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Trace element concentrations in harvested auks from Newfoundland: Toxicological risk of a traditional hunt

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ABSTRACT

Common (*Uria aalge*) and Thick-billed Murres (*Uria lomvia*) are apex predators in the North Atlantic Ocean, and are also subject to a traditional hunt in Newfoundland and Labrador during the winter months, along with small numbers of illegally harvested Razorbills (*Alca torda*). Because of their high trophic position, auks are at risk from high contaminant burdens that bioaccumulate and biomagnify, and could therefore pose a toxicological risk to human consumers. We analysed trace element concentrations from breast muscle of 51 auks collected off Newfoundland in the 2011–2012 hunting season. There were few differences in contaminant concentrations among species. In total, 14 (27%) exceeded Health Canada or international guidelines for arsenic, lead, or cadmium; none exceeded guidelines for mercury. Cadmium concentrations >0.05 μg/g have persisted in Newfoundland murres for the last 25 years. We urge the integration of this consumptive harvest for high-trophic marine predators into periodic human health risk assessments.

1. Introduction

Many remote and indigenous populations harvest marine predators for economic, cultural, and subsistence reasons (Dehn et al., 2006; Diamond, 1987; Kuhnlein and Chan, 2000; Merkel and Barry, 2008; Skira et al., 1985). Globally, there are few regulated harvests of marine birds, and those that remain unregulated are generally declining in popularity (Gaston and Robertson, 2010; Richardson, 1984; Skira, 1990) or are stable (Newman et al., 2009; Olsen and Nørrevang, 2005). As apex predators in the marine environment, seabirds are exposed to bioaccumulated and biomagnified contaminants (Burger and Gochfeld, 2002). Recently, there has been an increased awareness by researchers of the human health effects of the consumption of traditional foods, including apex predators (Dewailly et al., 1992; El-Din Bekhit et al., 2011; Hoekstra et al., 2005; O'Hara et al., 1999; Ostertag et al., 2009), but there has been little toxicological monitoring of traditional harvests (Burger et al., 2007; Lavers and Bond, 2013).

There is a legal, non-indigenous, traditional hunt for murres (*Uria* spp.), large seabirds in the family Alcidae, in Newfoundland and Labrador (Chardine et al., 2008). This harvest is unique in that it is North America's only legal non-indigenous harvest of seabirds; both Common (*Uria aalge*) and Thick-billed Murres (*Uria lomvia*) are harvested at sea between September and March (Elliot, 1991; Environment Canada, 2011). The practice of harvesting seabirds in general, and "turr hunting" in particular, is a long-standing tradition in Newfoundland and Labrador (Montevecchi et al., 2007; Pope, 2009; Tuck, 1952), and though its practice is generally decreasing (Gaston and Robertson, 2010), technological advances have allowed the remaining hunters to exploit the murre populations considerably (Montevecchi et al., 2007; Regular et al., 2010). In the 1970s and 1980s, upwards of 400,000–750,000 murres were shot annually (Chardine et al., 1999; Wendt and Cooch, 1984), but this declined in the 1990s to less than 200,000 through a combination of tighter hunting regulations and a decreasing number of hunters (Chardine et al., 1999; Gaston and Robertson, 2010). The majority of harvested birds are Thick-billed Murres, but Common Murres comprise 5–20% in some areas (Elliot, 1991; Hedd et al., 2011); up to 4–5% of the annual harvest is composed of Razorbills (*Alca torda*), a similar-looking auk for which there is no legal hunt (Blanchard, 1984; Lavers et al., 2009).

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In general, the entire murre is cooked and most is consumed, particularly breast muscle (Montevecchi et al., 2007), and often the viscera, known locally as the "lights" (PCR, pers. obs.).

Murres feed on fish, such as capelin (*Mallotus villosus*), Arctic cod (*Boreogadus saida*), or Atlantic cod (*Gadus morhua*) as well as invertebrates (Elliot et al., 1990; Moody and Hobson, 2007; Rowe et al., 2000). Furthermore, murres are harvested using lead (Pb) shot, which can become embedded or leave small fragments in edible portions, causing high Pb concentrations in foods (e.g., soup, meat) that are up to 25 times higher than other food sources of Pb (Johansen et al., 2001, 2004, 2006b).

Previous assessments of contaminants in murres involved pooled samples (which eliminates individual variation), considered one (or few) elements or compounds, had small sample sizes, or did not discuss the human health implications of the murre harvest directly (Braune et al., 1999; Donaldson et al., 1997). All previous sampling was conducted at least 20 years ago, and global concentrations of some contaminants, such as mercury (Hg) have increased substantially since then (Lamborg et al., 2014; Streets et al., 2009; UNEP, 2013).

Current Health Canada guidelines limit mercury (Hg) and lead (Pb) in meat to 0.5 μg/g, and arsenic (As) to 3.5 μg/g in meat products and fish protein on a wet weight basis (Government of Canada, 2013; Health Canada, 2007). There are no current Canadian national guidelines for cadmium (Cd), but both the European Commission, and Australia and New Zealand have adopted a recommendation of 0.05 μg/g in meat and meat products (Department of Health and Ageing, 2011; European Commission, 2006).

Our objectives were to (1) assess the toxicological threat posed by the consumed portions of harvested murres in Newfoundland, (2) compare these results with previous studies of contaminants in murre muscle, and (3) place the results in a broader context of wildlife toxicology and human health interactions.

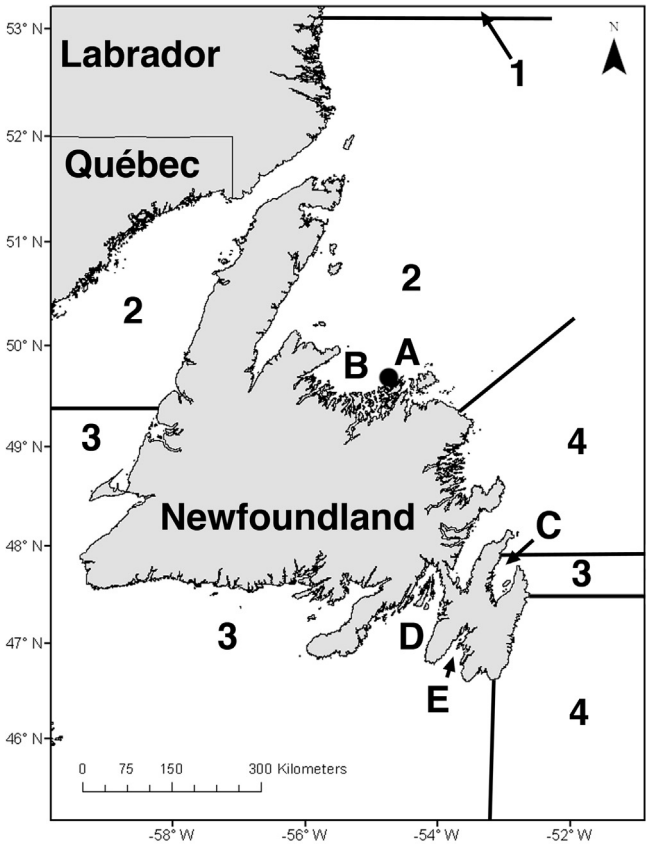

Fig. 1. We collected murres (*Uria* spp.) from Twillingate (A, circle), Conception Bay (C), and St. Mary's Bay (E). Confiscated Razorbills (*Alca torda*) were shot in Notre Dame Bay (B), and murres examined for lead shot also came from Placentia Bay (D) and Conception Bay. The approximate boundaries of murre hunting zones (1–4) are also indicated (Environment Canada, 2011).

2. Methods

2.1. Sample collection and preparation

Birds were collected under permit from the Canadian Wildlife Service off the Newfoundland coast near Twillingate (49.67°N, 54.79°W, $n=34$) in November 2011, St. Mary's Bay in January 2012 (46.93°N, 53.69°W, $n=6$) and Conception Bay in January 2012 (47.75°N, 53.00°W, $n=4$). Razorbills ($n=7$ from Notre Dame Bay (49.83°N, 55.37°W)) were obtained from seizures of illegally shot birds (Environment Canada enforcement personnel; Fig. 1). Birds were frozen within 8 h of collection, and shipped frozen to the National Wildlife Research Centre in Ottawa, Ontario for dissection. Birds were thawed, and the species identified. The left breast muscle from each bird was removed and placed in a sterile glass jar covered with aluminium foil to prevent moisture loss, and frozen. Prior to analysis, 3–5 g (wet weight) was transferred to a small vial, and freeze-dried for 48 h.

2.2. Trace element analysis

The resulting 1.0–1.5 g dried muscle was subsampled for analysis using inductively coupled plasma mass spectrometry (ICP-MS) at Memorial University of Newfoundland, or for analysis of total Hg using atomic absorption spectrometry at the University of New Brunswick. For ICP-MS analysis, between 0.3 and 0.7 g of each sample was placed in an acid-cleaned screw cap Teflon vessel with 1 ml of 8 M HNO_3 on a 70 °C hotplate. After the first hour, another 1 ml of 8 M HNO_3 was added. After digesting for 24 h, the hotplate temperature was lowered to 50 °C, and 1 ml H_2O_2 was added, and the caps removed. When the tissue was completely digested, the vessels were recapped, and the hotplate temperature was raised to 70 °C for 3 h. The digested samples were transferred to clean, sealed containers, and diluted 500× with Millipure water. For ICP-MS analysis, 1 ml of this solution was pipetted into a clean 10 ml tube with 4 ml of Millipure water, making the final solution a 2500× dilution. All tools were either cleaned with 95% ethanol or were single-use; all chemicals were ACS analytical grade.

ICP-MS analysis was conducted on a PerkinElmer ELAN DRCCII, and instrument set-up followed Bond and Lavers (2011) and Friel et al. (1990). Procedural blanks and certified reference materials were run every 15–20 samples. The reference materials used were NIST 2976 and NIST 2977 (mussel tissue), and recovery details are presented in Table 1. We restricted our analysis to those elements that could be measured reliably as indicated by recovery of the reference materials: Ca, Fe, Mn, Co, Cu, Zn, As, Br, Rb, Sr, and Pb. Elemental concentrations are presented as mean ± S.D. in parts per million (μg/g) based on wet weight.

Samples were analysed for total Hg using a Milestone DMA-80 direct mercury analyser (Haynes et al., 2006) and calibrated using procedural blanks, and reference materials DORM-2 and TORT-3 (National Research Council, Ottawa) every 10 samples; recovery of reference materials was 90.5 ± 5.8% and 104.5 ± 8.3% respectively. Approximately 10% of samples were analysed in duplicate, and the mean standard deviation of duplicates was 0.015 ± 0.009 μg/g. Detection limits for all elements are presented in Table 2.

2.3. X-ray procedures for detecting lead shot

Because murres are hunted with lead shot, and shot or fragments of shot can contaminate tissue (Johansen et al., 2001), muscle samples were x-rayed to determine the quantity of lead