Quantifying Microplastic Exposure in Coastal and Marine Sentinel Species

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Research is continuously uncovering the vast amounts of plastic debris polluting our marine environment, with an estimated 4.8 to 12.7 million tonnes of plastic entering the ocean each year. Plastic has now been reported in sediments – from the deepest parts of the ocean to coastal beaches, the atmosphere, and the top of our highest mountain peaks. Due to the buoyancy of plastics and the dynamic nature of marine environments, plastic items are easily dispersed throughout the ocean. Smaller fragments of plastics, termed microplastics, are particularly concerning due to their ubiquitous nature. Despite being invisible to the naked eye, microplastics represent over ninety percent of plastic debris found in our oceans today.

Microplastics can be divided into two groups – primary and secondary. Primary microplastics refer to microplastics that are purposely manufactured for specific uses, such as microbeads found in personal care products and industrial pellets. Whereas, secondary microplastics refers to smaller fragments of larger plastics that have mechanically broken down over time. Most microplastics found in marine environments are secondary particles, having been weathered and degraded by physical and biological forces such as wave action and ultraviolet (UV) light exposure. The combination of microplastics being both miniscule and pervasive make them especially difficult to identify, and as a result, their effects on marine ecosystems are poorly understood.

One of the reasons why microplastics are difficult to study is because of the inconsistencies surrounding the classification of microplastics by size and polymer type (composition). Currently, particles less than five millimetres in diameter are considered microplastics. However, microplastics can include particles that are visible to the naked eye (1–5 millimetres) down to nanoparticles (less than 0.1 micrometre) that are only visible through a powerful microscope. Precise definitions of these size categories have been the source of much scientific debate, and few data exist for birds, particularly in Australia. The lack of data is primarily due to the complexity and resources required to analyse such small particles. However, without accounting for nano-plastic particles, accurate assessments of plastic exposure within individual organisms (i.e., when wildlife accidentally ingest plastic) cannot be achieved, resulting in underestimations and data gaps. Additionally, providing information on the polymer type will enable researchers to assess the exposure of wildlife to plastic-derived chemicals.

The dissection of a short-tailed shearwater (*Ardenna tenuirostris*), showing part of the gastrointestinal tract. Image: Lillian Stewart.

Why Are Microplastics a Concern?

Increasing evidence of the harm posed by plastic ingestion in marine birds consists of blocked digestive tracts leading to harmful perforation, altered feeding and foraging behaviours, and exposure to harmful chemicals. The health implications of exposure to small microplastics and especially nano-plastics, are poorly known. It has been reported that nano-plastics are able to cross the boundaries of membranes in marine organisms, impacting biological functions, for example, changes in growth rate, malformations, and mortality. However, before we can begin to understand the consequences of microplastic exposure on marine birds, we first need to know how much plastic the marine birds are consuming.

Two projects are being conducted, one on seabirds and the other on shorebirds. Both projects aim to:

1. Investigate and quantify plastics found within the gastrointestinal tract of seabirds, and compare size ranges between all stomach compartments,
2. Investigate and quantify whether shorebirds in Australia are also ingesting microplastics, and
3. Generate baseline data sets specifically for nano-plastics, as there is currently limited data on their accumulation in marine wildlife.

Seabird Project

Most seabird studies have focussed on the ingestion of larger plastic items (greater than one millimetre) and have provided data only for the main stomach compartments (proventriculus and/or gizzard). For this project, plastics will be collected from the entire digestive tract of two Australian seabirds: the short-tailed shearwater (*Ardenna tenuirostris*) and flesh-footed shearwater (*Ardenna*

Top: Collaborative teamwork during shearwater dissections. Image: Doctor Jennifer Lavers.

A hooded plover (*Thinornis rubricollis*) providing a precious guano sample on a Tasmanian beach. Image: Doctor Eric Woehler.

Karli Mylius is looking for shorebirds. Image: Javier Merrill.

Karli Mylius is a Master student at the Institute for Marine and Antarctic Studies at the University of Tasmania. Karli hopes to contribute to wildlife conservation by shining a light on the impacts of plastic pollution unseen to the naked eye. Image: Doctor Eric Woehler.

Bianca Keys with a red-footed booby (*Sula sula*). Bianca Keys is an Honours student at the Institute for Marine and Antarctic Studies at the University of Tasmania. After participating on a research voyage for one month in the Coral Sea, she instantly fell in love with seabirds and their adaptations to life at sea. Moving to Tasmania and discovering a new part of Australia allowed Bianca to immerse herself in a unique environment and join a collaborative and supportive laboratory team while contributing to seabird research. Image: Kaarel Raia.

carneipes). Few data are available that describe the role seabirds play in transporting and depositing plastics in their breeding habitats (e.g., islands). Therefore, the project will also discuss the fate of ingested particles, with reference to nanoparticles for which there is currently no data. Freshly deceased carcasses of both shearwater species will be necropsied to quantify the ingested plastics and describe their distribution within the digestive tract.

Shorebird Project

The second project focuses on two Tasmanian resident shorebird species, the hooded plover (*Thinornis rubricollis*) and Australian pied oystercatcher (*Haematopus longirostris*). The project will assess micro- and nano-plastic exposure by examining guano. The data on plastic ingestion in shorebirds is extremely limited, globally, with no research on Australian resident shorebird species. The project will provide insight into whether the birds are ingesting small plastics via the intertidal sediments where they forage. By assessing the microplastics found in the guano of the birds and comparing these to sediment samples, we can assess whether the plastics are being excreted or retained by the birds (i.e., within their digestive tract).

Both projects have been designed with non-invasive methodology in mind, using necroscopy of already deceased shearwaters and the guano of shorebirds, thereby limiting disturbance to these vulnerable species. Two digestion treatments will be used to extract the plastics and eliminate any biological material to assess microplastics within the digestive tract and guano samples. The first will be an enzymatic digestion using trypsin, and parallel to this, the project will also use potassium hydroxide for a chemical digestion. Flow cytometry and Fourier transform infrared spectroscopy (FT-IR) will be used to obtain precise measurements of the abundance and composition (polymer type) of the ingested plastics.

FUNDS PROVIDED BY THE AUSTRALIAN WILDLIFE SOCIETY will contribute to field and travel expenses to the chosen study sites, including University car hire. Funds will also be used to purchase laboratory equipment such as anodisc filters, which will allow the researchers to perform the desired analysis using flow cytometry and FT-IR. These instruments provide accurate and efficient quantification and identification of microplastics.