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Plastic ingestion and trace element contamination of Manx shearwaters *Puffinus puffinus* on the Faroe Islands

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ABSTRACT

Procellariiform seabirds can accumulate high levels of plastic in their gastrointestinal tracts, which can cause physical damage and potentially provides a contamination route for trace elements. We examined plastic ingestion and trace element contamination of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption in 2003 and 2018 on Skúvoy, Faroe Islands (North Atlantic Ocean). Overall, 88% of fledglings contained plastic in their gastrointestinal tracts, with a mean (± SD) of 7.2 ± 6.6 items weighing 0.007 ± 0.016 g. Though the incidence was similar, fledglings ingested significantly more plastic in 2018 compared to 2003. Hepatic trace element concentrations were unrelated to plastic ingestion. Hepatic carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope values were significantly lower in birds sampled in 2018 versus 2003, potentially reflecting further offshore feeding at lower trophic levels. Future research is needed to understand the extent of plastic ingestion by Faroe Islands seabirds.

Plastic pollution is a pervasive threat to marine ecosystems, and the release of plastic waste into aquatic environments is projected to increase into the future (Gall and Thompson, 2015; Borrelle et al., 2020). To date, >1200 marine species are known to have ingested plastics, and these include a large proportion of the world's seabirds (Gall and Thompson, 2015; Kühn and van Franeker, 2020; Santos et al., 2021). Plastic ingestion by pelagic seabirds was first documented in the early-1960s and by 2050 it is predicted that 99% of all seabird species (and 95% of individuals within these species) will have ingested plastic (Rothstein, 1973; Harper and Fowler, 1987; Wilcox et al., 2015). Seabirds may ingest plastics directly (e.g., accidentally or by mistaking plastics for potential prey), indirectly (e.g., secondary ingestion in their prey) or, in the case of chicks, via intergenerational transfer (Ryan, 1987, 1988, 2016; Hammer et al., 2016a). Ingested plastics were recorded in 63.2% of species of Procellariiformes (with available data from 71.5% in the order), and in 41.5% of individuals, which was higher than in other seabird groups (Kühn and van Franeker, 2020). One reason for the higher plastic loads is that the proventriculus (forestomach) and ventriculus (gizzard) of procellariiform seabirds are separated by a narrow, angled isthmus, which hinders regurgitation and contributes to the accumulation of indigestible items (Furness, 1985; Ryan, 2015).

There are few definitive examples of plastic ingestion impacting seabirds at the population level (Roman et al., 2019a; Phillips et al., 2023); however, ingested plastics can have harmful and potentially fatal impacts at an individual level, including from direct physical obstructions and injuries to the gastrointestinal tracts (GIT) (Ryan and Jackson, 1987). There are also concerns that ingested plastics may provide a route by which potentially toxic pollutants, such as trace elements, are transferred to seabird tissues (Lavers et al., 2014; Lavers and Bond, 2016; Puskic et al., 2020; Roman et al., 2020). Trace elements may be added during the production and manufacture of plastics or adsorbed onto the surface of plastics from the surrounding seawater (Turner and Filella, 2021; Lopes et al., 2022; Hamilton et al., 2023).

Feeding behaviours and at-sea distributions can influence the exposure of seabirds to plastics (Clark et al., 2023; Phillips and Waluda, 2020; Roman et al., 2019b; Clark et al., 2023). For instance, surface-feeders and shallow-divers with generalist diets are more likely to ingest plastics than pursuit-diving seabirds, which is partly because plastics are

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more concentrated at the surface than at depth (Reisser et al., 2015; Ryan, 2016). Hence, diet analyses can provide insights into the drivers of plastic ingestion (Caldwell et al., 2020; Jardine et al., 2021). Stable isotope analysis is one method of inferring the diets and distributions of seabirds, as the isotopic composition of their tissues relates predictably to that of their prey. Carbon stable isotope values ($\delta^{13}C$) vary little with trophic level (~1 ‰) but can be used to infer feeding areas of seabirds, such as the relative dependence on inshore vs. offshore, benthic vs. pelagic diet, and latitude/water mass where gradients exist. In contrast, those of nitrogen ($\delta^{15}N$) are primarily used to infer trophic positions, although baseline $\delta^{15}N$ values can also vary spatially in marine environments (Peterson and Fry, 1987; Hobson and Clark, 1992; Bearhop et al., 2002; Cherel and Hobson, 2007; Phillips et al., 2009; Hammer et al., 2016b; Reinert et al., 2023; Mills et al., 2024).

Plastic pollution impacts even the most remote marine ecosystems. In Arctic and subarctic environments, plastic pollution derives from local sources (e.g., fisheries, landfills) and also from distant sources via ocean currents, rivers, wind and biota (Baak et al., 2020; Collard and Ask, 2021; Bergmann et al., 2022). Although plastic ingestion by seabirds appears to be widespread in the Arctic, the topic has received comparatively little attention in the Faroe Islands and has only focused on the northern fulmar *Fulmarus glacialis* and great skua *Stercorarius skua* (Hammer et al., 2016a; van Franeker et al., 2011; Collard et al., 2022).

In this study, we quantified plastic ingestion and trace element contamination of fledgling Manx shearwaters *Puffinus puffinus* at the Faroe Islands. Here, the Faroe Islands are considered as Arctic, as defined by the Conservation of Arctic Flora and Fauna working group of the Arctic Council (CAFF) (Irons et al., 2015). Although there are exceptions, Manx shearwaters typically forage <200 km from colonies during the chick rearing period and obtain prey from the sea surface and via pursuit diving (Dean et al., 2015; Shoji et al., 2015, 2016). Indigestible items are seldom regurgitated (Furness, 1985). The objectives of our study were to: (i) establish baseline data on plastic ingestion and trace element contamination; and (ii) examine correlations between trace element contamination and plastic ingestion. Additionally, we used $\delta^{13}C$ and $\delta^{15}N$ values of liver tissue to provide further insights into the potential drivers of annual variation in contamination.

The most recent estimates suggest that there are ~25,000 breeding pairs of Manx shearwaters on the Faroe Islands (Jensen et al., 2005). At-sea surveys in the waters surrounding the Faroe Islands show that, during their chick-rearing period (July to September), the highest densities of Manx shearwaters are concentrated on the Faroe Bank, the southwestern edge of the Faroe Shelf and the waters west of Sandoy (Skov et al., 2002). On Skúvoy, Faroe Islands (61°45′N, 6°48′W), the permanent residents are legally permitted to undertake an annual harvest of Manx shearwater fledglings for their consumption (Olsen and Nørrevang, 2005). Fowling occurs at night when the fledgling birds are in, or close, to burrow entrances (Olsen and Nørrevang, 2005). Birds are ~70 days old at this time. We collected whole GITs (proventriculus, gizzard and intestines) and livers from a subset of these harvested birds ($n = 34$ individuals) in September 2003 ($n = 14$) and 2018 ($n = 20$). Samples were then stored frozen (–20°C) before examination at Havstovan Faroe Marine Research Institute and the Faroese Environment Agency (Tórshavn, Faroe Islands). No birds were killed for the purposes of this research. As birds were preferentially selected for human consumption, we infer that they were healthy and likely to be representative of the wider population. Complete carcasses were unavailable and hence standard morphometric measurements were not recorded.

Only fully intact GITs were included in our study, which were thawed and slit longitudinally over a dissection tray (Provencher et al., 2019). The proventriculus and gizzard were flushed with water over stacked stainless-steel sieves (mesh sizes of 1 mm and 0.5 mm) and plastics, which were identified via visual examination, were removed, dried, weighed (g) with an electronic balance (±0.0001 g) and the maximum length (mm) was measured under a microscope. Plastics were categorised as either industrial (e.g., nurdles used as raw materials in plastic production) or user plastics (e.g., from consumer/commercial sources) (van Franeker et al., 2011; Provencher et al., 2017). User plastics were further categorised into the following groups: fragments (e.g., unidentifiable hard plastics), threadlike plastics (e.g., rope, line), sheetlike plastics (e.g., bag, film), foam (e.g., polystyrene) and other (e.g., balloon, rubber and unidentifiable items) (Provencher et al., 2017; van Franeker et al., 2011). Plastic items were also grouped into broad colour categories (Provencher et al., 2017).

A small section of liver tissue (~1 cm^3) was removed using a sterilized scalpel blade, rinsed with ultrapure water (Milli-Q®) and freeze-dried for 48 h. Freeze-dried samples were then homogenised using an agate mortar and pestle. Aliquots (~5.0 mg) of liver tissue were pre-digested overnight at room temperature using trace element grade concentrated nitric acid (HNO_3, 70%, Fisher Scientific), purified hydrogen peroxide (H_2O_2, 30%, Fisher Scientific) was then added and samples were heated to 60°C for 120 min in a water bath. After cooling, samples were then made up to volume with ultrapure (Milli-Q®) water and then stored at 4°C prior to analysis. Trace element concentrations (Ag, Al, As, Cd, Co, Cr, Cs, Cu, Fe, Ga, In, Mg, Mn, Pb, Rb, Se, Sr, Tl, U, Y, Zn) were measured in the digests via inductively coupled plasma-mass spectrometry (ThermoFisher™ iCAP-Q ICP-MS) at the Chemical Analysis Facility (CAF) at the University of Reading. Sample blanks were run for quality control purposes and a 50 ppb multielement standard was analysed routinely throughout the sampling sequence (every 10 samples) to quantify the instrument drift which was subsequently corrected. ^{103}Rh was used as the internal standard during analysis. Quantification was carried out with a five-point calibration curve (all $r^2 > 0.995$, range: 0 to 1000 ppb) using serial dilutions of a multielement standard (SPEX CertiPrep™, NIST traceable). Concentrations of all trace elements were above the limit of detection (LoD; calculated as the concentrations corresponding to 3 × the standard deviation (SD) of the blank solution signal) in >70% of samples. Concentrations below the LoD were assigned a value equal to half the LoD for statistical analysis (Anderson et al., 2010). Concentrations are expressed as $\mu g\ g^{-1}$ dw.

Stable isotope analyses were carried out on the same homogenised liver samples as above. Avian liver tissue integrates dietary information during a short period prior to sampling (e.g., half-life of 2.6 days for carbon in Japanese quail *Coturnix japonica*) (Hobson, 1993; Hobson and Clark, 1992). Owing to a high lipid content, stable isotope analyses were undertaken on bulk and lipid-extracted samples of liver tissue. Lipids were extracted using repeated rinses with chloroform:methanol solution (2:1 *v*/v) and ultra-pure water (Milli-Q®). Samples were then dried under a fume hood for 48 h and sub-samples of homogenised material (~0.2 mg) were weighed into 6 × 4 mm tin capsules using a microbalance. Stable isotope ratios of carbon and nitrogen were measured using a continuous flow-isotope ratio mass spectrometer coupled to a ThermoFisher™ DeltaV Advantage fitted with an Isolink CNSOH Temperature Conversion Elemental Analyzer (TC/EA) and smart function at the CAF. Results are expressed in the conventional δ-values in parts per thousand (‰) relative to the international references Vienna PeeDee Belemnite (VPDB) and atmospheric N_2 (AIR) for carbon and nitrogen, respectively. Data were corrected for linearity and instrument drift by analysing an in-house standard every 5 samples and were then stretch corrected using international standards. Replicate measurements of internal and international laboratory standards indicated analytical precisions of ±0.1 ‰ and ± 0.2 ‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively. C:N ratios of bulk and extracted liver samples indicated satisfactory lipid removal (mean ± SD, 4.90 ± 0.98 and 2.15 ± 0.22, respectively). Lipid-extracted $\delta^{13}C$ values were significantly less negative than bulk values, whereas $\delta^{15}N$ values were similar (Wilcoxon rank sum tests, W = 1089, $p < 0.001$ and W = 589.5, $p = 0.568$, respectively), hence lipid-extracted values were used in subsequent analyses.

Data were analysed using R version 4.0.3. and visualised using the ggplot2 package in R (R Core Team, 2020; Wickham, 2016). The assumptions of normality of residuals and homogeneity of variances were tested using Shapiro-Wilk and Levene's tests, respectively. Following best practice recommendations, we report a range of summary statistics based on all individuals (i.e., including those that did not ingest plastic) (Provencher et al., 2017, 2019). The percentage frequency of occurrence (%FO) of plastic ingestion (i.e., incidence) was calculated as the percentage of individuals that ingested plastic and the 95% confidence intervals (CIs) were calculated using the Jeffreys interval. Annual differences in %FO were assessed with a Fisher's exact test. Wilcoxon rank sum tests were used to assess differences in the number and mass of plastics ingested by Manx shearwater fledglings in 2003 and 2018, and the data were visualised in relation to those from young (two weeks) and old (six weeks) northern fulmar chicks from Stóra Dímun (Faroe Islands) sampled in 2020 (Collard et al., 2022). Spearman's rank correlations were used to test for associations between hepatic trace element concentrations and the plastic load (number and mass), with a Bonferroni correction applied to account for multiple testing. Annual differences in hepatic δ^{13}C and δ^{15}N values were assessed using Wilcoxon rank sum tests. Statistical significance was assumed at $\alpha = 0.05$ in all cases.

The majority of plastic items ingested by fledgling Manx shearwaters ($n = 246$) were recovered from the gizzard ($n = 239$, 97.2%) and far fewer from the proventriculus ($n = 7$, 2.8%). The overall %FO of ingested plastic was 88.2% (95% CIs, 74.4–95.9%) and the %FO was not significantly different between 2003 (78.6%, 53.1–93.6%) and 2018 (95.0%, 78.9–99.5%) (Fisher's exact test, $p = 0.28$) (Table 1). The overall %FO in our study was higher than that of adult (68%) or fledgling (75%) Manx shearwaters from Skomer Island (Wales) sampled in 2018 and 2019, but lower than that of northern fulmar chicks (95%) sampled from Stóra Dímun in 2020 (Alley et al., 2022; Collard et al., 2022).

Manx shearwater fledglings ingested a mean (± SD) of 7.2 ± 6.6 plastic items weighing 0.007 ± 0.016 g. The number of ingested plastics was significantly higher in 2018 than in 2003 (Wilcoxon rank sum test, $W = 28.5$, $p < 0.001$) (Table 1; Fig. 1). The mass of ingested plastics was positively skewed, with most fledglings having ingested very little plastic (Fig. 1). Owing to the strong influence of an outlier, the arithmetic mean (but not geometric nor median) of ingested mass in 2003 was higher than 2018 (Fig. 1). Nonetheless, the mass of ingested plastics was significantly higher in 2018 than in 2003 according to the Wilcoxon rank sum test ($W = 57$, $p < 0.01$) (Table 1). Fledglings from our study sampled in 2003 ingested fewer items, and those sampled in 2018 ingested more items, than adults or fledglings on Skomer (mean ± SD, 3.06 ± 3.07 and 2.70 ± 1.93 items, respectively; Alley et al., 2022). Alley et al. (2022) did not record the ingested mass of plastics in the Manx shearwaters sampled at Skomer. The mass of plastics ingested in our study was lower in both years than in young and old northern fulmar chicks (0.16 ± 0.26 g and 0.14 ± 0.15 g, respectively) (Fig. 1). The number of plastic items ingested in our study in 2003 was also lower than in young or old northern fulmar chicks (8.0 ± 9.3 and 16.8 ± 22.7 items; Collard et al., 2022). However, in 2018 the number was higher than in young but not in old northern fulmar chicks (Fig. 1).

Most ingested plastics were user plastics ($n = 245$, 99.6%) and these were mainly hard fragments ($n = 219$, 89.0%), followed by other plastics ($n = 10$, 4.1%), threads ($n = 9$, 3.7%) and sheetlike items ($n = 7$, 2.8%) (Table 2). Only one industrial plastic item was identified, which is consistent with declining industrial plastic ingestion by northern fulmars in the North Sea since the 1980s (van Franeker et al., 2011). Ingested items were mostly off-white/clear ($n = 194$, 78.9 %), followed by black ($n = 21$, 8.5 %) and blue ($n = 19$, 7.7%) (all other colours represented <5%) (Fig. 1). Most plastics ingested by northern fulmar chicks and in great skua pellets from the Faroe Islands were white/yellow (Collard et al., 2022; Hammer et al., 2016a). The relative proportions of different colours could reflect visual similarities with prey or possibly conspicuousness of floating plastic in the marine environment (Ryan, 1987). An extension of Thayer's law suggests that surface-feeding seabirds prefer light-coloured items because they are easier to see against the dark water (Santos et al., 2016); however, clear plastics are presumably less conspicuous than opaque/coloured items. Regardless, without knowing the at-sea distributions and availability of different plastic colours, as is the case in the waters surrounding the Faroe Islands, concluding selectivity for particular colours by seabirds is not possible (Baak et al., 2020).

Trace element contamination can negatively impact seabirds even at low concentrations (Ibañez et al., 2024). Here, there were no significant correlations between hepatic trace element concentrations and the number or mass of ingested plastics (Spearman's rank correlations with Bonferroni correction, all $p > 0.05$) (Table 3). In observational studies such as ours, demonstrating causal relationships between trace element contamination and plastic ingestion is difficult (Roman et al., 2021). The non-significant relationships could be due to the low amount of plastic ingested by Manx shearwaters, low statistical power (due to small sample size), or a greater influence of pollutants in prey compared to those associated with ingested plastic. Though our study found no significant relationships, there are mixed outcomes among other studies of procellariiform seabirds. For instance, plastic ingestion was related to concentrations of Cr and Ag in feathers of fledgling flesh-footed shearwaters *P. carneipes*, Cl concentrations from Laysan albatrosses *Phoebastria immutabilis* and Fe, Mn, Rb, Sr and Pb from Bonin petrels *Pterodroma hypoleuca* (Lavers et al., 2014; Lavers and Bond, 2016). However, trace element concentrations in breast muscle were unrelated to plastic ingestion by short-tailed shearwaters *Ardenna tenuirostris* (Puskic et al., 2020). In beached prions *Pachyptila* spp., ingested plastic was negatively associated with hepatic concentrations of Al, Mn, Fe and Co, and positively with Cu and Zn; these relationships were interpreted as being due to dietary dilution, malnutrition and potential transfer of Zn from ingested plastics (Roman et al., 2020). As plastic waste is increasing in marine environments and trace element contamination can have negative impacts on seabirds (Mills et al., 2020; Ibañez et al., 2024), further work is required to examine the links between plastic ingestion and trace elements.

Annual differences in plastic ingestion could be explained by two non-mutually exclusive reasons. First, exposure to plastics may have differed between the two years (e.g., due to higher pollution levels within foraging areas of parents in 2018 than 2003). There are no long-term monitoring schemes for either marine plastics or plastic ingestion by seabirds in the Faroe Islands (Linnebjerg et al., 2021); hence it is difficult to conclude whether availability increased from 2003 to 2018. Alternatively, the feeding areas or behaviour of adults may have changed between the two years, with repercussions for exposure and hence ingestion. The δ^{15}N values of liver tissue of the fledglings were significantly higher and δ^{13}C values significantly less negative in 2003 (+11.6 ± 0.5 ‰ and −19.7 ± 0.3 ‰) than in 2018 (+10.4 ± 0.5 ‰ and

Table 1

Percentage frequency of occurrence (%FO; with 95% confidence intervals calculated using the Jeffreys interval), mass (g) and number of ingested plastic items recovered from gastrointestinal tracts of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption on Skúvoy, Faroe Islands (North Atlantic Ocean), in 2003 and 2018.

			Mass (g)			Number		
Year	*n*	%FO	Mean ± SD (range)	Geometric mean	Median	Mean ± SD (range)	Geometric mean	Median
2003	14	78.6 (53.1–93.6)	0.009 ± 0.025 (0–0.095)	0.002	0.001	2.3 ± 2.7 (0–9)	1.5	1
2018	20	95.0 (78.9–99.5)	0.006 ± 0.003 (0–0.014)	0.005	0.006	10.7 ± 6.3 (0−21)	8.6	10
Total	34	88.2 (74.4–95.9)	0.007 ± 0.016 (0–0.095)	0.004	0.004	7.2 ± 6.6 (0–21)	4.5	6

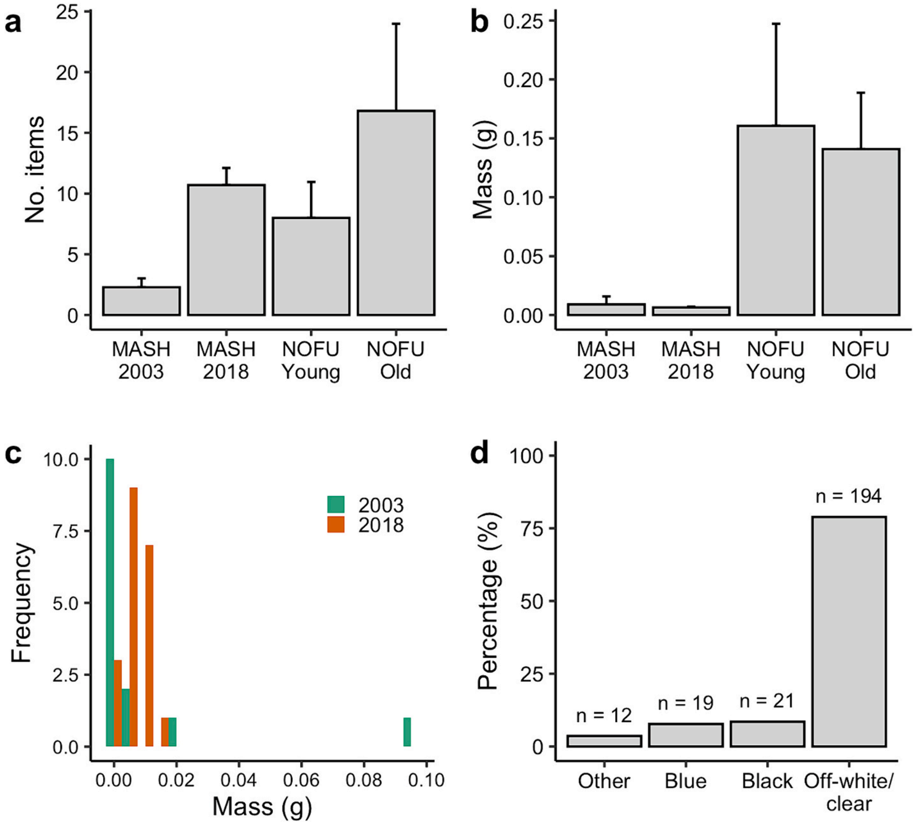

Fig. 1. Mean (± SE) (**a**) number and (**b**) mass (g) of plastic items recovered from gastrointestinal tracts of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption on Skúvoy (Faroe Islands) in 2003 and 2018 (this study) and from young (two weeks) and old (six weeks) northern fulmar *Fulmarus glacialis* chicks from Stóra Dímun in 2020 (Faroe Islands) (Collard et al., 2022). Species abbreviations are MASH = Manx shearwater; NOFU = northern fulmar. (**c**) Histogram showing the distribution of the mass (g) and (**d**) colour of plastic items ingested by Manx shearwater fledglings on Skúvoy in 2003 and 2018.

Table 2
Mass (g) and length (mm) of ingested plastic items recovered from the gastrointestinal tracts of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption on Skúvoy, Faroe Islands (North Atlantic Ocean), in 2003 and 2018.

			Mass (g)			Length (mm)		
Year	Plastic type	*n*	Mean ± SD	Median	Range	Mean ± SD	Median	Range
2003	Fragments	13	0.0071 ± 0.0097	0.0035	0.0001–0.0335	4.19 ± 2.51	3.90	1.12–7.97
	Industrial	1	0.0103	0.0103	–	3.55	3.55	–
	Thread	5	0.0007 ± 0.0006	0.0006	0.0001–0.0016	3.76 ± 0.54	3.81	2.95–4.45
	Sheet	3	0.0023 ± 0.0023	0.0021	0.0001–0.0046	4.22 ± 0.34	4.07	3.98–4.61
	Other*	10	0.0013 ± 0.0018	0.0006	0.0001–0.0057	4.49 ± 2.98	4.11	2.03–11.91
2018	Fragments	206	0.0006 ± 0.0006	0.0005	0.0001–0.0038	1.59 ± 0.47	1.50	0.73–4.40
	Industrial	–	–	–	–	–	–	–
	Thread	4	0.0002 ± 0.0002	0.0002	0.0001–0.0005	2.02 ± 0.31	2.10	1.57–2.30
	Sheet	4	0.0010 ± 0.0018	0.0002	0.0001–0.0037	2.93 ± 2.21	2.19	1.27–6.09
	Other	–	–	–	–	–	–	–

[*] Including rubber, balloons and unidentifiable materials.

−20.1 ± 0.3 ‰) (W = 258, $p < 0.001$ and W = 236, $p < 0.001$, respectively) (Fig. 2). Assuming limited differences in isotopic baselines, this suggests there were differences in the diets and distributions of Manx shearwaters between years, and that parents delivered lower-trophic-level prey from further offshore in 2018 than 2003. However, this would need to be confirmed by further sampling of stable isotope ratios and pollutants in the marine environment around the Faroe Islands, including in prey of Manx shearwaters (small shoaling fish, cephalopods and crustacea). Overall, more research is required to understand the extent of plastic ingestion within the Faroe Islands seabird community.

CRediT authorship contribution statement

William F. Mills: Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Catrin Norris:** Writing – review & editing, Investigation. **Stuart Black:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Richard A. Phillips:** Writing – review & editing, Funding acquisition, Conceptualization. **Sjúrður Hammer:** Writing – review & editing, Investigation. **Bergur Olsen:** Writing – review & editing, Resources. **Jóhannis Danielsen:** Writing – review & editing, Resources, Project administration, Funding acquisition, Conceptualization.

Table 3
Mean (± SD) concentrations (μg g^{-1} dw) of trace elements measured in the livers of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption on Skúvoy, Faroe Islands (North Atlantic Ocean), in 2003 and 2018.

Element	2003 (*n* = 14)	2018 (*n* = 20)	Overall
Ag	0.56 ± 0.19	0.43 ± 0.21	0.49 ± 0.21
Al	37.88 ± 25.58	113.95 ± 130.21	77.93 ± 102.41
As	0.75 ± 0.19	0.90 ± 0.31	0.83 ± 0.27
Cd	1.76 ± 0.67	1.68 ± 0.60	1.72 ± 0.63
Co	0.48 ± 0.24	0.41 ± 0.32	0.44 ± 0.29
Cr	0.43 ± 0.27	0.46 ± 0.27	0.45 ± 0.27
Cs	0.05 ± 0.03	0.05 ± 0.03	0.05 ± 0.03
Cu	27.81 ± 25.86	25.86 ± 6.21	26.78 ± 10.27
Fe	1290.48 ± 587.70	1673.72 ± 504.34	1492.18 ± 571.76
Ga	0.07 ± 0.14	0.09 ± 0.20	0.08 ± 0.17
In	0.47 ± 0.92	0.52 ± 1.25	0.50 ± 1.09
Mg	793.34 ± 177.34	1169.64 ± 245.93	991.39 ± 285.96
Mn	11.90 ± 2.60	19.49 ± 4.95	15.89 ± 5.51
Pb	0.78 ± 1.10	0.36 ± 0.50	0.56 ± 0.85
Rb	4.64 ± 1.12	6.84 ± 1.33	5.80 ± 1.65
Se	1.65 ± 1.08	2.78 ± 1.39	2.24 ± 1.36
Sr	2.11 ± 1.57	1.89 ± 1.60	1.99 ± 1.57
Tl	0.02 ± 0.02	0.01 ± 0.02	0.02 ± 0.02
U	0.06 ± 0.12	0.07 ± 0.16	0.07 ± 0.14
Y	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.02
Zn	68.05 ± 54.21	77.49 ± 43.47	73.02 ± 48.41

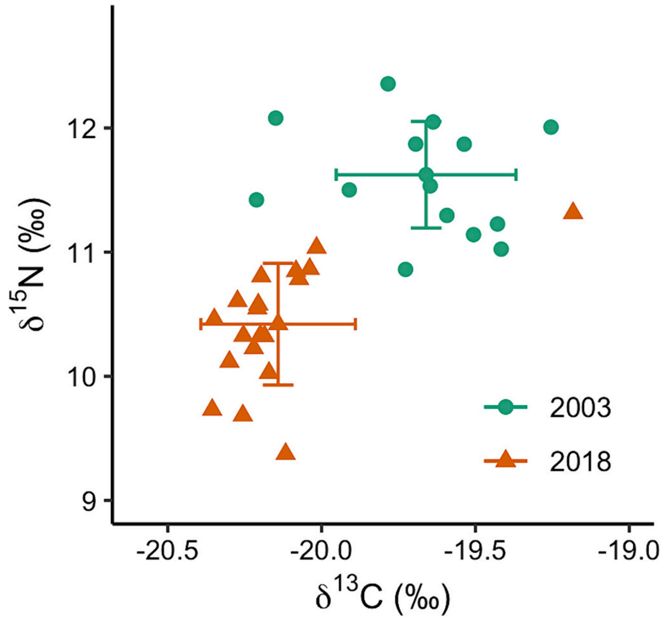

Fig. 2. Mean (± SD) and individual hepatic stable isotope values of carbon (δ^{13}C) and nitrogen (δ^{15}N) of fledgling Manx shearwaters *Puffinus puffinus* that were harvested for human consumption on Skúvoy, Faroe Islands (North Atlantic Ocean), in 2003 and 2018. Lipids were extracted from liver tissue prior to stable isotope analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available from the corresponding author upon reasonable request.

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