



Plastic litter from shotgun ammunition on Danish coastlines – Amounts and provenance[☆]

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ABSTRACT

Plastic litter in the marine environment is a major global issue. Discarded plastic shotgun ammunition shells and discharged wads are an unwelcome addition and feature among the top ten litter items found on reference beaches in Denmark.

To understand this problem, its scale and origins, collections were made by volunteers along Danish coastal shorelines. In all 3669 plastic ammunition items were collected at 68 sites along 44.6 km of shoreline. The collected items were scored for characteristic variables such as gauge and length, shot type, and the legibility of text, the erosion, and the presence of metallic components. Scores for characteristics were related to the site, area, and season and possible influences discussed.

The prevalence of collected plastic shotgun litter ranges from zero to 41 items per 100 m with an average of 3.7 items per 100 m. Most ammunition litter on Danish coasts originates from hunting on Danish coastal waterbodies, but a small amount may come from further afield. North Sea coasts are the most distinctive suggesting the possible contribution of long distance drift as well as the likelihood that such litter can persist in marine habitats for decades.

The pathway from initial discard to eventual wash-up and collection depends on the physical properties of plastic components, marine tides and currents, coastal topography and shoreline vegetation.

Judging from the disintegration of the cartridge and the wear and decomposition of components, we conclude that there is a substantial supply of polluting plastic ammunition materials that has and will accumulate. These plastic items pose a hazard to marine ecosystems and wash up on coasts for many years to come. We recommend that responsible managers, hunters and ammunition manufacturers will take action now to reduce the problem and, thereby, protect ecosystems, wildlife and the sustainability of hunting.

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1. Introduction

Marine pollution by plastic litter is a major global environmental issue. Macro plastic items are a cosmetic and aesthetic problem that causes serious harm to marine animals that try to eat them (Lusher et al. 2013; Wilcox et al. 2015) or which become entangled by them (Laist 1997). Micro plastic particles or beads created by the decomposition of macro plastic items are ingested by small animals and filter-feeders, then accumulate up food chains and create hazards for ecosystems, other wildlife and human

health. The issue is more thoroughly described in Derraik 2002, Thevenon et al. 2014, UNEP 2016, and Lamb et al. 2018.

Shotgun ammunition cartridges used for hunting are an additional unwelcome source of plastic litter in the marine environment. Empty cartridge shells cases (in the following called shells) may not be picked up by the hunter who fired them, or they may be irretrievably ejected into the sea on firing and not recovered. Plastic wads that serve to separate the propellant from the shot load, are invariably lost down-range when a shot is fired. Uncollected plastic shells and wads are distinct but avoidable sources of macro plastic pollution that in the later stages of decomposition break down into harmful micro plastic particles or beads (Andrady 2011).

Hunting in modern society is a valued recreational activity that benefits from broadly favorable but not uncritical political and public perceptions. Any avoidable negative impact on the natural

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environment, ecosystems and human health, risks undermining the perception of hunting and threatens its long-term sustainability.

Denmark's widespread coastal habitats located centrally on the Western European migratory bird flyway support a long-established tradition of waterbird hunting. The hunting takes place on open waterbodies from specially designed small boats as well as from adjacent private and state lands. Residents in Denmark enjoy a free right to hunt on such open salt and brackish waters known as the "the fishery territory". The total annual harvest of waterbirds in Denmark is approximately 800,000 (Christensen et al. 2017). Some 150,000¹ of these are taken during the free hunting on coastal salt and brackish water bodies. Based on the annual harvest and an estimated number of cartridges fired per bagged bird (estimated here at four²) we estimate a total annual discharge of some 600,000 cartridges while hunting in Danish coastal salt and brackish water bodies.

Denmark banned the use of lead shot for all hunting in coastal ecosystems in 1993, and steel shot is now the commonly preferred alternative.

A shotgun cartridge consists of a plastic cartridge shell containing the powder and the shot load. The cartridge's brand name and some specification details (cartridge type, gauge, shot size and shot type if not lead) are usually printed on the shell. When lost to the environment and subjected to abrasion the printed information becomes increasingly illegible and disappears over time. Cartridges that have lost all such marking cannot be identified and the only recordable indicator is its gauge and length. In some instances head marks may be stamped on the shell. The cartridge shell has a metallic base, commonly known as "the brass" which is, notwithstanding, mostly made from iron. A metallic primer is situated at the centre of the brass's baseplate. The gradual loss of printing and metal features provides clues to the length of time a cartridge shell has been subjected to abrasion and wear. The powder and shot are separated by a wad (also known as a shot cup). Wads come in different designs but they are insufficiently distinctive to enable them to be linked to a brand or type of cartridge. Wads have no labelling. Their gauge can however be recorded and the wad construction is indicative of the shot material used.

The predominant plastic material used for production of shells and wads used for hunting in wetlands is low density polyethylene (LDPE). This may show signs of abrasion but takes long time to break down completely. The shell plastic is colored, mostly black, red, blue or green, but colors cannot be used for identification. Wads are usually white/greyish.

Responsible hunters in normal circumstances take care to collect their empty cartridges after shooting and later discard them.

¹ The Danish waterbird wing survey programme was used to make this estimation after consultation with Aarhus University, Bioscience, Kalø. This programme suggests that some 10% of the dabbling duck and goose harvest is taken under hunting forms that relate to the free hunting right at sea. To this, we added the total harvest of all diving ducks and coot. On this background we suggest an overall estimation of 150,000 birds taken annually under the regime of the free hunting right on the Danish fishery territory.

² Noer et al. 1998 found for Danish duck hunters an average cartridge consumption at 3.6 per bagged duck (total 240 shots fired). The same study found for Eider Duck hunting a cartridge consumption at 2.5 per bagged bird (total 141 shots fired). However, this did not include shots to kill wounded birds. Noer et al. 2001 found for two groups of Danish duck hunters (dusk hunting) a cartridge consumption at 2.63 resp. 4.05 per harvested bird (total 390 shots fired). For goose hunting in Denmark the study referred to much higher levels of cartridge consumption, up to 8.0 (1996 estimates) and 8.7 (1997 estimates) depending on hunting form (shooting crossing birds or decoying). On this background and based on common practical experience we suggest a level of 4 shots per harvested birds as an average of the many different hunting forms that relate to the free hunting right on the Danish fishery territory.

However, empty cartridges may sometimes be lost into the environment. The use of semiautomatic and pump action guns may accentuate this loss. The wads are invariably dispersed with the shot load and lost.

Systematic analysis of the plastic litter from hunting ammunition collected by volunteers in coastal habitats sheds light on its scale and provenance, and can help inform programs to counteract further dispersal. It may also contribute to wider understanding of movements and turnover of other plastic waste in marine habitats and ecosystems.

The principal objective of this study is to evaluate the amount and provenance of plastic waste from hunting ammunition washing up on Danish beaches. For this, we use litter characteristics (*inter alia* quantity, shot type, and wear) and relate this to site and season. We analyse possible movements of the litter types, and, finally, present some management perspectives for reduction of this pollution.

2. Materials and methods

2.1. Collection and registration of litter

From 2010 to 2017, volunteers associated with the Danish Nature Protection Society, as well as local clubs and individuals, collected shotgun ammunition litter from 68 sites along 44.9 km of Danish coastline. From 2010 to 2014 the collection was limited to two stretches of coast in the East Kattegat (Begrtrup Bay and Ebeltoft Bay). In 2015 the collection was extended to 66 additional sites (Fig. 1). Based on the adjacent waterbodies we grouped each site as belonging to one of six areas with at least three collections within each area, except one with only one site (Roskilde).

For each collection, wads and shells found were retrieved and in most cases collection date, collector's name, site name, stretch length, and total number of plastic items in each batch was recorded. Items were registered individually and the following data, so far as possible, were recorded:

Shells: their gauge, brand, type, other text (labelling), text wear index (TW) (group 1 to 5, see caption Fig. 3), brass erosion index (BE) (group 1 to 5, see caption Fig. 3), presence of plastic bottom, and presence of primer. If possible, cartridges were categorised as "steel shot", "lead shot", "bismuth" or "unknown" depending on printed text, if present, or other indicative characteristics.

Wads: their gauge and design for use with "steel shot" or "lead shot" based on three distinguishing characteristics: volume of the shot cup, the construction and splitting of the cup wall, and design of the buffer forming the wad base. Remains of rusty pellets embedded in the wad cup base could also sometimes confirm a steel shot categorisation. Wads for bismuth or other soft shot types are the same as wads for lead shot, but due to *inter alia* price we expect that the use of bismuth for coastal hunting is negligible.

One single project staff (leading author Niels Kanstrup) carried out all registrations and categorisations centrally.

2.2. Metrics of litter samples and cartridge

The weight and volume of samples of empty cartridge shells and wads was measured, and mean weights and specific gravity calculated. In addition, the weight of components (shell plastic, shell metal, wad plastic, powder, and shot) of unfired standard cartridges was measured.

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