

Accumulation of Perfluorooctane Sulfonate in Marine Mammals

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Perfluorooctane sulfonate (PFOS) is a perfluorinated molecule that has recently been identified in the sera of nonindustrially exposed humans. In this study, 247 tissue samples from 15 species of marine mammals collected from Florida, California, and Alaskan coastal waters; the northern Baltic Sea; the Arctic (Spitsbergen); and Sable Island in Canada were analyzed for PFOS. PFOS was detected in liver and blood of marine mammals from most locations including those from Arctic waters. The greatest concentrations of PFOS found in liver and blood were 1520 ng/g wet wt in a bottlenose dolphin from Sarasota Bay, FL, and 475 ng/mL in a ringed seal from the northern Baltic Sea (Bothnian Sea), respectively. No age-dependent increase in PFOS concentrations in marine mammals was observed in the samples analyzed. The occurrence of PFOS in marine mammals from the Arctic waters suggests widespread global distribution of PFOS including remote locations.

Introduction

Perfluorooctane sulfonate (PFOS) and associated salts are fully fluorinated organic molecules produced synthetically in an electrochemical fluorination process (1). Some of the fluorinated organic compounds, similar in structure to PFOS, are utilized in fire-fighting foams, herbicide and insecticide formulations, greases and lubricants, adhesives, paints, and polishes (1). Given the energy of the carbon-fluorine bond, it is expected that many fluorinated organic compounds will be resistant to hydrolysis, photolysis, biodegradation, or metabolism (2).

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PFOS was recently identified in each of 65 nonindustrially exposed human sera samples previously characterized, indicating possible widespread distribution of this compound (3). Additionally, this analyte and organic fluorochemicals of similar structure have been identified in some water samples (4, 5). Our recent study has documented global distribution of PFOS in animals of various trophic levels in the food chain (6). In this study, PFOS was measured in the tissues of marine mammals from coastal and open ocean waters, including the Arctic Ocean. While our earlier paper has documented the presence of PFOS in marine mammals, this study provides detailed information on the accumulation of PFOS in marine mammals.

Materials and Methods

Samples. A total of 247 tissue samples from 15 species of marine mammals and a freshwater mammal (river otter, *Lutra canadensis*) were analyzed in this study. The species analyzed include pygmy sperm whale (*Kogia breviceps*), short-snouted spinner dolphin (*Stenella clymene*), striped dolphin (*Stenella coeruleoalba*), rough-toothed dolphin (*Steno bredanensis*), bottlenose dolphin (*Tursiops truncatus*), California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), harbor seal (*Phoca vitulina*), northern fur seal (*Callorhinus ursinus*), southern sea otter (*Enhydra lutris nereis*), polar bear (*Ursus maritimus*), Steller sea lion (*Eumetopias jubatus*), ringed seal (*Phoca hispida*), gray seal (*Halichoerus grypus*), and Weddell seal (*Leptonychotes weddellii*). Samples included liver and blood as well as a few samples of brain and kidney from sea otters. The marine mammals analyzed in this study originated from coastal waters of Florida including the Gulf of Mexico, California, Alaska, northern Baltic Sea (Bothnian Bay), the Arctic (Spitsbergen), Sable Island in Canada, and Terra Nova Bay in the Antarctic.

Tissues of marine mammals were acquired from Federal or State agencies or university laboratories. All samples were collected under permission of relevant State or Federal agencies. Liver tissues of stranded cetaceans from the East Coast of the United States were acquired from Mote Marine Laboratory, Sarasota, FL, and had been originally collected under letters of authorization issued by the National Marine Fisheries Service. Pinniped tissues from the California Coast were acquired from the Marine Mammal Center (MMC), Sausalito, CA. The pinnipeds, which stranded on the coast of northern and central California in the 1990s, were diagnosed and treated at MMC. Dead animals were dissected, and samples were wrapped in aluminum foil, placed in airtight plastic bags, and frozen immediately at -20 °C until analysis. Concentrations of organochlorine pesticides, polychlorinated biphenyls (PCBs), and butyltins residues in tissues of pinnipeds from California coastal waters have been previously reported (7). River otter tissues were obtained from licensed trappers in Oregon. Sea otter tissues were from the National Wildlife Health Center, Madison, WI. Blood and liver of northern fur seals from the Pribilof Islands in Alaska were acquired from archived tissues of the Institute of Arctic Biology, Fairbanks, AK, and the Northwest Fisheries Science Center, Seattle, WA. Polar bear livers were from native subsistence hunters and the U.S. Fish and Wildlife Service in Anchorage, AK, and were taken in northern and western Alaska. Blood samples of ringed and gray seals were collected from the Bothnian Bay in the Baltic Sea, from Spitsbergen in the Arctic Ocean (ringed seals), and from Sable Island in Canada (gray seals) (8, 9). The Weddell seal was collected from Terra Nova Bay in Antarctica. Information regarding