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Understanding the effects of marine debris on wildlife

Executive Summary

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Executive Summary

Marine debris is a global environmental issue of increasing concern. Marine ecosystems worldwide are affected by human-made refuse, much of which is plastic. The potential impacts of waste mismanagement are broad and deep. Marine debris comes from both land and sea-based sources and can travel immense distances. It can pose a navigation hazard, smother coral reefs, transport invasive species and negatively affect tourism. It also injures and kills wildlife, can transport chemical contaminants and may pose a threat to human health.

Marine debris includes consumer items such as glass or plastic bottles, cans, bags, balloons, rubber, metal, fibreglass, cigarettes and other manufactured materials that end up in the ocean and along the coast. It also includes fishing gear such as line, ropes, hooks, buoys and other materials lost on or near land, or intentionally or unintentionally discarded at sea.

The Australian government has recognised marine debris as a key threatening process, because of the potential harm it poses to wildlife. In 2003, 'injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' was listed as a key threatening process under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). A key threatening process is defined as one that 'threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community'. Under the EPBC Act, the Australian government implemented the Threat Abatement Plan (TAP) which focuses on strategic approaches to reduce impacts and injuries to marine fauna and ecological communities.

CSIRO's national marine debris project set out to address knowledge gaps identified in the TAP. The project engaged with young Australians while collecting robust, scientific data relevant to the global marine litter problem. To understand the patterns and sources of marine debris and assess the potential harm posed to Australia's marine fauna, our research sought to address four questions:

1) What are the sources, distribution, and ultimate fate of marine debris?

2) What is the exposure of marine wildlife to debris?

3) When wildlife are exposed to debris, what factors determine whether animals ingest or are entangled by debris?

4) What is the effect of ingestion or entanglement on marine wildlife populations?

To address the first question, we carried out a national coastal marine debris survey at sites approximately every 100 km along the Australian coastline. Parts of this work and related research activities were incorporated into TeachWild, a national three-year marine debris research and education program developed by Earthwatch Australia together with CSIRO and Founding Partner Shell. This is the world's largest scale, integrated, rigorous collection of marine debris data.

As part of TeachWild, we engaged with more than 5,500 students, teachers and Shell employees in one-day research and training projects that helped to build knowledge, skills and to change attitudes in issues relating to ocean health. We engaged with more than 150 teachers and Shell employees in immersive, single and multi-day field-based research expeditions led by CSIRO scientists. We also developed curriculum content using marine debris as a teaching tool for science and mathematics to meet the Australian national curriculum guidelines. CSIRO scientists inspired students to explore their world through science in ways that were meaningful and relevant, motivated teachers through innovative learning, and helped increase

capacity and networks for educators and citizen scientists, in Australia and beyond. Staff scientists engaged in live-links and video calls that enabled students and Shell employees to ask questions, promoting deeper community engagement. Through this project we connected schools, communities and industry with scientists on a globally important conservation issue through extensive communication, outreach, interviews, webinars, video calls and face-to-face activities. Overall, we reached more than one million Australians, helping to educate them about and increase their understanding of marine debris.

Another key area of deep engagement for CSIRO scientists took place through mentoring and advising the next generation of researchers. CSIRO scientists have been mentors to eight international students who participated in the marine debris project. This included postgraduate students and undergraduates seeking experience in research institutions outside of their home institution as part of their undergraduate or post-graduate education. CSIRO scientists also supervised four Australian honours and PhD students whose research is focused on marine debris issues.

We also developed a public, online, national marine debris database. Here, members of the public can contribute data they collect about local beach litter, following our simple methodology that is freely available online. We also engaged with existing initiatives such as Clean Up Australia, Tangaroa Blue and Surf Rider Foundation, as well as other remarkable NGOs and state based organizations that are cleaning up Australia's beaches. Together, all of these organisations and citizen scientists contribute to the improved understanding of the types, amounts and sources of debris that arrives on Australia's coastline.

Type, source and quantity

We found that within Australia, approximately three-quarters of the rubbish along the coast is plastic. Most is derived from nearby sources, with some likely to be from overseas. In coastal and offshore waters, most floating debris is plastic and the density of plastic ranges from a few thousand pieces of plastic per km^2 to more than 40,000 of pieces of plastic per km^2. Debris is more highly concentrated around major cities, suggesting local source point pollution.

Threats to marine fauna

As the quantity of debris increases in the marine environment, so does the likelihood of impacts from debris to marine fauna. Plastic production rates are intensifying, and the volume of refuse humans release into marine systems is growing at an exponential rate. Litter impacts wildlife directly through entanglement and ingestion and indirectly through chemical affects. We have documented rates of each of these mechanisms through dissections, literature reviews, chemical analyses and modelling.

Ingestion risk to marine turtles

We found that the ingestion of anthropogenic debris by marine turtles has increased since plastic production began in the 1950s. Smaller, oceanic-stage turtles are more likely to ingest debris than coastal foragers, and carnivorous species are less likely to ingest debris than herbivores or gelatinovores. Our findings indicate oceanic leatherback turtles and green turtles are at the greatest risk of both lethal and sub-lethal effects from ingested marine debris. Benthic phase turtles favour soft, clear plastic, supporting the hypothesis that marine turtles ingest debris because it resembles natural prey items such as jellyfish. Most items ingested by turtles are plastic and positively buoyant. We estimated the risk of ingestion across turtle populations at the global scale, and identified regions, such as the north-eastern Indian Ocean, where risks appear to be particularly high.

Ingestion risk to seabirds

We developed a new simple, minimally invasive way of quantifying plastics exposure in seabirds. It can be applied at individual, population and species levels and it has no observed detrimental impacts. We also carried out a global risk analysis of seabirds and marine debris ingestion for nearly 200 species and found that 43% of seabirds and 65% of individuals within a species have plastic in their gut. Our analyses predict that plastics ingestion in seabirds may reach 95% of all species by 2050, given the steady increase of plastics production. We identified high risk regions for seabird impacts, finding a global hotspot in the Tasman Sea between Australia, New Zealand, and the Southern Ocean. In a species-specific study involving TeachWild participants, we found that 67% of short-tailed shearwaters (*Puffinus tenuirostris*) ingested litter. Juvenile birds were more likely to ingest debris than adult birds, and young birds ate more pieces of debris than adults. Birds ate everything from balloons to glow sticks, industrial plastic pellets, rubber, foam and string.

Entanglement risk to turtles and pinnipeds

Entanglement poses a significant risk to marine fauna. Seabirds, turtles, whales, dolphins, dugongs, fish, crabs and crocodiles and numerous other species are killed and maimed through entanglement. We estimate that between 5,000 and 15,000 turtles have become ensnared by derelict fishing nets in the Gulf of Carpentaria region. For pinnipeds in Victoria, the majority of seal entanglements involved plastic twine or rope, and seals become entangled in green items more than in any other colour. In general, young seals are entangled in greater numbers than adults.

Prevention and Recommendations

The most effective way to reduce and mitigate the harmful effects of marine debris is to prevent it from entering the marine environment: cleaning up our oceans is a much less practical solution. To reduce litter inputs requires incorporating an improved understanding of debris at the local, regional and national levels. Improved waste management efforts, targeted education and outreach activities, and technology solutions are also required.

We investigated drivers for releases of debris into the ocean and the potential effectiveness of responses in three contexts. Using our coastal survey data and interviews with more than 40 coastal councils around Australia we investigated the likely drivers for marine debris and effectiveness of local policy responses. We found evidence for two main drivers, general consumer/user behaviour and illegal dumping of refuse. Similarly, we found that local council outreach, which presumably affects user behaviour, and anti-dumping campaigns were both effective in reducing the debris found in coastal areas. We examined the drivers for lost fishing gear and found that they were a mix of overcrowding on fishing grounds, poor crew training, and enforcement evasion. We also evaluated the effectiveness of incentive schemes, such as South Australia's container deposit scheme, in reducing waste lost into the environment. The scheme appears to be very successful, reducing the number of beverage containers, the dominant plastic item in the environment, by a factor of three.

By garnering the information needed to identify sources and hotspots of debris, we can better develop effective solutions to tackle marine debris. For example, fisheries management aimed at reducing losses of fishing gear at sea would undoubtedly result in less wildlife harmed by entanglement and educating the next generation will improve our world for the future. Working together, scientists, industry partners, coastal managers and citizen scientists can make significant strides to reduce marine debris impacts in coastal areas and in the marine environment.

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