THE SEABIRD TISSUE ARCHIVAL AND MONITORING PROJECT

The analysis of seabird tissues, particularly eggs, has played an important role in environmental monitoring in Europe and Canada. The Canadian Wildlife Service (CWS) collects, banks, and analyzes eggs and tissues from northern Atlantic and Pacific seabirds as part of its Wildlife Toxicology Program. (Mineau *et al.* 1984, Elliott 1985, and Wakeford and Kasserra 1997). Eggs are particularly useful for temporal and spatial monitoring of persistent organic pollutants [e.g., polychlorinated biphenyls (PCBs), chlorinated pesticides, dioxins] and mercury. For example, the CWS successfully documented temporal changes in PCBs and pesticides in the Great Lakes by analyzing banked herring gull (*Larus argentatus*) eggs (Mineau *et al.* 1984, Wakeford and Kasserra 1997). Also, eggs from alcids (seabirds belonging to the family Alcidae that include murres, murrelets, auklets, guillemots, and puffins) were identified as key materials for circumpolar monitoring of persistent organic pollutants (POPs) by all arctic nations participating in the International Arctic Monitoring and Assessment Programme (AMAP) Phase II - Years 1998-2003 (AMAP Scientific Experts Workshop, Girdwood, Alaska, April 1998).

Although the first AMAP report on the state of the arctic environment summarizes information on POPs and mercury from seabirds living in northern regions, it is limited to Canada and Scandinavia (AMAP, 1998). This report, which is presently being revised, contains data indicating that piscivorous seabirds feeding near the top of the marine food web (e.g., cormorants, puffins, kittiwakes) have higher concentrations of PCBs in their eggs than those feeding at lower levels (e.g., eiders). POPs levels in seabird eggs were higher in the Scandinavian arctic than in the Canadian arctic and, within Canada, levels were greater in the high eastern arctic regions than in the lower western arctic regions. Also, PCB concentrations approaching levels known to affect hatching success were found in thick-billed and common murre (*Uria lomvia* and *U. aalge*), puffin (*Fratercula* spp.), black guillemot (*Cepphus grylle*), and black-legged kittiwake (*Rissa tridactyla*) eggs from northern latitudes in Canada and Norway (AMAP 1998).

Few data exist on POPs in colonial seabirds nesting in Alaska. Kawano *et al.* (1988) reported chlordane concentrations in thick-billed murres collected in the North Pacific and Gulf of Alaska in 1980 and 1982. The only other (and more comprehensive) information on organochlorine residues in Alaskan seabirds was obtained in the 1970s (see Ohlendorf *et al.* 1982).[1] Extrapolating POPs and mercury values from the Canadian arctic database is not appropriate, because sources for Alaska are different. Atmospheric and oceanic transport of contaminants from Southeast Asia eastward and northward into the Gulf of Alaska and Bering Sea, and the oceanic transport of other substances eastward along the northern and eastern coasts of Siberia and into the Chukchi and Bering seas probably affect overall contaminant levels and patterns in Alaskan seabirds. Local sources from existing and former military installations may also play roles in Alaskan pollutant patterns.

More than 95% of the seabirds breeding in the continental United States breed at Alaskan colonies in the Gulf of Alaska and Bering and Chukchi seas (USFWS 1992), and about 80% of the Alaskan birds' nest on Alaska Maritime National Wildlife Refuge (AMNWR) land (G.V. Byrd, pers. comm.). In 1998 and 1999, the U.S. Geological Survey Biological Resources Division (USGS-BRD), AMNWR, and the National Institute of Standards and Technology (NIST) initiated a joint project to develop and test protocols for

[1] Ohlendorf *et al.* (1982) analyzed common murre eggs from Middleton, Bogoslof, and St. George islands, and both common and thick-billed eggs from Ugaiushak Island. He also analyzed black-legged kittiwake eggs from Middleton Island and Bluff, and fork-tailed storm-petrels *(O. furcata)* from East Amatuli Island. Compounds reported from these early POPs analyses include DDE, dieldrin, heptachlor epoxide, osychlordane, HCB, and PCBs.

collecting, processing, transporting, and banking seabird tissues, including eggs, collected at several AMNWR colonies. Based on the results of this work, a 100-year-long monitoring program named the Seabird Tissue Archival and Monitoring Project (STAMP; see York *et al.* 2001) was established in 1998. STAMP is currently collecting and cryogenically storing common and thick-billed murre and black-legged kittiwake eggs from 11 AMNWR and 2 privately owned seabird colonies for future research, and it is also analyzing aliquots from the banked eggs for temporal and spatial monitoring of persistent bioaccumulative contaminants at these Alaskan nesting locations.[2]

Common (center) and Thick-billed Murres

Black-legged Kittiwakes on Nests incubating Eggs (a typical 2-egg clutch can be seen at top-center)

Protocols for collecting, sampling, processing, transporting, and banking murre eggs were developed and tested in 1998–1999 (see York *et al.* 2001), when murre eggs were obtained from Cape Lisburne in the Chukchi Sea, Little Diomede Island in Bering Strait, St. George Island in the southern Bering Sea, Bogoslof Island in the Aleutian Islands, East Amatuli Island in the northern Gulf of Alaska, and St. Lazaria Island in the southeastern Gulf of Alaska. Once testing was completed, protocols were modified as needed for use during long-term studies of POPs and mercury levels in Alaskan murres (e.g., see Becker *et al.* 2001a, 2001b; Christopher *et al*. 2001; Kucklick and Vander Pol 2001; Vander Pol *et al.* 2001). After baseline data sets have been developed for the complete suite of STAMP colonies, eggs will be periodically collected from the nesting locations and checked for potentially harmful contaminants (tentatively, about every 5 years). As funding becomes available, the long-term STAMP program will be methodically expanded to monitor levels of POPs and mercury in other seabirds breeding in the Gulf of Alaska and Bering and Chukchi seas. STAMP is currently adding black-legged kittiwakes (*Rissa tridactyla*) to its list of sampled species. Other species tentatively identified for inclusion in the monitoring program include glaucous and glaucous-winged gulls *(Larus glaucescens* and *L. hyperboreus),* storm-petrels *(Oceanodroma spp.),* and auklets *(Aethia* spp.*).*

Preliminary analytical results suggest that there are substantial geographical differences between concentrations of anthropogenic contaminants in murre eggs from Gulf of Alaska and Bering Sea colonies**.** Common murre eggs from St. Lazaria and East Amatuli islands in the Gulf of Alaska were found to contain significantly higher concentrations of total mercury (691 ± 19 and 665 ± 253 ng/g dry

[2] STAMP sampling sites currently include Cape Lisburne and Cape Thompson in the eastern Chukchi Sea; Little Diomede Island in Bering Strait; Bluff in Norton Sound; St. Lawrence and St. George islands in the Bering Sea; Bogoslof Island in the Aleutains; Chowiet, Kodiak, East Amatuli, Middleton, and St. Lazaria islands in the Gulf of Alaska; and Shoup Bay in Prince William Sound**.**

weight, respectively) than those from St. George Island in the Bering Sea and Little Diomede Island in Bering Strait (85 ± 27 and 178 ± 68 ng/g dry weight, respectively). Samples from these eggs will be analyzed for methyl mercury to determine what proportion of the total mercury consists of this toxic organic form.

Total PCBs, as expressed by the sum of 43 individual PCB congeners, and 4,4'-DDE were higher in the eggs of common murres from the Gulf of Alaska colonies (St. Lazaria and East Amatuli islands) than those from the Bering Sea (Little Diomede, St. George, and Bogoslof islands). Total PCBs were significantly higher in the St. Lazaria eggs (1970 ± 800 ng/g lipid weight) and 4,4'-DDE was significantly higher in both the St. Lazaria and East Amatuli eggs (2440 ± 800 and 1560 ± 740 ng/g lipid weight, respectively) than the eggs from the other locations. The contribution of 4,4'-DDE to the total concentration of POPs was twice as high in the St. Lazaria and East Amatuli eggs as it was in the eggs from the three Bering Sea colonies. Also, HCB was significantly lower in the St. Lazaria eggs (i.e., 316 ± 72 ng/g lipid weight) and this contaminant increased westward and northward, with the highest concentrations occurring in eggs from Little Diomede (685 ± 190 ng/g lipid weight).

There also appeared to be differences between common and thick-billed murres. For example, eggs from both species were collected at Bogoslof and St. George islands, and concentrations of 4,4'-DDE were higher in the thick-billed murre eggs than in the common murre eggs in both cases (1040 ± 225 vs. 712 ± 140 ng/g lipid weight at Bogoslof Island and 1374 ± 631 vs. 594 ± 150 ng/g lipid weight at St. George Island, respectively).

Regional differences in individual POPs contributions to total POPs levels in the eggs were tested using principal components analysis. Results indicated that there were both colony and species specific differences in regional patterns of contamination. A geographic gradient appeared to be present in the patterns, with the largest differences occurring between the northern Bering Sea and Gulf of Alaska common murre colonies, while values from Bogoslof Island in the Aleutians fell between these levels. The higher chlorinated PCB congeners tended to show significant geographic differences compared to the less chlorinated congeners. This was expected, because highly chlorinated congeners are more resistant to metabolic breakdown and tend to be conserved and more reflective of bioaccumulation differences. Differences in pollutant patterns were also found between common and thick-billed murres at the same nesting locations (St. George and Bogoslof islands).

In summary, preliminary STAMP program analyses indicate that there are major differences in patterns of anthropogenic contaminants among Alaskan seabird colonies. As additional data become available from STAMP sampling sites, they will be compared with previous analyses and relevant historical information from the northern North Pacific and North Atlantic oceans to help define the boundaries of the differences and learn how they may be related to known sources, transport processes, and bioaccumulation patterns in Alaskan marine ecosystems.

Current Project Partners and Participants

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