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ORIGINAL ARTICLE

Metals and radionuclides in birds and eggs from Amchitka and Kiska Islands in the Bering Sea/Pacific Ocean ecosystem

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Abstract Metals and radionuclide levels in marine birds of the Aleutians are of interest because they are part of subsistence diets of the Aleut people, and can also serve as indicators of marine pollution. We examined geographic and species-specific variations in concentrations of radionuclides in birds and their eggs from Amchitka, the site of underground nuclear tests from 1965 to 1971, and Kiska Islands (a reference site) in the Aleutians, and the levels of lead, mercury and cadmium in eggs. In 2004 we collected common eiders (*Somateria mollissima*), tufted puffins (*Fratercula cirrhata*), pigeon guillemot (*Cepphus columba*) and glaucous-winged gulls (*Larus glaucescens*) from Amchitka and Kiska, and eggs from eiders and gulls from the two island. We also collected one runt bald eagle (*Haliaeetus leucocephalus*) chick from both Amchitka and Kiska Islands. For most species, the levels of radionuclide isotopes were below the minimum detectable activity levels (MDA). Out of 74 cesium-137 analyses, only one composite (gulls) was above the MDA, and out of 14 composites tested for plutonium (Pu-239, 240), only one exceeded the MDA (a guillemots). Three composites out of 14 tested had detectable uranium-238. In all cases, the levels were low and close to the MDAs, and were below those reported for other seabirds. There were significant interspecific differences in metal levels in eggs: gulls had significantly higher levels of cadmium and mercury than the eiders, and eiders had higher levels of lead than gulls. There were few significant differences as a function of island, but eiders had significantly higher levels of cadmium in eggs from Kiska, and gulls had significantly higher levels of mercury on Kiska. The levels of cadmium and mercury in eggs of eiders and gulls from this study were above the median for cadmium and mercury from studies in the literature. The levels of mercury in eggs are within the range known to affect avian predators, but seabirds seem less vulnerable to mercury than other birds. However, the levels of mercury are within the action levels for humans, suggesting some cause for concern if subsistence Aleuts eat a large quantity of eggs.

Keywords Birds · Eggs · Radionuclides · Mercury · Lead · Human consumption · Risk

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1 Introduction

Increasingly the public, governmental agencies, conservationists, researchers and public policy makers are

interested in assessing the health and well-being of the environment. Contaminants are one important environmental stressor of concern that derive from geological and oceanic processes, as well as from anthropogenic sources, including industrial emissions, agricultural runoff and effluents (Mailman, 1980). Atmospheric transport and deposition contribute to local sources (Fitzgerald, 1989). Once in aquatic environments, contaminants enter the food chain by different routes, and with each step in the food chain, there is the potential for bioamplification, particularly for mercury (Lewis and Furness, 1991). Contaminants, such as metals and radionuclides, can have adverse effects on the health and well-being of organisms, including humans, creating the need for information on contaminant trends.

Top-level carnivores are often used as bioindicators because they are exposed to higher levels of contaminants than species that are lower on the food chain (Monteiro and Furness, 1995). Seabirds are ideal indicators of environmental contaminants because they are often at the top of food chains, are common and widespread, numerous, long-lived, and are of interest to the public (Monteiro and Furness, 1995; Thompson and Furness, 1998; George, 1999; Burger and Gochfeld, 2000, 2001). While there is a voluminous literature on metal and organochlorines in marine birds (Burger and Gochfeld, 2001), there is much less on radionuclides (Brisbin, 1991); still fewer studies examine two of these classes at once, especially in areas where radionuclide exposure may have occurred.

In the 1960's Amchitka Island was chosen by the Atomic Energy Commission (a predecessor of the Department of Energy) for nuclear testing. *Cannikin*, the last and largest shot (ca 5 megatons), had an elevator shaft that was over 1800 m below the surface, and the blast and resulting chimney collapse formed a new lake (Cannikin Lake) on the island surface. The three Amchitka test shots accounted for about 16% of the total energy released from the US underground testing program, and *Cannikin* was the largest U.S. underground blast (Robbins *et al*., 1991; Norris and Arkin, 1995; DOE, 2000). Although there was some release of radioactivity to the surface, the leaks were not considered to pose serious health risks at the time (Seymour and Nelson, 1977; Faller and Farmer, 1998). Since Amchitka Island is in one of the most volcanically and seismically active regions of the world (Jacob, 1984; Page *et al.*, 1991), stakeholders are concerned that earthquakes could open pathways into the sea and marine food webs (Kohlhoff, 2002). BEST (2003) noted that over 40% of all the United States fish and shellfish landings (by weight) derive from the Eastern Bering Sea (including Dutch Harbor). This fish/shellfish community also serves as the food base for many marine birds, as well as for subsistence fishing by Aleuts (NRC, 1996; Jewett, 2002; Patrick, 2002; Hamrick and Smith, 2003). Some of the most abundant and diverse seabird communities breed in the Northern Pacific/Bering Sea ecosystem (Kenyon, 1961; Rocque and Winker, 2004). Thus there is interest not only in ascertaining the levels of radionuclides in marine biota around Amchitka, but in assessing particular organisms as potential bioindicators of future exposure.

In this paper we report on the levels of radionuclides and metals in seabirds and their eggs from near Amchitka and Kiska Islands in the Aleutian Chain in the Bering Sea/Northern Pacific. We studied the birds living on Amchitka Island as part of an assessment of possible radioactive contamination from the underground nuclear tests, and Kiska was selected as a reference site because of the similarity of its marine communities to those at Amchitka. A major concern of stakeholders is that the radioactive residues in the underground cavities could migrate through porous rock or through faults and fractures to reach the sea and contaminate the marine food chain. A Department of Energy (DOE) groundwater model predicted that such breakthrough of radionuclides to the sea might occur between 10 and 1000 years after the tests (DOE, 2002), making it important to examine biota for evidence of possible radionuclide seepage into the marine environment. This was one of the overall objectives of the CRESP expedition which collected marine algae, invertebrates and fish as well as birds; no clear evidence of such breakthrough was identified in 2004 (Powers *et al.*, 2005).

We examined several radioisotopes in tissues of common eiders (*Somateria mollissima*), tufted puffins (*Fratercula cirrhata*), pigeon guillemots (*Cepphus columba*) and glaucous-winged gulls (*Larus glaucescens*), and in eggs from eiders and gulls from the two islands in 2004. We also collected one runt bald eagle (*Haliaeetus leucocephalus*) chick from nests on each island. Eagles were collected as a screen for radionuclides, and to compare with previous work (Anthony *et al.*, 1999). We also examined the levels of lead, mercury and cadmium in the eggs of gulls and eiders; these three metals are contaminants of