THE SEABIRD TISSUE ARCHIVAL AND MONITORING PROJECT
2002 SUMMARY

The analysis of seabird tissues, including eggs, has played an important role in environmental monitoring in Europe and Canada. Eggs are particularly useful for temporal and spatial monitoring of persistent organic pollutants (POPs; e.g., polychlorinated biphenyls [PCBs], chlorinated pesticides, dioxins) and mercury. Levels of these contaminants have been monitored in murre (*Uria* spp.) eggs from colonies in the Baltic Sea since 1969 (see Bignert et al. 1995), and colonies in the Barents Sea since 1983 (see Barrett *et al.* 1996). The Canadian Wildlife Service successfully documented temporal changes in PCBs and pesticides in the Great Lakes by analyzing herring gull (*Larus argentatus*) eggs that were collected and banked as part of its Wildlife Toxicology Program (see Mineau *et al*. 1984, Elliott 1985, Wakeford and Kasserra 1997). Also, analyses of northern fulmar (*Fulmarus glacialis*), black-legged kittiwake (*Rissa tridactyla*), and thick-billed murre (*U. lomvia*) eggs from colonies on Prince Leopold Island in the eastern Canadian arctic suggest that most POP levels have decreased and mercury levels have increased in this region since the early 1970s (Braune *et al.* 2001).

The International Arctic Monitoring and Assessment Programme (AMAP) identified alcid eggs as key tissues for long-term circumpolar monitoring of POPs by arctic nations (AMAP Scientific Experts Workshop, Girdwood, Alaska, April 1998). Alcids (seabirds belonging to the family Alcidae) include murres, murrelets, auklets, guillemots, puffins, dovekies, and razorbills. Although the first AMAP report on the state of the arctic environment summarized information on POP and mercury levels in seabirds living in northern regions, it was limited to Canada and Scandinavia (AMAP, 1998). The report, which is currently being updated, contains data indicating that piscivorous seabirds feeding near the top of the marine food web (e.g., cormorants, *Phalacrocorax* spp.; murres; puffins, *Fratercula* spp.; kittiwakes) have higher concentrations of PCBs in their eggs than those feeding at lower levels (e.g., eiders, *Somateria* and *Polysticta* spp.). POPs levels in seabird eggs were higher in the Scandinavian arctic than in the Canadian arctic. 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 murre, common murre (*U. aalge*), puffin, black guillemot (*Cepphus grylle*), and black-legged kittiwake eggs from northern 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 Canadian and Scandinavian databases is not appropriate for Alaska, because the likely sources of these contaminants are different. Atmospheric and oceanic transport of pollutants from Asia and Japan eastward and northward into the Gulf of Alaska and southern Bering Sea, and the oceanic transport of other substances eastward along the northern and eastern coasts of Siberia into the western Chukchi and northern Bering seas probably affect overall contaminant patterns and levels in Alaskan seabirds. Local sources from both former and existing military installations may also play roles in pollutant patterns in Alaska.

More than 95% of the seabirds breeding in the continental United States nest at colonies in the Bering and Chukchi seas and Gulf of Alaska (see USFWS 1992), and about 80% of these birds are found on Alaska Maritime National Wildlife Refuge (AMNWR) lands (G.V. Byrd, pers. comm.). In 1998, AMNWR, the U.S.

[1] Ohlendorf *et al.* (1982) analyzed eggs from nine seabird nesting locations in the Gulf of Alaska (the Copper River delta, Amalik and Chiniak bays, the Barren Islands, and Hinchinbrook, Middleton, Choweit, Ugaiushak, and Hall islands) and nine seabird nesting locations in the Bering Sea and Aleutian Islands (Bluff and King, St. Paul, St. George, Shaiak, Round, Bogoslof, Buldir, and Attu islands). The eggs, representing 18 species of seabirds, were primarily from glaucous-winged gulls (*L. hyperboreus*), common and thick-billed murres, northern fulmars, black-legged kittiwakes, tufted puffins (*F. cirrhata*), fork-tailed storm-petrels (*Oceanodroma furcata*), Leach's storm petrels (*O. leucorhoa*), and pelagic cormorants (*Phalacrocorax pelagicus*). Compounds reported from these early POP analyses includee DDE, DDD, dieldrin, heptachlor epoxide, oxychlordane, cis-chlordane, cis-nonachlor, HCB, mirex, toxaphene, and PCBs.

Geological Survey Biological Resources Division (USGS-BRD), and the National Institute of Standards and Technology (NIST) initiated a joint effort to develop and test protocols for collecting, processing, transporting, and storing seabird eggs collected at several AMNWR colonies. Based on this preliminary work, the 100-year-long Seabird Tissue Archival and Monitoring Project (STAMP) was designed and implemented in 1999 (see York *et al.* 2001). This long-term, cooperative project is currently collecting, processing, and cryogenically storing common and thick-billed murre and black-legged kittiwake eggs from nine AMNWR and three privately owned seabird colonies at the NIST National Biomonitoring Specimen Bank (NBSB) for current and future studies of pollutants, and it is also analyzing subsamples of the banked eggs to establish baseline levels for persistent bioaccumulative contaminants (e.g., chlorinated pesticides, PCBs, mercury) at these Alaskan nesting locations.[2]

Common (center) and Thick-billed Murres

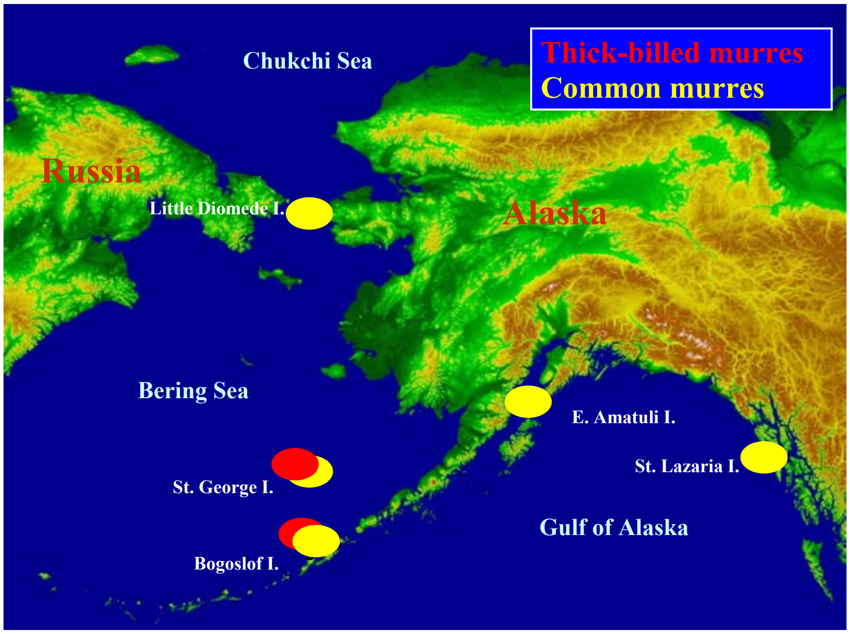
Black-legged Kittiwakes on Nests incubating Eggs (a typical 2-egg clutch can be seen at top-center)

Protocols for collecting, sampling, processing, transporting, and storing murre eggs were developed and tested in 1998–1999, 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 (see York *et al.* 2001). Eggs from five of these six initial test colonies have been analyzed for a variety of potentially harmful contaminants to begin establishing baseline values for use in long-term studies of POPs and mercury levels in Alaskan murres (e.g., see Christopher *et al*. 2002; Kucklick *et al*. 2002; Vander Pol *et al*. 2002a, 2002b). After baseline data sets have been developed for the complete suite of STAMP colonies, eggs will be collected from these sampling locations on alternating schedules and checked for potentially harmful contaminants about every 5-10 years. Unanalyzed portions of the eggs will be cryogenically stored at the NBSB for future retrospective research. As funding increases, the project will be expanded to monitor POPs and mercury in other seabirds breeding in the Bering and Chukchi seas and Gulf of Alaska. Black-legged kittiwakes were integrated into the long-term sampling program in 2002, and glaucous-winged and glaucous gulls (*L. glaucescens*) will be added in 2003-2004. Other species that may become part of the project in future years include black guillemots, fork-tailed storm-petrels, and auklets (*Aethia* spp.).

Preliminary results suggest that there are substantial geographical differences in concentrations of anthropogenic contaminants in Gulf of Alaska and Bering Sea murre eggs. Common murre eggs from St. Lazaria and East Amatuli islands in the Gulf of Alaska contained significantly higher concentrations of total mercury (207 ± 60

[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 eastern Aleutians; Kodiak, East Amatuli, Middleton, and St. Lazaria islands in the Gulf of Alaska; and Shoup Bay in Prince William Sound. Current plans call for adding several more sampling locations during 2003-2004 (potential colonies include Chamisso-Puffin islands and Cape Deceit in Kotzebue Sound; Cape Denbigh and King and Sledge islands in Norton Sound; Chowiet Island in the southwestern Gulf of Alaska; and Chisik-Duck and Gull islands in Cook Inlet and Kachemak Bay).

and 200 ± 80 ng/g wet weight, respectively) than eggs from St. George Island in the southeastern Bering Sea (26 ± 10 ng/g wet weight) and Little Diomede Island in Bering Strait (53 ± 20 ng/g wet weight).



Locations where STAMP has conducted Preliminary POPs Analyses

Mercury levels in the Gulf of Alaska common murre samples were substantially lower than levels recently reported by Braune *et al.* (2001) for thick-billed murre eggs from Prince Leopold Island in the Canadian arctic (330 ± 20 ng/g wet weight). The range in total mercury values in the Alaskan common murre eggs was similar to the range reported for common and thick-billed eggs from the Barents Sea, where the highest thick-billed levels from Svaldbard were equivalent to the highest Gulf of Alaska levels (see Barrett *et al.* 1996). Braune *et al.* (2001) demonstrated that mercury has increased at the Prince Leopold Island seabird colony since the mid-1970s. This finding is consistent with other pollutant studies that suggest mercury is increasing in the environment worldwide, and it supports the concept that monitoring this toxic contaminant in Alaskan seabirds is warranted. The initial set of Alaskan subsamples is currently being reanalyzed to determine what proportion of the total mercury consists of toxic methylmercury.

Common murre eggs from Little Diomede, St. George, and Bogoslof islands in the Bering Sea and East Amatuli and St. Lazaria islands in the Gulf of Alaska were analyzed for POPs. Thick-billed eggs from St. George and Bogoslof islands were also analyzed for these potentially harmful contaminants. In general, POPs levels were higher at the Gulf of Alaska colonies than at the Bering Sea colonies, and ΣPCBs (sum of 46 PCB congeners), 4,4'-DDE, HCB, and oxychlordane were the compounds with the highest values. Concentrations of 4,4'-DDE were significantly higher in the St. Lazaria and East Amatuli island common murre eggs (2440 ± 800 and 1570 ± 740 ng/g lipid weight, respectively) than in the Little Diomede, St. George, and Bogoslof island eggs. They were also higher than the values reported by Braune *et al.* (2001) for the Prince Leopold Island thick-billed murre eggs (775 ± 54 ng/g lipid weight). Also, the contribution of 4,4'-DDE to the total amount of POPs was two times higher at St. Lazaria and East Amatuli than at the Bering Sea colonies.

Mean concentrations of 4,4'-DDE were significantly lower in the Bogoslof and St. George island common murre eggs than the values reported for this species at these colonies in 1973-1976 (35% lower at Bogoslof and 73% lower at St. George; see Ohlendorf *et al.* 1982). This suggests that levels of this pesticide metabolite have declined in these Bering Sea populations over the last 25-30 years, which is consistent with a 50% decline reported for thick-billed murres at Prince Leopold Island during the same time period (see Braune *et al.* 2001).

Common murre eggs from St. Lazaria Island had concentrations of ΣPCBs that were significantly higher (1970 ± 800 ng/g lipid weight) than the levels found at any of the other Alaskan colonies, and the levels reported for Prince Leopold Island thick-billed murres (see Braune *et al.* 2001). However, HCB was significantly lower in the St. Lazaria eggs (i.e., 316 ± 72 ng/g lipid weight), compared to the other Alaskan nesting locations. This contaminant increased westward and northward, with the highest concentrations found in the Little Diomede Island eggs (685 ± 190 ng/g lipid weight). The Little Diomede Island HCB levels were also almost twice as high as the concentrations reported for Prince Leopold Island thick-billed murres (see Braune *et al.* 2001). In contrast to this high arctic Canadian colony, levels of both dieldrin and oxychlordane were substantially lower at the Alaskan nesting locations.

Differences also occurred between murre species. At St. George and Bogoslof islands, 4,4'-DDE levels were higher in thick-billed murre eggs than in common murre eggs (1030 ± 240 vs. 712 ± 140 ng/g lipid weight at Bogoslof Island and 914 ± 170 vs. 594 ± 150 ng/g lipid weight at St. George Island, respectively). Other POP compounds also exhibited differences between species at these Bering Sea colonies. For example, HCB was significantly lower, and some PCB congeners were significantly higher in the thick-billed murre eggs.

A principal components analysis was run to test regional differences in individual POPs contributions to total POPs levels in the murre eggs. Results indicated that there were both colony and species-specific differences in regional patterns of contamination. A geographic gradient was present, with the largest differences occurring between the northern Bering Sea and Gulf of Alaska common murre colonies, while values from Bogoslof Island in the eastern 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 they tend to be conserved and more reflective of bioaccumulation differences.

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

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