

How successful are waste abatement campaigns and government policies at reducing plastic waste into the marine environment?

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ABSTRACT

Plastic production is increasing globally and in turn there is a rise of plastic waste lost into the coastal and marine environment. To combat this issue, there is an increase in policies that target specific types of plastic waste (such as microbeads and plastic shopping bags). Given that such anthropogenic waste have environmental impacts, reduce the tourism income of an area and result in human health issues, identifying effective abatement policies is imperative to reducing waste and litter before it enters the ocean. Within Australia, state and local governments employ a plethora of policies, campaigns and strategies to target abatement and reduce litter and waste inputs to the environment. Waste managers were interviewed from 40 local councils around Australia on waste abatement strategies and investments implemented in their council. Generalised linear models (GLMs) were used to compare outreach programs (such as 'Don't be a Tosser', Clean Up Australia and Bin your Butts cigarette campaign) and state-enacted policies (e.g. Plastic Shopping Bag Ban, Zero Waste Strategy and Recycling Strategy) aimed at targeting human behaviour to reduce waste. Investments in campaigns led to larger reductions of waste in the environment than did investment in policies. Illegal dumping, litter prevention, recycling, education and Clean Up Australia programs all significantly reduced waste along a council's coastline. Additionally, councils that invested in a coastal waste management budget had fewer littered or waste items on the coastline within their jurisdictions.

1. Introduction

Littering (i.e. discarding any material intentionally or unintentionally into the environment), is a relatively common form of illegal behaviour which creates an enormous cost to society and environments at local, regional, national and global scales. Land-based waste, such as litter, pollutes the shores and waters of oceans [1], rivers [2–4], estuaries [5,6] and lakes [7,8]. Such waste has been shown to reduce tourism revenue of regions [9,10] and is a threat to human health, via flooding, increase in disease risk and potential transfer of chemicals [11–14]. Plastic waste, in particular, entangles and is ingested by aquatic and terrestrial species which can result in starvation and mortality [15,16]. Seventeen percent of species affected by plastic waste entanglement and ingestion are listed as threatened or near threatened [15] and it is estimated by 2050 99% of all sea bird species will ingest plastic [17]. In Ethiopia and Nigeria numerous cattle, sheep and goats have plastic in their stomachs [18,19] and there are increasing cases of terrestrial birds dying from plastic waste ingestion [20–22].

With an estimated 8.4 million tonnes of plastic waste entering the

oceans per year [23], the global problem of plastic waste is a significant environmental concern for governments and the public. To combat the damage from plastic waste, government and non-government organisations invest in numerous waste abatement infrastructure, policies and outreach programs (Fig. 1). Waste abatement strategies intervene at different stages along the plastic waste pathway from production to coastal deposition (Fig. 1). The conceptual map (Fig. 1) illustrates that waste abatement policies commonly target plastic production and use i.e. before the plastic becomes waste. Policies do not target plastic waste once it has entered the environment; instead they aim to reduce the quantity of plastic production and use, before it is likely to enter the environment. In contrast, waste abatement outreach programs and infrastructure commonly target plastic waste before and after it has entered the environment. These strategies try to prevent and remove plastic waste from entering the environment and prevent coastal deposition.

Anti-litter campaigns such as 'Do the Right Thing' [24] and 'Neat Streets' [25] educate and encourage the public to improve their waste disposal behaviour. Community programs such as the International

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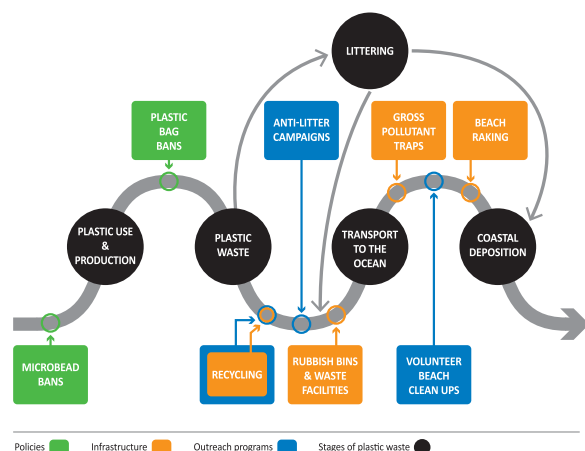


Fig. 1. The type and point of waste abatement interventions along the plastic waste pathway. Thin arrows indicate the point of intervention, shapes indicate the type of intervention and large arrows indicate the pathway flow.

Coastal Cleanup [26] and Keep America Beautiful [27] and citizen science projects like Bravo et al. [28] encourage local community members to be custodians of their environment by involving them in beach clean up activities.

Waste management policy frameworks such as the National Waste Policy in Australia and the EU Waste Framework Directive set guidelines and regulations that control varying waste and recycling streams and minimise environmental pollution. More recently grass-root campaigns such as ‘Beat the Microbead’ [29] and ‘Bye Bye Plastic Bags’ [30] have pushed for legislation to focus on individual litter items that are in high frequency in the environment. In Canada, the US, the UK and the Netherlands legislation is underway to ban the manufacture of microbeads, commonly found in cosmetics [31]. Globally plastic bag consumption has been progressively levied, such as in Ireland and Australia, or completely banned, such as in Germany, India and numerous countries in Africa [31,32].

Waste infrastructure focuses on containing waste before or whilst transported through the environment. The placement of rubbish bins in popular public areas, such as beaches and shopping malls, provides the public with containers to dispose of their rubbish correctly. Gross pollutant traps (GPTs) catch large litter items flowing along waterways such as storm water drains and rivers. In the Derwent Estuary, Australia, GPTs capture 136 t of litter per year [33] and in San Francisco Bay GPTs capture 44% of litter [34]. To remove large litter items from popular beaches, councils often use large mechanical rakes towed by tractors. For example, Cape Town runs an extensive beach raking program [35] and an average of fifteen tonnes of litter per week is raked off Bondi Beach in Sydney, Australia [36].

Since the 1970s littering has been illegal in all Australian states and territories. Recently, litter and waste in the marine environment (i.e. marine debris) has become a major concern for the Australian government. In 2003, marine debris was identified as a key threatening process under the Australian *Environment Protection and Biodiversity Conservation Act 1999*. In 2016, a Senate inquiry was conducted on the threat of marine plastic waste in Australia [37]. Australian waste and litter is managed by state governments in accordance with their respective legislation, policies and programs. However, the local governments are responsible for implementing and managing their respective state waste strategies i.e. the collection of waste and recycling, management and operation of landfill, delivery of awareness programs and providing and maintaining waste infrastructure [38].

There are 560 local governments in Australia [39] who each implement waste strategies to suit their socio-economic status, population and geography. The diversity in local governments has led to their investment in a variety of waste abatement strategies to prevent plastic

waste. Unfortunately, the success of each strategy in preventing or removing plastic waste from the coastline is unknown. The clean up of litter costs Australia over one billion dollars annually, with approximately 80% of those costs paid by local and state governments [40]. Given these costs, efficient targeting of waste management funds towards the most effective strategies will be a key feature in determining their success in reducing plastic pollution.

To evaluate how effective various strategies are at reducing plastic waste into the environment, the analysis compared the level of investment, and type of waste abatement policies and programs implemented by local governments in Australia. The study asked: 1) What level of investment of council budget reduces plastic pollution along coastlines by the greatest amount; 2) What waste abatement strategies reduce plastic pollution along coastlines by the greatest amount; and 3) What specific waste abatement strategies are most effective at reducing plastic pollution along Australia's coastline.

2. Materials and methods

2.1. Site selection

Questionnaires were carried out at the local council level drawn from regions around Australia where coastal debris surveys took place (Fig. 2). Sites were selected to span a wide range of debris densities and council regions. Initially 52 councils were contacted, however interviews were completed with 40 councils around the country. Six sites were chosen in New South Wales (NSW), Victoria (VIC), South Australia (SA), Queensland (QLD) and Tasmania (TAS). Seven sites were chosen in Western Australia (WA) to geographically represent the length of Western Australia's coastline. Due to restricted access three sites were surveyed in the Northern Territory (NT) [41]. Two of those sites in the NT were subsequently removed from the study as they were situated in the same council. One site in Tasmania was also removed. Hence, a total 37 councils completed the questionnaire. Questionnaire results were compared with debris densities from a national dataset on plastic pollution loads along the coast at 100 km intervals from 2011 to 2013 [41].

2.2. Questionnaire

The waste manager from each focal council was contacted. Waste managers were chosen based on the presumption that the person in this role would provide the most accurate information on waste management, council activities and waste abatement strategies in their council. Managers were interviewed over the phone using the questionnaire (see [Supplementary information](#)). The questionnaire was divided into three sections. The first section covered general information about the council (e.g. council population, surface area, coastline length). The second section focused on information about waste management on beaches within the council (e.g. number of rubbish bins at the beach, frequency of beach cleaning, are there active clean up groups in the council), any partnerships with other state associations or councils and finally the amount of funding the council puts towards general waste management and waste management specifically for coastlines. The third section listed a series of legislations and policies, waste facilities and outreach programs and asks whether they are present in the council, if so, what are their names. All interviews were recorded and kept for reference and to clarify any uncertainties. To enable prompt responses, answers in the third section of the questionnaire were pre-filled, where possible, based on information from the council website. Interviewees checked pre-filled answers and modified or corrected where required.

2.3. Statistical analysis

Council policies and programs were compared against patterns of

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