2009). The size of microplastics is equivalent to many plankton species and it has been hypothesised that planktivores, filter feders and suspension feeders passively ingest microplastics during normal feeding patterns (Wright et al. 2013). Once microplastics settle into sediments, they also become available for incidental ingestion by detritus feeding organisms (Murray and Cowie 2011; Thompson et al. 2004), including sea cucumbers (Graham and Thompson 2009). The ingestion of microplastics is hypothesised to have the same effect as that observed for ingestion of macroplastics in vertebrates, including internal and/or external abrasions and ulcers, and blockages of the digestive tract, resulting in reduced reproductive fitness, and increases in natural mortality rates due to increased potential for drowning, diminished predator avoidance and impairment of feeding ability (Wright et al. 2013).

The manufacture of many plastics often includes additives (e.g. polybrominateddiphenyl ethers, nonylphenol, triclosan) to extend the longevity of the product, and these additives are potentially toxic to biota if they leach out during ingestion (Barnes et al. 2009; Browne et al. 2007; Thompson et al. 2009b). Microplastics also provide surfaces for the attachment of other waterborne-pollutants, including metals (Ashton et al. 2010; Holmes et al. 2012), and POPs (persistent organic pollutants) (Hirai et al. 2011; Mato et al. 2001; Rios et al. 2007; Teuten et al. 2009), some of which are endocrine-disrupting chemicals (Rochman et al. 2014). POPs are hazardous humanmade chemicals such as polychlorinated biphenyls (PCBs), different sorts of organochlorine pesticides (e.g. DDTs and HCHs) and brominated flame-retardants. All of these toxins can impact the mobility, reproduction and development, and immune responses and carcinogenesis in wildlife and humans (Barnes et al. 2009; Cole et al. 2011; Teuten et al. 2009). POPs accumulate in fatty tissues of marine organisms. Although bioaccumulation has been detected in marine organisms (Cole et al. 2011; Besseling et al. 2013; Teuten et al. 2009) the importance of microplastics as a vector for magnification of persistent, bioaccumulative and toxic substances in higher trophic organisms remains uncertain (Gouin et al. 2011).

Microplastics may also act as a vector for more indirect ecosystem change. Species that were once restricted by a lack of hard substrate are potentially able to proliferate from the increase in surfaces for attachment (Goldstein et al. 2012; Gregory 2009). The consequences to industries that are reliant upon current ecosystem structures (e.g. some mariculture businesses) may be detrimental if such species are invasive.

The international response

The prevalence of microplastics in the marine environment is likely to increase in the immediate future given the rising consumption of plastics worldwide (Thompson et al. 2009a). International awareness and response on microplastics, however, is gaining momentum. Global initiatives such as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, the International Convention for the Prevention of Pollution from Ships, and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter have been in existence for several decades. More recently national initiatives have been initiated. For example, in the United States, legislation banning microbeads has been introduced to the US House of Representatives. Similar legislation has also been introduced to legislators in New York, and recently passed in Illinois and California. The European Parliament has also voted to phase out plastic bags that fragment rather than degrade.

The implications of microplastics for Pacific fisheries

The implications for fisheries from microplastics are poorly understood and largely speculative due to a lack of knowledge in key areas for policy formation. The prevalence of microplastic pollution across the Pacific needs to be clarified. There is sufficient evidence to indicate higher densities in the north Pacific tropical gyre and the coastal habitats of Asia, Japan and the Americas, although information on the prevalence of microplastics in the coastal regions of the Pacific Island countries and other oceanic habitats is missing. Based on observations from other oceans and modelling, microplastics can be expected to be present in those areas as well. A surveillance programme for Pacific Island countries would resolve this data gap but also identify which fisheries are most likely to be impacted. For example, a better understanding of microplastic distribution may assist with planning for sea cucumber aquaculture and/or mariculture investments in the region to avoid potential for lowered performance or product contamination.

Similarly, initiatives to improve food security through increases in fish consumption in the region may be compromised from bioaccumulation of toxins in coastal and oceanic fishes. Designing a surveillance programme that establishes a baseline reference of toxin accumulation in food security species would determine the potential for acute or chronic health consequences for Pacific Island communities from exposure to this pollutant.

A better understanding of the spatial distribution of microplastics and the bioaccumulation in higher order predators may also assist with the trade associated with the region's tuna fisheries. Opportunities may exist to obtain a higher price for products that come from areas with very low or zero prevalence of microplastic pollution.

The longevity and buoyancy of microplastic means that pollutants can cross several jurisdictional boundaries before they settle into sediments. The transboundary nature of the pollutant calls for both regional and national policies to minimise impacts. Developing a regional strategy for microplastics would be an important first step that would guide the development and implementation of surveillance activities, identify risk to industry and trade (e.g. invasive species), and guide the development of appropriate national policies on this topic.

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