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Baseline

Plastic and metal ingestion in three species of coastal waterfowl wintering in Atlantic Canada

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ABSTRACT

Relatively little attention has been paid to the occurrence of anthropogenic debris found in coastal species, especially waterfowl. We examined the incidence of ingested plastic and metal in three waterfowl species wintering in Atlantic Canada: American black ducks (*Anas rubripes*) and mallards (*A. platyrhynchos*), two species that use marine and freshwater coastal habitats for foraging in the winter, and common eider (*Somateria mollissima*), a coastal marine species that feeds on intertidal and subtidal benthic organisms. Plastic was found in the stomachs of 46.1% (6/13) of mallards and 6.9% (6/87) of black ducks, the first report of ingested anthropogenic debris in these species, while 2.1% (1/48) of eider stomachs contained plastic. Metal was found in the stomachs of 30.8% (4/13) of mallards, 2.3% (2/87) of black ducks, and in 2.1% (1/48) of eiders. Our results indicate that species using coastal marine and freshwater environments are exposed to and ingest anthropogenic debris.

Debris in the marine environment has been identified as one of the leading threats to the health of the world's oceans (UNEP, 2011), and emerging evidence suggests that freshwater systems are similarly affected (Eriksen et al., 2013; Driedger et al., 2015). In 2010, it was estimated that 4.8–12.7 million metric tons of plastic entered the ocean from land-based sources, and if waste management practices do not improve on a global scale, this number could increase by an order of magnitude by 2025 (Jambeck et al., 2015).

Plastics and other debris enter aquatic systems through direct or accidental dumping, and transport from land by wind or mismanagement of waste disposal (Jambeck et al., 2015). Most plastics that enter aquatic systems are broken down through physical and chemical stress into small fragments that persist in the environment, and many surface-feeding animals experience high rates of plastic ingestion in areas of high plastic contamination. The occurrence of plastics in many surface-feeding pelagic seabirds in Canadian waters has been recently summarized (Avery-Gomm et al., 2013; Provencher et al., 2014a,b), and is an issue garnering considerable media attention in Canada.

Detrimental effects of plastic ingestion include impaction and physical damage to the digestive tract (Gregory, 2009; van Franeker et al., 2011). As well, plastics can adsorb high concentrations of organic contaminants and may act as vectors for contaminant transfer into marine food webs, when plastics are ingested (Mato et al., 2001; Teuten et al., 2009). Negative effects of plastic-related organic contaminants has not yet been explicitly shown in birds, but has been demonstrated in fish (Rochman et al., 2013). Lead and steel shot is the most reported type of non-plastic anthropogenic debris ingested by waterfowl (Mateo et al., 1998; Moore et al., 1998; Pain, 1990), and reports of other types of metal ingested by waterfowl are limited (e.g., whooping crane *Grus americana* research by Olsen and Wise, 2001). Lead poisoning as a result of lead shot ingestion has been well-documented, and in many cases lead to the death of the organism.

While numerous studies have focused on debris in the marine environment, comparatively little attention has been paid to the occurrence of anthropogenic debris in freshwater systems (Wagner et al., 2014; Driedger et al., 2015). In the Laurentian Great Lakes, microplastics reach surface concentrations as high or higher than some ocean gyres (Eriksen et al., 2013; Driedger et al., 2015). Remote lakes are also susceptible to plastic contamination, and in some cases can be more polluted than the Great

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Lakes (Free et al., 2014). To date, only one study has reported plastic ingestion in a freshwater species, a small fish (Sanchez et al., 2014); most published studies on plastic pollution in freshwater systems report on availability and distribution of microplastics, not on ingestion or frequency of occurrence in biota (e.g., Driedger et al., 2015). Importantly, few studies have examined the incidence of anthropogenic debris in species that use both coastal freshwater and marine habitats seasonally, despite that many species (e.g., shorebirds/waders, waterfowl) typically breed near freshwater sites but winter along the ocean.

The ingestion of plastics and metal has rarely been reported in waterfowl species, except for species that live at sea (Provencher et al., 2014a). In this paper, we provide the first report of plastic and metal ingestion in two species of common waterfowl in Atlantic Canada: the mallard (*Anas platyrhynchos*) and the American black duck (*Anas rubripes*), both of which overwinter along coastal marine sites but use a wide-range of freshwater habitats as well. We also document the occurrence of plastic and metal ingestion in common eiders (*Somateria mollissima*).

Common eider were collected off Newfoundland's northeast coast from 21 Dec 2013 to 17 January 2014 during the annual sea duck hunt. Mallards were collected during the winters of 2014 and 2015 in a rural area in New Brunswick (a tidal creek) and two rural areas in Nova Scotia (a tidal cove and a pond in a farmer's field). American black ducks were collected during the winter of 2014 in rural, coastal, and freshwater areas in Nova Scotia and New Brunswick, and in an urban pond in the city of St. John's, Newfoundland and Labrador (Fig. 1). Since the urban and rural black ducks came from very different habitats, they were treated separately.

Birds were frozen after collection and shipped to Acadia University, where they were subsequently thawed and dissected. The proventriculus and gizzard contents of all birds were examined under a dissecting microscope for the occurrence of any anthropogenic debris. Methods used were consistent with the internationally standardized approach for quantifying plastic ingestion among seabirds (e.g., van Franeker et al., 2011). When found, debris was weighed to the nearest 0.1 mg, measured to the nearest 0.25 mm, classified, and photographed. Plastics were identified as either user or industrial plastics, and user plastics were further categorized (i.e., sheet-like, foam-like, fragmented, thread-like, and other).

We analysed 87 American black ducks (all adults; 43 female, 44 male), 13 mallards (all adults; seven female, six male) and 48 common eiders (32 females, 16 males: 26 adult, 10 juvenile, 12 unknown age) in this study. We did not test for an effect of age or sex on debris ingestion as our incidence rates were too low. The type of debris ingested by the waterfowl we examined consisted of user plastics and small metal fragments (Fig. 2). Except for one piece of rope 10 cm long and found in a mallard, all other debris measured in the black ducks and mallards was 0.5–5 mm long and 0.25–3 mm wide. The eiders examined contained a piece of rope measuring 2×52 mm and a piece of metal measuring 12×10 mm that likely would have sunk to the benthos where these birds forage.

There were no significant differences between the overall amount of debris found in rural or urban American black ducks (Fisher Exact test, $p = 0.29$). Of the 49 rural black ducks examined, three had some form of debris (6.2%), while five of the 38 urban black ducks contained some form of debris (13.2%). Plastic was found in one rural black duck (2.0%), and in five (13.2%) urban black ducks, but this difference was not statistically significant (Fisher Exact test, $p = 0.08$). Metal was found in two rural black ducks (4.1%), and was not found in any urban black ducks (0%), but this difference was not statistically significant (Fisher Exact test, $p = 0.50$). Due to there being no statistically significant differences in debris in these two groups of black ducks, these groups were pooled for further analyses.

Of the 148 waterfowl examined, 17 (11.5%) contained anthropogenic debris (plastic and metal combined), but the proportions differed among species (Table 1). Debris was most common in mallards (7/13, 53.8%), lower in American black ducks (8/87, 9.2%) and lowest in common eiders (2/48, 4.2%; $\chi^2_2 = 20.0$, $p < 0.001$). These differences were attributable to mallards having significantly higher occurrence of debris than the other species (Fisher Exact tests, both $p < 0.003$); frequency of occurrence in black ducks and eiders was not statistically different ($p = 0.32$).

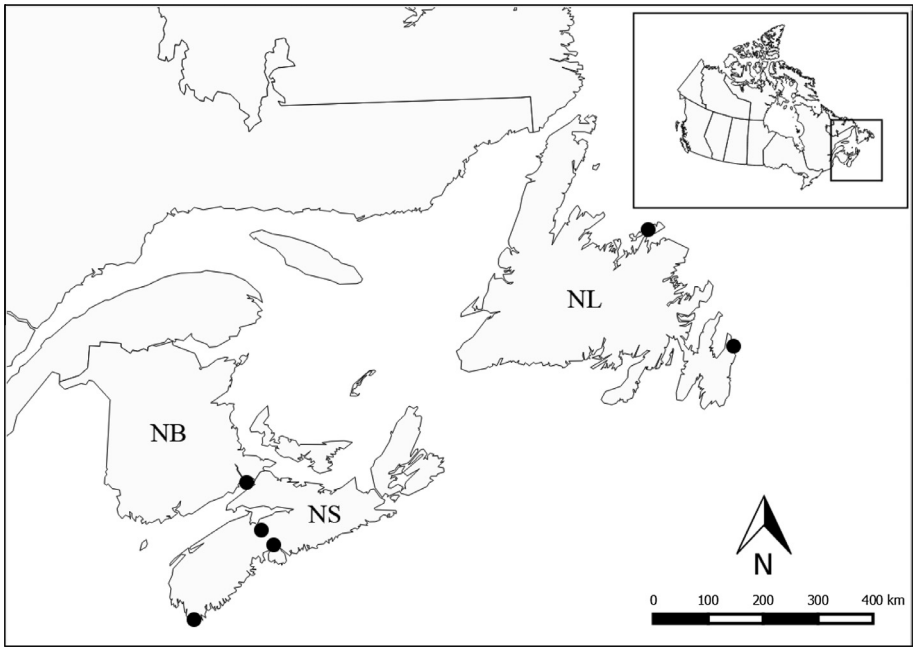

Fig. 1. The sample sites used for this study. NB: New Brunswick, NS: Nova Scotia, NL: Newfoundland.