Geographical, Species and Temporal Trends of Persistent Organic Pollutants (POPs) in Alaskan Murre (*Uria* spp.) Eggs

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Introduction

Murre (*Uria* spp.) eggs have been used to monitor environmental contaminants in the Baltic Sea and eastern Canadian arctic since 1969 and 1975, respectively.[1,2] However, little work was done in the North Pacific prior to the 1990s. Murres are a group of seabirds that are particularly well suited for monitoring contaminants because they are found throughout the northern latitudes, migrate relatively short distances between winter and summer ranges, feed primarily on fish, and lay single eggs that are usually replaced if they are lost during the early incubation period.[3-5] Contaminant levels in the eggs have been found to be representative of adult females at the time of laying.[2,6] In addition, murres and their eggs are important items in subsistence diets.[7]

In 1999, the Seabird Tissue Archival and Monitoring Project (STAMP) was implemented by the U.S. Fish and Wildlife Service's Alaska Maritime National Wildlife Refuge (USFWS-AMNWR), the U.S. Geological Survey's Biological Resources Division (USGS-BRD), and the National Institute of Standards and Technology (NIST) as a long-term collaborative Alaska-wide effort to monitor trends in environmental quality by collecting and banking colonial seabird eggs and analyzing them for contaminants (e.g., chlorinated pesticides, polychlorinated biphenyls [PCBs], and mercury). In 2004, the Bureau of Indian Affairs Alaska Region Subsistence Branch (BIA-ARSB) joined this effort as a fourth federal partner.

Persistent organic pollutants (POPs) were first reported in Alaskan birds in the early 1960's.[8-10] Although few POPs have been used in arctic and subarctic regions, several common characteristics, including low water solubility and long atmospheric residence times, facilitate long-range atmospheric and oceanic transport of these potentially harmful compounds.[11] As a result, the northern latitudes have become a sink for some POPs, because cold temperatures favor condensation over evaporation and they also slow decomposition times.[12] Because of human health concerns and stable or increasing POP levels in some wildlife species, monitoring contaminants in the Arctic has received international support.[13]

Study objectives were to assess spatial and temporal trends and species differences in PCBs and organochlorine pesticides using murre eggs.

Materials and Methods

Since 1999, STAMP has collected and banked nearly 350 murre eggs. In this paper we report organochlorine contaminants in 99 eggs obtained in 1999-2002 (Fig. 1). Cryogenic homogenization, chemical analyses, and statistical methods have been reported by Vander Pol *et al*.[14] Beginning with the 2001 samples, analyses were conducted using GC/MS as described by Tuerk *et al*.[15] The only exception was a PTV injector used for sample introduction. Liquid nitrogen vapor at 84.0 mL/min was used to cool the inlet to 10 ^{o}C for 1.6 minutes during four sample injections of 5.0 µL each (20 µL total) onto the column. The inlet was than heated to 250 ^{o}C at a rate of 720 ^{o}C/min. Split flow was set at 65.0 mL/min and 0 Pa for the first 1.5 min, purged at 80.0 mL/min at 2.3 min, and then stabilized at 1.2 mL/min and 1.67 x 10^5 Pa.

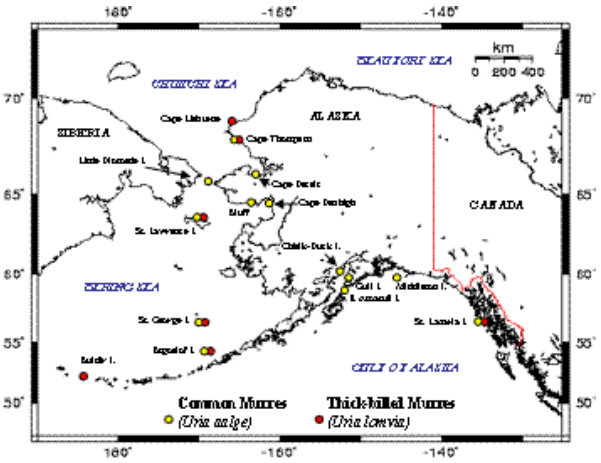

Figure 1. Seabird Tissue Archival and Monitoring Project (STAMP) 1999-2004 murre (*Uria* spp.) egg sampling sites.

Only primary POP compounds are addressed in this paper. Compounds used for a principal components analysis (PCA) based on a correlation matrix as described in Vander Pol *et al.* are: PCB 28+31, PCB 66, PCB 56, PCB 99, PCB 118, PCB 146, PCB 153+132, PCB 105, PCB 138, PCB 163, PCB 187, PCB 183, PCB 180+193, PCB 170, 4,4'-DDE, HCB, α-HCH, oxychlordane, and dieldrin.[14]

Results and Discussion

Because significant ($p < 0.05$) differences were found in the percent lipid in eggs among colonies (Fig. 2), data are reported on a lipid mass basis. Previous work has shown significant differences between contaminant concentrations in common murre (*Uria aalge*) eggs from Bering Sea and Gulf of Alaska colonies.[14] In contrast, results from this study indicate that fewer significant differences are present between thick-billed murre (*U. lomvia*) eggs from these same regions, with eggs from St. Lazaria Island in the Gulf of Alaska still containing slightly higher organochlorine concentrations than the colonies in the Bering Sea (Fig. 2). Differences between Gulf of Alaska and Bering Sea contaminant loads followed the same pattern observed in mercury levels in these same eggs, and they were also similar to the pattern found in murre eggs from these regions about a quarter of a century ago.[16,17] Differences in POP levels between these regions probably resulted from differences in summer and winter foraging areas, prey species, and concentrations of contaminants entrained in regional food webs, as well as differences in atmospheric and oceanic transport patterns and sources of contaminants.

In the Bering Sea, contaminant levels were significantly ($p < 0.05$) higher in thick-billed murre eggs than in common murre eggs.[14] However, recent analyses of Gulf of Alaska eggs found fewer significant differences, but higher concentrations in common murre eggs (Fig. 2). Although the two murre species are similar, thick-billed murres dive deeper than common murres and tend to forage on benthic fish and invertebrates, while common murres primarily take semi-pelagic forage fish.[18,19] Wintering areas may also differ between the species. The reversal in contaminant patterns between common and thick-billed murres may be related to differences in water bodies and near-shore and insular habitats.

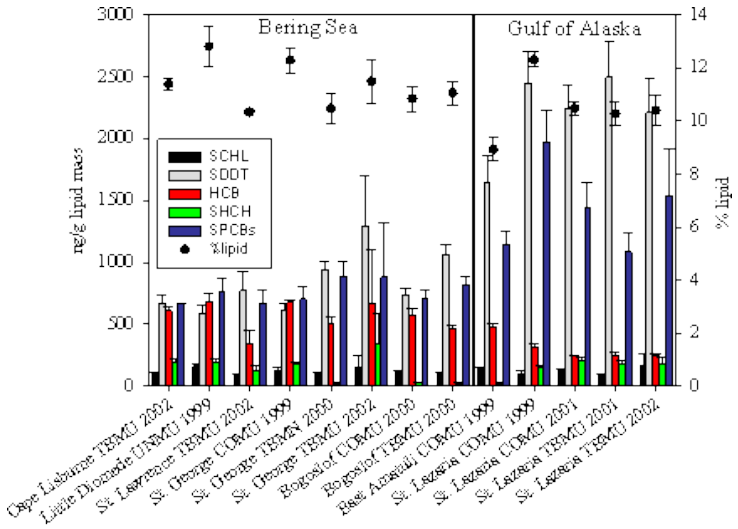

Figure. 2. Means and standard errors for percent lipid and major contaminants in murre (*Uria* spp.) eggs from Alaskan nesting colonies. Eggs collected in 2000 and from East Amatuli I. were not analyzed for β-HCH, resulting in much lower sum of HCH values.

Concentrations of PCBs 66, 56+60 and 118, HCB, and mercury were significantly ($p < 0.05$) lower in common murre eggs at St. Lazaria Island in 2001 compared to 1999 (Fig. 2).[16] In contrast, similar changes were not found in thick-billed murre eggs collected at St. George Island in 2000 and 2002, and St. Lazaria Island in 2001 and 2002 (Fig. 2). Strong El Niño conditions prevailed in the Gulf of Alaska in 1998, and this warm-water event may have contributed to the differences that were observed in the St. Lazaria common murre eggs. Water body and species differences may help explain why a similar difference was not apparent in the thick-billed murre eggs from St. George Island. Also, the short one year interval between the St. Lazaria collections may have made detecting changes difficult.

PCA helps illustrate the differences among colonies (Fig. 3). The first two principal components (PCs) helped explain about 61 % of the variation. For PC 1, PCBs 170 and 180+193 and HCB loaded high and oxychlordane, PCB 28 and α-HCH loaded low. For PC 2, HCB loaded low and PCBs 153+132, 99, 118, and 138 loaded high.

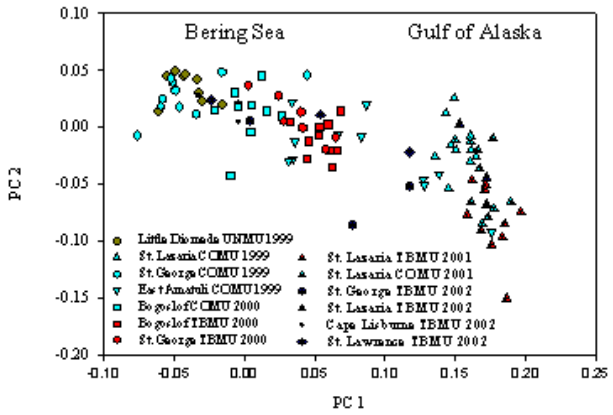

Figure 3. Principal components analysis showing some separation of Gulf of Alaska and Bering Sea murre (*Uria* spp.) egg colonies as well as common (*U. aalge*) and thick-billed (*U. lomvia*) eggs from the same colony.

STAMP plans to continue collecting, banking, and analyzing murre eggs to monitor long-term trends in contaminants. However, studies are also needed to help identify sources of annual, regional and between-species variation, and to better describe differences between summer and winter foraging areas, local and regional food webs, and prey types taken by the two murre species. Studies are also needed to clarify contaminant offloading processes and identify transport pathways.

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