Marine plastic debris in northern fulmars from Davis Strait, Nunavut, Canada

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Waste marine plastic debris on the ocean surface, bottom and coastlines is a worldwide, marine pollution problem that affects a wide range of wildlife species (Laist, 1987, 1997). The debris can be divided into industrial plastics, typically small plastic pellets that are the precursors to plastic manufacturing, and user plastics, the moulded, manufactured items made from industrial plastics. Industrial plastics enter the marine environment during manufacturing and transport (see Van Franeker, 1985), and user plastics enter the oceans from commercial shipping, fisheries, marine garbage disposal, and runoff from terrestrial sources (Dixon and Dixon, 1981). Wildlife ingest these plastic particles, presumably mistaking them for prey species. Once swallowed, the particles can lead to reduced digestive efficiency, blockages or ulcerations of the digestive tract, and increased contaminant loads due to plastic digestion (Van Franeker, 1985; Azzarello and van Vleet, 1987; Laist, 1987; Ryan, 1987; Ryan et al., 1988; Burger and Gochfield, 2002).

Ingestion of plastic is a potential problem for marine birds, and especially for procellariids (petrels), because they have the highest incidence of plastic ingestion among seabirds (Nisbet, 1994; Robards et al., 1995), and do not regurgitate indigestibles like other species. The northern fulmar, *Fulmarus glacialis*, is a common fulmarine petrel of the North Atlantic and North Pacific oceans which seems particularly vulnerable to plastic ingestion. Indeed, more than 80% of the fulmars sampled in the North Pacific and North Atlantic oceans contained plastic (Van Franeker, 1985; Moser and Lee, 1992; Robards et al., 1995). Disturbingly, levels of plastic debris in the oceans have increased (Ryan and Moloney, 1993), and concomitantly, ingestion in seabirds, including fulmars, appears to have increased in both the North Atlantic and North Pacific oceans (Moser and Lee, 1992; Robards et al., 1995).

The Canadian Arctic archipelago and western Greenland support more than one million fulmars (Salomonsen, 1979; Gaston et al., in press), but there is no published information on plastic debris in the diet of birds from this region. Here we present the first evidence of plastic debris found in fulmars collected in the Arctic waters of Davis Strait, Nunavut, Canada, between Baffin Island and Greenland.

Forty-two northern fulmars were retrieved between 15 August and 10 September 2002, by a fisheries observer stationed aboard a Norwegian longliner fishing for Greenland halibut, *Reinhardtius hippoglossoides*, operating under licence in Canadian waters (North Atlantic Fisheries Organization Division 0A). Collections were made between 67°19′ to 69°32′ N, and 58°29′ to 65°08′ W. An estimated 500 seabirds, mostly fulmars, are caught in longline fisheries in this region annually (Chardine et al., 2000), although the numbers are probably higher because Greenlandic fishermen undoubtedly capture some as well, but these are not reported. The fulmar carcasses were frozen and delivered to the Canadian Wildlife Service in St. John's, NL, and then sent to the National Wildlife Research Centre in Ottawa. Each carcass was thawed and the proventriculus and gizzard removed, and the contents were then flushed out with distilled water into a white tray. Each proventriculus was mostly empty, except for bait items from the fishery, but there were a few hard parts in the gizzards. Obvious items were removed (squid beaks, large plastic pieces), and other items were checked under a microscope. Plastic debris were removed, dried, measured (±0.1 mm) and weighed (±0.01 g). These birds were all adults, but we could not determine whether they were breeding or non-breeding individuals.

We found at least one piece of plastic in 15 of 42 fulmars (36%), principally in their gizzards, and a total of 54 pieces in these 15 birds (mean 3.6 ± 2.7 SD per affected bird; mean over all birds in sample 1.3 ± 2.3 pieces per individual), all of which were user plastic. The plastic was in a wide range of colours: red, green, beige, blue, white, yellow, orange, brown, and grey. Only two (4%) of the plastic pieces were soft (rubber or foam-like) and one was apparently a thread from a fishing net (Fig. 1), all others were rigid. Plastic pieces were generally small (Fig. 1), with a mean length 0.7 ± 0.4 cm, width 0.4 ± 0.2 cm, thickness 0.12 ± 0.10 cm, and volume of 0.03 ± 0.03 cm^3. Twenty-eight of the 54 plastic pieces were heavy enough to weigh (i.e., >0.01 g), with a mean mass of 0.03 ± 0.02 g. Total mass of plastic per bird ranged from 0.02–0.31 g (maximum 0.04% of a 700 g adult).

The 36% incidence of plastic in fulmars collected in Davis Strait is lower than reported for fulmars elsewhere

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in the North Atlantic Ocean (79–92% – Van Franeker, 1985; 86% – Moser and Lee, 1992; 95–99% – Van Franeker and Meijboom, 2002) and the North Pacific Ocean (84–88% – Robards et al., 1997). Both Van Franeker (1985) and Robards et al. (1997) have found lower incidence of plastic debris in fulmars collected further north in the North Atlantic and North Pacific oceans, respectively, compared to fulmars collected further south in these regions. The number, size and volume of plastic we observed in individual fulmars were generally less than in other North Atlantic studies (e.g., Furness, 1985; Van Franeker, 1985; Moser and Lee, 1992). We also found that 100% of the plastic in Davis Strait fulmars was user plastic. Van Franeker (1985) noted that plastic debris in fulmars collected at the most northerly location (Bear Island, 74° N) was dominated by user plastic (about 75% of the plastic items). Further south, on Jan Mayen (71° N) and in the North Sea (53° N) only 50% of the plastic items were user plastics. In Alaska, industrial plastics dominated particles ingested by seabird species (Robards et al., 1995).

The regional differences in proportions and types of ingested plastic are probably attributable to variations in the abundance of plastic debris across these waters (e.g., Day and Shaw, 1987), with higher levels in the more southern regions near larger manufacturing centres and areas with high ship traffic. Plastic that is found in Davis Strait probably arrives in part by ocean currents (notably the Gulf Stream and West Greenland Current), and in part by local waste management practices. There is comparatively little shipping or manufacturing activity in Davis Strait, and the entire region is unavailable to ships (other than icebreakers) for several months of the year due to extensive sea-ice cover, so lower incidences of plastic debris in fulmars of this region should be expected. No observations of industrial plastics in Arctic fulmars was surprising, given that they have been found in other sites remote from shipping or manufacturing and seem to be distributed globally in marine waters (e.g., Van Franeker and Bell, 1985; Ryan and Moloney, 1993). Although we suspect that industrial plastics in Canadian Arctic waters are indeed rare, it is possible that our results on the proportion of industrial plastics may be confounded in part by the timing of our collections. Fulmars from this region spend the winter in the North Atlantic Ocean and Labrador Sea, and summer in Arctic waters (Hatch and Nettleship, 1998). Given that these birds were collected in August and September, it is possible that any small industrial plastics that might have been ingested during the previous winter or on spring migration could have been digested by late summer, and only larger, user plastic items remained discernible. This, combined with user plastic pieces picked up in Davis Strait (as evidenced by minimal digestion of some pieces) would lead to the conclusion of zero incidence of industrial plastic. We recommend that sampling of Arctic fulmars earlier in the year be conducted to determine whether they are picking up industrial plastics in the winter.

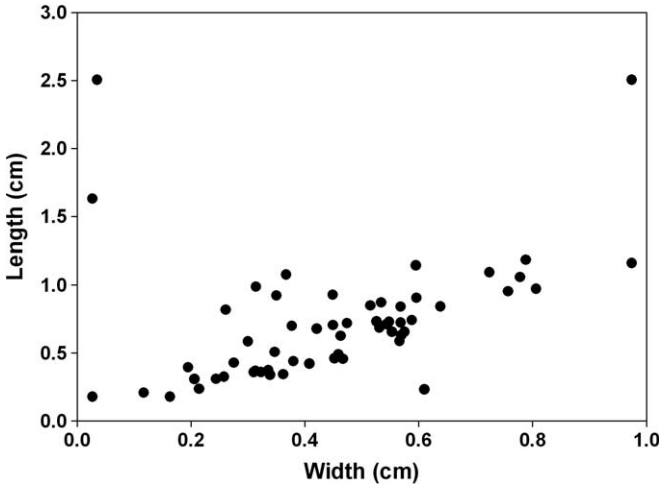

Fig. 1. Distribution of sizes of plastic particles removed from the proventriculus and gizzards of northern fulmars from Davis Strait, Nunavut, Canada.

However, extensive dietary studies conducted in the 1970s in the Canadian Arctic failed to mention any plastic debris in northern fulmars (Bradstreet, 1976; Bradstreet and Cross, 1982; Hatch and Nettleship, 1998), but we found at least one third of birds carrying plastic in 2002. This suggests that the incidence of plastic debris in fulmars has increased over this period, which would be consistent with patterns found elsewhere in the North Atlantic (Moser and Lee, 1992) and North Pacific (Robards et al., 1995).

Plastic debris has now been documented in petrels collected in Arctic, boreal, tropical and Antarctic waters (e.g., Van Franeker, 1985; Van Franeker and Bell, 1985; Robards et al., 1995, 1997; Laist, 1997; this study). It continues to occur in highest levels in fulmars in the southern North Sea, where a biomonitoring program is being considered (Van Franeker and Meijboom, 2002; Van Franeker et al., 2005). Despite the 1988 ratification of Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL), which prohibits the dumping of plastic at sea, it appears that marine plastic debris is being ingested by birds in the most remote marine locations on earth, far from apparent sources. In fact, rates of plastic incidence in some birds may still be increasing. Continued biomonitoring will be required to determine if and when the amount of plastic debris scattered in the oceans begins to decline.

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