The Foundation for Global Action on Persistent Organic Pollutants: A United States Perspective

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Executive Summary

Persistent organic pollutants (POPs) are a small group of organic chemicals exhibiting the combined properties of environmental persistence, bioaccumulation, toxicity, and long-range transport. This small group of pollutants encapsulates the genesis and development of pollution awareness in the United States. These are the pollutants that Rachel Carson described in Silent Spring, that contaminated Agent Orange during the Vietnam War, and that contributed to Love Canal, Times Beach, and the pollution of the Great Lakes. Legislative, regulatory, legal, and voluntary actions in the United States have eliminated domestic production of many POPs as pesticides and industrial chemicals, and have greatly reduced their emissions as byproducts. Yet, although uses and levels in the lower 48 United States have stabilized or declined, elevated levels are now being found in what had been thought pristine, uncontaminated environments, notably in the Arctic and remote oceans. Air and water movement are transporting POPs across international borders to these remote locations, where they can be reconstituted to potentially toxic levels through bioaccumulation in the food chain. Most poignantly, the first exposure of offspring may be through a loading dose of toxin to the fetus or in milk, during the most sensitive period of development.

Bald eagle, chick, and egg. POPs impacts have been particularly severe on the reproductive success of birds of prey.

Photo: D. Best

On May 23, 2001, the United States joined 90 other nations in signing the Stockholm Convention on Persistent Organic Pollutants. Under the Convention, countries commit to reduce and/or eliminate the production, use, and release of the 12 POPs of greatest concern to the global community and to establish a mechanism by which additional chemicals may be added to the treaty in the future. This report summarizes the science underpinning this global action, focusing on the 12 priority substances or substance groups, commonly known as the "dirty dozen."

The 12 Priority POPs of Global Concern

aldrin
dieldrin
endrin
DDT
chlordane
heptachlor
mirex
toxaphene
hexachlorobenzene (HCB)
polychlorinated biphenyls (PCBs)
polychlorinated dibenzo-*p*-dioxins
polychlorinated dibenzofurans

This report provides an overview of the human and ecological risks posed by POPs to U.S. ecosystems and citizenry. Recognizing the immense technical literature on these POPs, the report focuses on the most salient topics, while pointing to additional literature sources for readers requiring further information. The chapters are based on the following general themes:

- *Chemical profiles*: A narrative introduction is provided for each of the 12 POPs. This is accompanied by tables summarizing important chemical properties and the regulatory history covering production and use in the United States. The narrative highlights selected toxicological issues not directly discussed elsewhere in this report. For instance, the agricultural problems caused by prolonged, indiscriminate toxicity from the cyclodiene POPs insecticides are noted (e.g., dieldrin), along with the availability over time of improved chemical, physical, and integrated alternatives for pest management. For DDT, particular attention is drawn to the fundamental need to balance malaria vector control in some developing countries with epidemiological evidence of increased preterm human births associated with DDT exposure, and its demonstrated adverse ecological impacts. Notable in this context, the Stockholm Convention provides for continued DDT use for disease vector control in countries where safe and cost-effective alternatives are not available, subject to World Health Organization recommendations.

Alaska native hunter and boat; a way of life for many communities.

Photo: U.S. Department of the Interior

- *Human and ecological effects in the United States:* Historical and contemporary data are summarized demonstrating why POPs gained notoriety in the United States and internationally. Two regions are highlighted: the Great Lakes and marine ecosystems. In the Great Lakes, the contribution of POPs, especially DDT, to eggshell thinning and population declines in raptors (e.g., bald eagles, osprey, falcons) is well known. PCBs and polychlorinated dioxins and furans have combined to affect Great Lakes fish populations (blue-sac disease), fish-eating birds (GLEMED syndrome), and mammalian reproductive success, especially in mink. For humans, POPs intakes continue through the consumption of Great Lakes sport fish. Epidemiological evidence in these populations has associated PCB levels in mothers with adverse neurodevelopmental outcomes in their children.

POPs effects have also been demonstrated in marine ecosystem bird and marine mammal populations, both in coastal areas and in remote oceans. In the early 1970s, brown pelican populations on U.S. coasts were brought to the edge of extinction following DDT-induced eggshell thinning, principally mediated through its long-lived metabolite DDE. Contemporary elevated levels of PCBs and dioxins accumulated in alba-

tross on Midway Atoll in the remote North Pacific Ocean are now linked to impaired reproductive outcomes.

These findings from the Great Lakes and marine ecosystems demonstrate that it is possible to sufficiently contaminate environments with POPs residues to cause adverse effects on a regional and global scale, along with the prolonged and continuing nature of these impacts. The experience is also one of hope, in that controls on the production, use, and release of POPs can, and have, resulted in reduced environmental concentrations and wildlife recovery. The bald eagle saga offers an inspiring metaphor. Once nearly extinct in the lower 48 United States, bald eagle populations have recovered dramatically with the cessation of DDT use in the United States, yet the reproductive impacts linger.

Birds on remote Midway atoll in the north Pacific are exposed to POPs.

Photo: NASA

- *Long-range transport of POPs:* POPs move to regions such as the Great Lakes, marine ecosystems, and the Arctic through long-range environmental transport in air, water, and migratory species. This transboundary movement occurs principally through the atmospheric pathway, either on suspended particles or through a process of global distillation and cold condensation. The global distillation effect is postulated to result from the semivolatile nature of some POPs, where they can be present in more than one phase in the atmosphere, either as gases or attached to airborne particles. Because of the normal decrease of temperature with increasing latitude, compounds in the vapor phase will tend to condense on surfaces as they are transported northward by winds associated with passing weather systems. This cold condensation results in a net transport of POPs from lower latitudes to high latitudes (polar regions) in a series of jumps. The different affinities of POPs for soil particles, water, and/or lipid molecules, and their rate of volatilization, determine the pathway and time course each chemical is likely to take in its journey through the environment.

- *POPs in Alaska:* Risks to Arctic environments and indigenous human populations were central to negotiating the Stockholm Convention on POPs. For the United States, many of the physical, climatic, and social aspects that make Alaska special — particularly for the indigenous population — also make this region peculiarly prone to risks from global pollutants. Alaska is downwind and geographically close to continuing sources of POPs production and use in Asia, where population and economic growth are expanding rapidly. The Alaskan climate facilitates the deposition of POPs, delays their degradation through environmental processes, and places unusual stresses on ecosystems. Fat becomes the currency of life in the harsh Arctic environment for both wildlife and humans, serving as the ideal medium for transferring and magnifying the concentration of lipophilic POPs between species and up the food chain.

Previously pristine in remote areas, all of Alaska's environmental media and species now contain measurable levels of POPs. However, POPs levels in Alaska are generally low compared with the lower 48 United States. Accompanying these comparatively low levels are isolated examples of elevations that serve as a cautionary warning in the absence of international action. DDT and PCB levels in transient Alaskan killer whales are as high as those found in highly contaminated east coast dolphins. On Kiska Island in the Aleutians, DDT levels in bald

eagle eggs approach effect levels seen in the Great Lakes. And, Alaska Natives have some of the highest average DDT and chlordane levels measured in Arctic human populations. It is important to emphasize, however, that there are no known POPs levels at this time in Alaska that should cause anyone to stop consuming locally obtained, traditional foods or to stop breastfeeding their children. Current information indicates that the risks associated with a subsistence diet in Alaska are low, whereas in contrast the benefits of this diet and breastfeeding children are well documented. Further investigation and assessment are needed for specific species and foods in traditional diets, and to broaden the database across Alaskan communities.

- What might the future hold in the absence of POPs controls? The passage of time is central to evaluating the merits of the Stockholm Convention. Emission scenario models forecast large increases in the scale of worldwide economic activity over the next half-century, with overall economic activity predicted to increase about fourfold in the "business as usual" scenario. The human population is predicted to increase to around 9 billion persons. The large majority of increases will occur in developing countries. Although different model inputs lead to different results, all projections share a common future of much higher total economic activity, and hence of potential uses and emissions of POPs in the absence of active control policies and alternatives.

The United States is not alone in having experienced POPs problems, with many countries suffering local and transboundary pollution effects. In response, the United States has signed international agreements on persistent toxic substances under the Great Lakes Binational Toxics Strategy (US, Canada); the North American Agreement for Environmental Cooperation (US, Canada, Mexico); and the UNECE Long-Range Transboundary Air Pollution POPs Protocol (US, Canada, Western and Eastern Europe, Newly Independent States, Russia). The consensus for global action on POPs under the Stockholm Convention is commensurate with the extent of the pollution and the need to include all countries in the solution. To this end, the Convention contains the following central elements:

- Measures to eliminate or restrict the production, use, and trade of intentionally produced POPs
- Development of action plans to address the release of byproduct POPs, along with the obligation to use best available techniques to reduce byproduct emissions from newly constructed facilities in major industrial source categories
- Measures to reduce or eliminate POPs releases from stockpiles and wastes
- Technical and financial assistance to developing countries to implement their obligations under the Convention
- Science-based criteria and procedures for the addition of new POPs chemicals

The Stockholm Convention will enter into force following ratification by 50 nations. The Convention is aimed at protecting human health and the environment from POPs chemicals on a global scale. Through implementation of the Convention, nations have the opportunity to make POPs an aberration and relic of the 20th century, and a warning from history for the 21st century.