Canada's Dirty Dozen: A Canadian policy framework to mitigate plastic marine pollution

Tony R. Walker[1] *, Shauna Pettipas[1], Meagan Bernier[1], Dirk Xanthos[1], Andrew Day[2]

Abstract

Marine pollution from plastic debris is a global problem causing negative impacts in the marine environment. Plastic marine debris as a contaminant is increasing, especially in Canada. While the impacts of macroplastics are well known in the literature, there are relatively few policy studies related to mitigating microplastic toxicity in the environment. Despite overwhelming evidence of the threat of plastic in the marine environment, there remains inadequate or limited policies to address their mitigation, particularly microplastic debris. Existing policies for waste management, marine debris monitoring and awareness campaigns were evaluated from other jurisdictions. Recommendations for inclusion in future policies were developed for the Canadian context. Recommendations include improved practices for: (1) law and waste management strategies; (2) education, outreach and awareness; (3) source identification; and (4) increased monitoring and further research.

Introduction

Plastic marine debris pollution is a pervasive global problem causing negative impacts in the marine environment (Cressey 2016). Marine impacts include entanglement or entrapment of seals, turtles and seabirds, ingestion, habitat destruction, transport and bioaccumulation of contaminants (Walker et al. 1997; Barnes et al. 2009). Additionally, marine plastic pollution may decrease the esthetic appeal of coastal areas (Walker et al. 2006). Plastics are highly durable, degrade slowly and create widespread environmental and waste disposal problems (Cole et al. 2011). Macroplastics (>5 mm) enter the marine environment via rivers, poor waste management or by being simply dumped into the ocean (Barnes et al. 2009). Degradation of macroplastics into microplastics (<5 mm) has received increased attention recently (Andrady 2011). Microplastics are the most abundant plastic in the ocean and exist in two forms, primary and secondary. Primary microplastics are tiny plastic granules (e.g., scrubbers in cosmetics), while secondary microplastics are derived from degradation of macroplastics (Cole et al. 2011). Marine microplastics are pervasive and ubiquitous with the potential to cause harm to biota (Andrady 2011; Desforges et al. 2014; IMO 2015; Ross and Morales-Caselles 2015).

Current international policy frameworks for reducing macro- and microplastic pollution

Environmental impacts of macroplastics are well known, with established programs designed to remove macroplastics from beaches, waterfronts, and oceans (Walker et al. 1997; 2006; UNEP and NOAA 2011). While management strategies for macro- and microplastics are lacking in Canada (Ross and Morales-Caselles 2015; Cressey 2016; Pettipas et al. 2016), a few global initiatives do exist that further knowledge on plastic contamination, disposal, and pollution prevention. However, because plastics are globally persistent, development of both international and Canadian management strategies are required to address the issue.

Although legislation aimed at preventing disposal of waste at sea is limited, the International Convention for the Prevention of Pollution of Ships (MARPOL) Annex V prevents pollution of plastic waste by ships through international agreements and domestic legislation (IMO n.d.). Some countries have their own domestic legislation (e.g., US Marine Plastic Pollution Research and Control Act), requiring all waste to be disposed of or recycled properly on shore (USEPA 2012). Many ports across North America have also adopted the Green Marine environmental program, requiring participants to provide adequate reception facilities at ports for ship generated waste (Walker 2016).

The United Nations Environment Programme (UNEP) governs the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities, which provides a mechanism for development and implementation of initiatives to address transboundary issues. Microplastic and other marine debris issues are addressed by this program. Additionally, UNEP collaborates with the International Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization to develop guidelines to monitor marine litter. The National Oceanic and Atmospheric Administration (NOAA) and UNEP developed the UNEP Honolulu Strategy, which has three main goals to reduce pollution from marine debris:

- Reduce amount and impact of land-based litter and solid waste introduced into the marine environment;
- Reduce amount and impact of sea-based sources of marine debris including solid waste; lost cargo; abandoned, lost, or otherwise; discarded fishing gear; and abandoned vessels introduced into the sea; and
- Reduce amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters (UNEP and NOAA 2011).

Some non-governmental organizations (NGOs) also monitor marine debris and promote waste management education practices. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an organization that "advise[s] the UN's system on the scientific aspects of marine environmental protection" (GESAMP n.d.). GESAMP has developed ecological quality standards and outlined standards that vary between countries. The International Coastal Cleanup (ICC) is a movement guided by Ocean Conservancy that unites volunteers around the world to clean up aquatic and marine environments. The goal is to strengthen science, engage people in solutions and promote sound policies (Ocean Conservancy 2015).

Recent discoveries by Vancouver Aquarium's Coastal Ocean Research Institute have attracted widespread scientific and media interest

Continued on next page

Continued from previous page

(Ross and Morales-Caselles 2015). The first of these studies revealed shockingly high concentrations of microplastics in seawater in the NE Pacific Ocean, with the highest levels nearshore (Desforges et al. 2014). Most of these microplastics were fibers, fueling speculation that land-based activities, possibly sewage, are releasing microplastics into coastal waters. The second of these studies found that two key species of zooplankton were ingesting microplastic particles, raising fears that sealife at the bottom of the ocean food chain may be impacted by microplastics (Desforges et al. 2015). This research is complemented by extensive education and direct action work. One example of education and direct action started the Great Canadian Shoreline Clean-Up (GCSC) in 1994, which grew to become one of Canada's largest direct action conservation programs, with approximately 60,000 volunteers cleaning close to 3000 km of shoreline annually. In 2010, the World Wildlife Fund Canada (WWF Canada) became a full partner in the Shoreline Clean Up (Shoreline Cleanup n.d.).

Current Policy Frameworks for Mitigating Plastic Pollution in Canada

Adding Microbeads to the List of Toxic Substances Under the Canadian Environmental Protection Act (CEPA) 1999

The Canadian government classified plastic microbeads (≤ 5 mm in size) as a toxin under Schedule 1 of the Canadian Environmental Protection Act (CEPA), 1999 on June 17th, 2016 (CEPA 2016). Declaring microbeads as a toxin under CEPA establishes preventative measures to mitigate their release into the environment. The order was accompanied by a notice of intent to develop microbead regulations, similar to other jurisdictions in the European Union or the United States (US) to prohibit the manufacture, import and sale of certain exfoliating personal care products. In the US legislation was passed by the US Congress in December 2015 to control microbead plastics (Schwartz 2015).

Waste management strategies in Canada

The majority of law and management regarding marine plastic pollution applies to macroplastics. Managing waste is an ongoing goal across Canada, where citizens are encouraged to sort and recycle waste. Throughout Canada, a four-bin garbage system is used to separate waste. These management practices transfer responsibility to consumers and aid in reducing plastic pollution, but enforcement is lacking (Pettipas et al. 2016). Without enforcement, consumers will likely refrain from sorting, reusing and recycling waste. While there have been some management practices to control macroplastic waste in Canada, microplastic waste management has received little attention. Since microplastic pollution is an emerging topic, many people are unaware of the impacts, making it difficult to force change. While primary microplastics may be mitigated through implementation of prohibitions to their use or through wastewater treatment, secondary microplastics can still accumulate in the environment through the degradation of macroplastics (Cole et al. 2011; Ross and Morales-Caselles 2015).

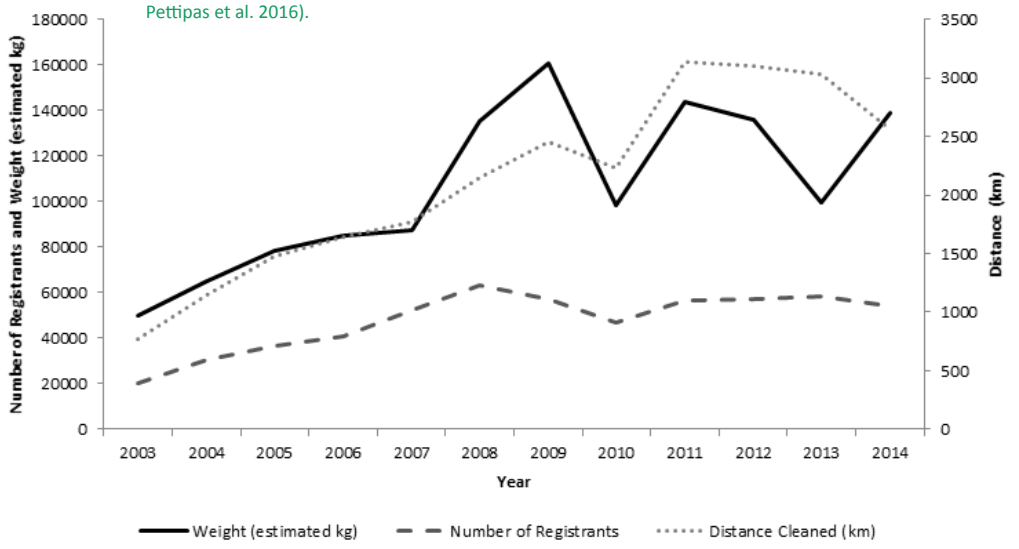
Education, outreach and awareness

Education, outreach, and awareness are effective ways to promote change to limit indiscriminate disposal (Pettipas et al. 2016). Promoting and including oceans education and awareness in schools would be a valuable method to mitigate plastic pollution. By targeting youth habits, practices can be fostered that may indirectly involve ocean protection (e.g., choosing alternatives or practicing efficient waste disposal). A growing number of NGOs in Canada focus primarily on ocean education and awareness. The Oceans Nova Scotia (Oceans NS) organization aims to promote oceans education and awareness in youth. It offers workshops and projects for students to learn more about oceans and associated issues. It also educates youth on how to protect oceans, get involved, and pursue marine related careers. Oceans NS also works with the International Ocean Institute (IOI)-Canada, Department of Labor and Advanced Education, Dalhousie University, Education and Early Childhood Development, and Ocean Technology Council of Nova Scotia. Other organizations in Canada, like the IOI-Canada works to "promote responsible ocean governance and the stewardship and sustainable use of coastal and ocean resources in Canada and around the world" (Pettipas et al. 2016). The Vancouver Aquarium Marine Science Centre runs school programs for over 60,000 students a year, and has developed and distributed school curriculum focused around marine debris. In addition, it hosts an annual Canada-wide event, the Great Canadian Shoreline Clean-Up. This is done in partnership with WWF Canada, which also focuses on improving ocean management. The aim of the event is to "promote understanding and education about shoreline litter issues by encouraging Canadians to rehabilitate shoreline areas through cleanups" (Shoreline Cleanup 2014).

Source identification

Through initiatives such at the GCSC, volunteers across Canada come together to clean up marine debris from shorelines. Vancouver Aquarium and WWF Canada categorize types of debris according to province. Since 2003, the amount of waste, distance cleaned, and number of volunteers has increased (Figure 1). Recent data from 2014, indicates that 2563 km of coastline was cleaned, representing only a fraction of the total Canadian coastline (~1%) (Shoreline Cleanup 2014). After each clean-up, the GCSC partners assess collected debris and compose a list of the 12 most common items collected. In 2014, >80% of waste collected from all provinces and territories was comprised of plastic (Figure 2). While the GCSC program only focuses on macroplastics and covers only a small fraction of the overall Canadian coastline, it provides valuable data to help promote behavioral changes. Ocean Conservancy has a similar yearly event with similar goals to the GCSC, the International Coastal Cleanup (ICC 2015). Unlike the GCSC, the ICC event is global. In 2014, over 1/2 million volunteers (mostly from developed countries), collected 7,357,616 kg of waste along over 21,376 km of coastline. Common debris items found globally compared

Figure 1. Overall total distance (km) cleaned, estimated weight of waste collected, and number of registrants for the Canadian Shoreline Cleanup from 2003-2014 (adapted from Pettipas et al. 2016).



favorably to the 2014 GCSC results (e.g., cigarette butts, food wrappers, plastic bottle caps, straws/stirrers, and plastic beverage bottles) (ICC 2015). For more information regarding volunteering for GCSC and for 2015 GCSC data, readers should refer to http://shorelinecleanup.ca/search/cleanups, and http://shorelinecleanup.ca/sites/default/files/gcscstaff/GCSC_AnnualReport2015_160211-online.pdf.

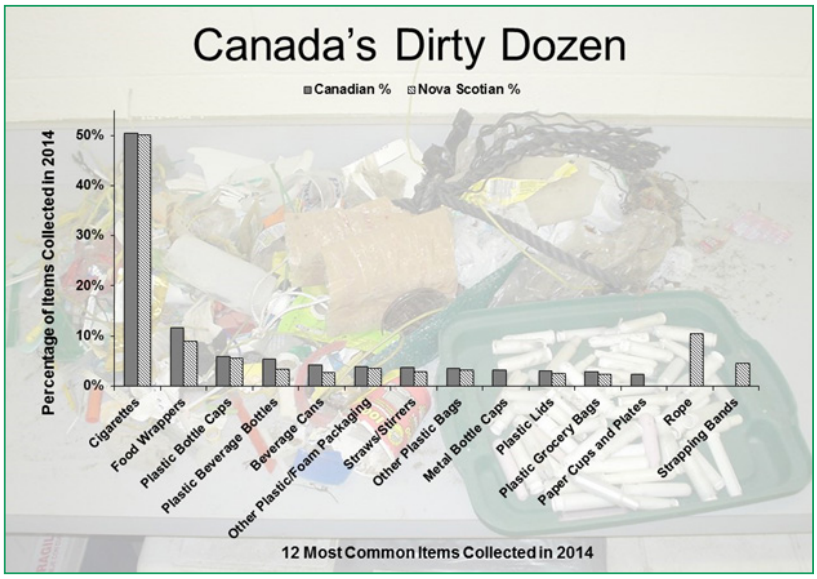
Source identification of specific items is necessary to mitigate and reduce plastic pollution. Initiatives like the GCSC and the ICC get individuals involved and provide an understanding of adverse effects of poor waste management practices. These initiatives provide information where further management efforts are required by determining the types of waste in the marine environment. By using this data, mitigation measures can be implemented to target and reduce specific waste items.

Future considerations for macro- and microplastic contamination

• Waste management strategies- Although some jurisdictions across Canada have banned disposal of plastics in landfills and littering, there is little enforcement, particularly for microplastics. Household plastic disposal cannot be easily regulated because of inadequate resources for auditing. Comprehensive programs to improve waste management need to be implemented. Programs could include improved design and application of deposits or levies on single-use plastics, increased consumer awareness and behavioral changes through environmental education, improved recycling and reuse, and the introduction of economic incentives to reduce littering and promote secondary uses of plastic debris as well as enforcement. Additionally, secondary microplastics may be managed by manufacturing more sustainable plastics. The next generation of plastics could be designed to be more biodegradable to decrease their half-life; therefore, decreasing their potential to accumulate in the marine environment and biota. Wastewater treatment may also be an important strategy, particularly for some microplastics (Ross and Morales-Caselles 2015) and the Vancouver Aquarium is working with partners including Metro Vancouver to explore this further.

• Education, outreach, and awareness- Education and outreach programs to encourage industry sectors and the general public to modify behavior and assume greater responsibility for individual actions should be adopted (Pettipas et al. 2016). Incorporating ocean education, pollution, and waste management into schools through curriculum changes and events, could be extremely effective. Schools can directly incorporate ocean and pollution education into lesson plans, enforce proper waste management, and help increase awareness, like Oceans Day. All Canadian stakeholders must continue to encourage and enforce innovative plastic management practices. Partnerships with organizations could be adjusted to host events, such as shoreline cleanups. These events would raise more awareness, educate, and encourage change.

• Source identification- Source identification is invaluable to control and mitigate marine plastic pollution effectively. Identifying common items at sea and along shorelines can help establish specific targets and goals. Advanced analysis, as is being conducted by the Vancouver Aquarium's Coastal Ocean Research Institute, can help 'fingerprint' microplastic sources (Ross and Morales-Caselles 2015). Further action can then be taken to eliminate these items and/or provide a basis for future research into alternatives and mitigation. Targets and goals will likely be highly specific and will require behavioral change, although



most will apply to macroplastics, rather than microplastics. The GCSC and the ICC events will hopefully continue to expand throughout Canada, and the world, covering coastline through increased participation. The GCSC 'Dirty Dozen' list will hopefully inspire people to choose alternatives to plastic products and packaging and be more aware of proper disposal practices.

• Monitoring and future research- Further research concerning sources, distribution, estimated quantities, fate, potential impacts of plastics, or effectiveness of plastic bans have on the marine environment, especially microplastics, is imperative. For example, the ability to count and characterize microplastics in environmental samples represents a crucial component of identifying sources and devising mitigative options. But isolating and identifying microplastic fibers and fragments from environmental samples is difficult, necessitating the use of new technologies and methods (Ross and Morales-Caselles 2015). Further, there are limited studies related to policies that aim to reduce single-use plastic consumption or examining the effectiveness of microbead bans. Research should be focused at local, regional, and global scales because sources, circumstances, capabilities, and mitigation strategies will vary at each level. Further knowledge of plastic composition (through widespread monitoring programs) will help develop concrete policies involving a broad spectrum of plastic contamination and its impacts (Desforges et al. 2014). Banning microbeads (recently added to the list of toxic substances under CEPA in Canada) will help reduce their continued input into the ocean in some locales. However, the broader issue of microplastics is not addressed. It is likely difficult to completely abolish them as they are so pervasive and there are currently few alternatives for those used in fields such as medical applications. Additionally, banning microbeads will not help mitigate secondary microplastic contamination in the ocean because they also result from the degradation of larger plastic pieces. Understanding the composition of plastics found in the marine environment through research will help develop policies that need to be implemented across Canada and internationally.

[1] School for Resource and Environmental Studies, Dalhousie University, Halifax, NS, Canada

[2] Coastal Ocean Research Institute, Vancouver Aquarium Marine Science Centre, Vancouver, BC, Canada

** E-mail address: trwalker@dal.ca*

References

A.L. Andrady. Microplastics in the marine environment. Mar. Pollut. Bull., 62 (2011), 1596–1605.

D.K.A. Barnes, F. Galgani, R.C. Thompson, M. Barlaz. Accumulation and fragmentation of plastic debris in global environments. Philos. Trans. R. Soc. B Biol. Sci., 364 (2009), 1985–1998.

CEPA (Canadian Environmental Protection Act, 2016). SOR/2016-150 June 17, 2016

Retrieved 18.07.16 from: (http://www.gazette.gc.ca/rp-pr/p2/2016/2016-06-29/html/sor-dors150-eng.php), 2016.

M. Cole, P. Lindeque, C. Halsband, T.S. Galloway. Microplastics as contaminants in the marine environment: a review. Mar. Pollut. Bull., 62 (2011), 2588-2597.

D. Cressey. Bottles, bags, ropes and toothbrushes: the struggle to track ocean plastics. Nature, 536, (2016), 263-265.

J.-P. Desforges, M. Galbraith, N. Dangerfield, P.S. Ross. Widespread distribution of microplastics in subsurface seawaters in the NE Pacific Ocean. Mar. Pollut. Bull. 79 (2014), 94-99.

J.-P. Desforges, M. Galbraith, P.S. Ross. Ingestion of microplastics by zooplankton in the Northeast Pacific Ocean. Archives 69 (2015), 320-330.

IMO (International Maritime Organization), International Convention for the Prevention of Pollution from Ships (MARPOL), n.d. Retrieved 23.01.15 from: http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

GESAMP, Microplastics in the Ocean: Sources, Fate and Effects, n.d. Retrieved 23.02.15 from: http://www.gesamp.org/data/gesamp/files/media/Publications/WG_40_Brochure_Microplastic_in_the_ocean/gallery_2191/object_2404_large.pdf

Ocean Conservancy, International Coastal Cleanup: 2015 Report, Retrieved 08.11.15 from: http://www.oceanconservancy.org/our-work/marine-debris/2015-data-release/2015-data-release-pdf.pdf

S. Pettipas, M. Bernier, T.R. Walker. A Canadian policy framework to mitigate plastic marine pollution. Mar. Policy 68 (2016), 117-122.

P.S. Ross and C. Morales-Caselles. Microplastics: Out of sight but not out of mind: microplastics as a global pollutant. Integr. Environ. Assess Manage. 11 (2015), 721-722.

Shoreline cleanup, facts and figures, n.d. Retrieved 09.11.15 from: http://shorelinecleanup.ca/en/content/facts-figures

J. Schwartz. Ban on microbeads proves easy to pass through pipeline. The New York Times. (22 December 2015). Retrieved 20.10.16 from http://www.nytimes.com/2015/12/23/science/ban-on-microbeads-proves-easy-to-pass-through-pipeline.html

UNEP and NOAA (United Nations Environment Program and National Oceanic and Atmospheric Administration), The Honolulu Strategy: A Global Framework for Prevention and Management of Marine Debris, 2011. Retrieved 23.02.15 from: http://unep.org/gpa/documents/publications/honolulustrategy.pdf

USEPA (United States Environmental Protection Agency), Prevention, Control and Reduction: Plastics, n.d. Retrieved 20.10.16 from: https://www.epa.gov/trash-free-waters

T.R. Walker. Green marine: an environmental program to establish sustainability in marine transportation. Mar. Pollut. Bull., 105 (2016), 199-207.

T.R. Walker, K. Reid, J.P.Y. Arnould, J.P. Croxall. Marine debris surveys at Bird Island, South Georgia 1990–1995. Mar. Pollut. Bull., 34 (1997), 61–65.

T.R. Walker, J. Grant, M.C. Archambault. Accumulation of marine debris on an intertidal beach in an urban park (Halifax Harbour, Nova Scotia). Water Qual. Res. J. Can., 41 (2006), 256–262.