Plastic ingestion by the northern fulmar (*Fulmarus glacialis*) in Iceland

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**Abstract**

In 2011, northern fulmars (*Fulmarus glacialis*) from Iceland were used to test the hypothesis that plastic debris decreases at northern latitudes in the Atlantic when moving away from major human centres of coastal and marine activities. Stomach analyses of Icelandic fulmars confirm that plastic pollution levels in the North Atlantic tend to decrease towards higher latitudes. Levels of pollution thus appear to link to regions of intense human coastal and marine activities, suggesting substantial current inputs in those areas.

As plastic production increases by 5% per year and global demand reaches over 265 million tons in 2010 (PlasticsEurope, 2011), plastic pollution in the marine environment is likely to remain an controversial topic (Thompson et al., 2009). Besides having economic costs like clean-ups and losses of valuable material, marine plastic debris is known to have many negative environmental impacts (Thompson et al., 2009). Entanglement and ingestion of plastic by various marine species of all trophic levels have been described (e.g. Laist, 1987; Derraik, 2002). In recent years, a new concern has emerged: the health effects of plastic components and additives on wildlife and humans (Oehlmann et al., 2009). Such concerns emphasize the urgency of establishing monitoring programs for marine plastic litter (Ryan et al., 2009).

In the Netherlands, long term monitoring of plastic ingestion by northern fulmars (*Fulmarus glacialis*) started in the early 1980s and was established as an annual program from the mid-1990s (van Franeker, 2004) including morphometric measurements and data on moult, organ health and body condition. Stomach contents including proventriculus and gizzard were sieved over a 1 mm mesh with cold fresh water. Plastic particles were taken from the sample and shipped to the Netherlands for further analyses. We have done so to calculate geometric mean mass of plastics, adding/subtracting 1 mg of mass at transformation and back-calculation to allow for inclusion of the zero values. Transformation averages' that include birds without plastic. These averages are mainly presented as arithmetic means and standard error (±se). The relatively small sample and non-normal distributed data suggested a substantial decrease in marine plastic debris with increasing latitude, but suffered from a major gap in data between temperate waters and high-arctic environments.

In 2011, a sample of fulmars from Iceland became available filling that major gap and allowing a test for the hypothesis of a decrease of plastic debris towards higher latitudes in the Atlantic when moving away from major human centres of coastal and marine activities.

The 58 fulmars used for this study were accidental bycatch of a long line fishery off Hornstrandir, Westfjords, Iceland in April, 2011. The fulmars were stored at –20 °C until dissection in the laboratory of the Natural History Museum of Bolungarvík (Westfords, Iceland). The dissections were conducted following the Dutch protocol (van Franeker, 2004) including morphometric measurements and data on moult, organ health and body condition. Stomach contents including proventriculus and gizzard were sieved over a 1 mm mesh with cold fresh water. Plastic particles were taken from the sample and shipped to the Netherlands for further analysis and sorted into categories under a Zeiss stereo microscope. For each plastic category, the number of particles was counted and the weight was measured on a Sartorius electronic scale to an accuracy of 0.0001 g. Averages for number and mass of plastics are ‘population averages’ that include birds without plastic. These averages are mainly presented as arithmetic means and standard error (±se). The relatively small sample and non-normal distributed data with outlying values indicates need for log transformation during analyses. We have done so to calculate geometric mean mass of plastics, adding/subtracting 1 mg of mass at transformation and back-calculation to allow for inclusion of the zero values. Transformation becomes increasingly unsuitable with higher proportions of zero values reducing accuracy in calculations for subcategories of plastic. Another approach to avoid bias from outlying values in non-normal distributions has been chosen in the OSPAR EcoQO.