

**Technical Report on Toxic Contaminants in the Chesapeake Bay and its Watershed:
Extent and Severity of Occurrence and Potential Biological Effects**

**U.S. Environmental Protection Agency
Region III
Chesapeake Bay Program Office
Annapolis, Maryland**

U.S. Geological Survey

**U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Annapolis, Maryland**

December, 2012

Acknowledgements

Technical Editorial Team and Contributing Authors

Multiple authors contributed to the report and an editorial team combined the various sections and also revised the report based on technical and Chesapeake Bay Program (CBP) partner reviews.

The editorial team included Greg Allen (USEPA), Fred Pinkney (USFWS), Mike Focazio (USGS), Jamie Mitchell (Hampton Roads Sanitation District), and Scott Phillips (USGS).

Other contributing authors include: Vicki Blazer (USGS), Barnett Rattner (USGS), Ashlee Harvey (Chesapeake Research Consortium); Maria Garcia (USEPA); Bruce Pluta (USEPA); Diana Eignor (USEPA); and Mary Ann Ottinger (University of Maryland)

Peer and CBP Partner Reviewers

The authors thank the four independent peer reviewers: Lisa Saban (Windward Environmental LLC), Scott Ator (USGS), Patrick Phillips (USGS), and Ted Smith (USEPA). Many CBP partners also provided review comments on the report including representatives from MD, VA, PA, WVA, VA, DE, and DC. Additionally, contacts from each jurisdiction listed above provided review and ensured accurate use of findings from their respective 2010 water quality assessment reports. The authors also thank Dale Simmons (USGS) for her editorial review.

**Technical Report on Toxic Contaminants in the Chesapeake Bay and its Watershed:
Extent and Severity of Occurrence and Potential Biological Effects**

Acknowledgements	ii
Executive Summary	v
1.0 Introduction and Background	1
2.0 Extent and Severity of Contaminants	14
2.1 Polychlorinated Biphenyls	14
2.2 Dioxins and Furans	28
2.3 Polycyclic Aromatic Hydrocarbons	34
2.4 Petroleum Hydrocarbons	44
2.5 Pesticides	48
2.6 Pharmaceuticals	65
2.7 Household and Personal Care Products	79
2.8 Polybrominated Diphenyl Ether Flame Retardants	85
2.9 Biogenic Hormones	90
2.10 Metals and Metalloids	100
3.0 Responses of Fish to Cumulative and Interacting Stressors	114
4.0 Contaminant Exposure and Responses in Wildlife	124
5.0 Summary and Conclusions	127
6.0 References	138
Appendix A: Supplementary tables	172

Technical Report on Toxic Contaminants in the Chesapeake Bay and its Watershed: Extent and Severity of Occurrence and Potential Biological Effects

Executive Summary

Purpose of the Report

For many years, scientists and resource managers have recognized that exposure to toxic contaminants can result in adverse effects on biological resources within the Chesapeake Bay and its watershed. In 2010, the Chesapeake Bay Program (CBP), a Federal-jurisdictional partnership, reported that 72 percent of the Bay's tidal-water segments are fully or partially impaired as a result of the presence of toxic contaminants. In some areas of the Bay watershed, fish-consumption advisories have been established as a result of concentrations of toxic contaminants. In recognition of these issues, the CBP developed the Toxics 2000 Strategy, in which commitments were made to prevent and reduce inputs of chemical contaminant and to eliminate toxic impacts on living resources that inhabit the Bay and its tributaries. Since 2000, new concerns, such as intersex conditions in fish, have arisen. Although the causes are undetermined, there is increasing evidence that contaminant exposures may play a role. In 2010, the President's Chesapeake Bay Executive Order (EO 13508) Strategy directed Federal agencies to prepare a report summarizing information on the extent and severity of occurrence of toxic contamination in the Bay and its watershed. Findings in this report will be used by the CBP partnership to consider whether to adopt new goals for reducing inputs of toxic contaminants entering the Bay. This report also identifies research and monitoring gaps that could be considered to improve the understanding of the extent and severity occurrence of toxic contaminants in the Chesapeake Bay and its watershed.

Approach

The findings in this report are based on a review of integrated water-quality assessment reports from the jurisdictions in the Bay watershed (Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and Washington, D.C.), Federal and State reports, and articles in scientific journals. The authors focused on summarizing results of studies conducted mostly

since 2000 and, in particular, the 2010 jurisdictional water-quality assessment reports were used to define the extent and severity of occurrence of the following contaminant groups:

- Polychlorinated Biphenyls (PCBs)
- Dioxins and Furans
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Petroleum Hydrocarbons
- Pesticides
- Pharmaceuticals
- Household and Personal Care Products
- Polybrominated Diphenyl Ethers (PBDEs)
- Biogenic Hormones
- Metals and Metalloids

The approach used to characterize the extent and severity of occurrence of contaminant groups is described in detail in Chapter 1 of this report. Extent is characterized as “widespread,” “localized,” or “uncertain” depending on the amount of information acquired from readily available reports and peer-reviewed literature and whether the contaminant has been detected throughout the watershed or only in a limited number of subwatersheds. Severity, as defined in this report, is based entirely on the jurisdictions’ impairment determinations as identified in the integrated assessment reports. Contaminants that have caused impairments in many locations are considered to have widespread severity, contaminants associated with impairments in few locations are classified as having localized severity, and other contaminants or contaminant groups are identified as having uncertain severity. Where possible and appropriate, additional information such as peer-reviewed literature is included to provide perspective on potential severity, including evidence of adverse sublethal effects at environmentally relevant concentrations.

Conclusions about the Extent and Severity of Occurrence of Contaminant Groups

Overall conclusions about the extent of occurrence of contaminant groups examined in this report are --

- **Widespread extent:** For polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), herbicides (primarily atrazine, simazine, metolachlor, and their

degradation products), and mercury, available information indicates widespread extent of occurrence throughout the Bay watershed.

- **Localized extent:** For dioxins/furans, petroleum hydrocarbons, some chlorinated insecticides (aldrin, chlordane, dieldrin, DDT/DDE, heptachlor epoxide, mirex), and some metals (aluminum, chromium, iron, lead, manganese, zinc), available information indicates localized extent of occurrence.
- **Uncertain extent:** For pharmaceuticals, household and personal-care products, polybrominated diphenyl ether (PBDE) flame retardants, some pesticides, and biogenic hormones, available information is insufficient to determine extent of contamination. However, the widespread distribution of known sources of these contaminants (e.g., wastewater effluents, agricultural runoff, etc.) in the watershed and the summarized occurrence data indicate that some contaminants from each of these groups may have the potential to be found in many locations throughout the Bay watershed.

Overall conclusions about the severity of contaminant groups examined in this report are --

- **Widespread severity:** For PCBs and mercury, impairments have been identified in many locations in the watershed, largely in response to concentrations in sediments and in fish tissues that frequently result in the need for fish-consumption advisories.
- **Localized severity:** For dioxins/furans, PAHs, petroleum hydrocarbons, some chlorinated pesticides (aldrin, chlordane, dieldrin, DDT/DDE, heptachlor epoxide, mirex), and some metals (aluminum, chromium, iron, lead, manganese, zinc), the report identifies localized severity on the basis of impairments in a limited number of areas in the Bay watershed.
- **Uncertain severity:** For atrazine, some pharmaceuticals, some household and personal-care products, some PBDEs, and biogenic hormones, severity as defined in this report could not be assessed. However, recent peer-reviewed research has documented sublethal effects for some compounds at environmentally relevant concentrations, raising concerns about the potential for adverse ecological effects.

Biological Effects of Toxic Contaminants on Fish and Wildlife

Additional supporting information on the toxic effects of contaminants on fish and wildlife is summarized to inform the discussion of severity. This information provides insights that can be

used in assessing the cumulative and interacting effects of toxic chemicals as well as other stressors on fish and wildlife.

The following indicators of degraded aquatic ecosystems have been observed within fish populations in the Chesapeake Bay watershed: increased incidence of infectious disease and parasite infestations contributing to increased mortality in several species of fish; feminization (intersex, plasma vitellogenin) of largemouth and smallmouth bass and other signs of endocrine disruption; reduced reproductive success and recruitment of yellow perch in tributaries in certain highly urbanized drainage basins; and tumors in bottom-dwelling fish. The evidence for associations between exposure to toxic contaminants and these indicators of compromised fish health is discussed.

Indications of responses to contaminant exposure have also been found among wildlife in the Chesapeake Bay watershed, primarily wild birds. In a few locations, eggshell thinning associated with *p,p'*-DDE is apparent, and reproduction may be impaired. In some cases, organochlorine pesticides are found in eggs of predatory birds at concentrations associated with embryo lethality. Several studies are cited in which PCB concentrations in addled bald eagle eggs may have been high enough to contribute to the failure to hatch. Detectable concentrations of PBDEs have been found in eggs of predatory birds that approach the lowest-observed-adverse-effect level for pipping and hatching success.

Research and Monitoring Gaps

Monitoring gaps were identified for the following contaminant groups: dioxins and furans, petroleum hydrocarbons, some pesticides currently in use (e.g., insecticides and fungicides), pharmaceuticals, household and personal-care products, flame retardants, and biogenic hormones. Biological monitoring at many levels of biological organization (molecular to population) along with systematic evaluation of water contaminants and other stressors would allow for more effective documentation of the extent and severity of occurrence of toxic contaminants in the watershed.

Research gaps that limit understanding of the relations between sources of these contaminants, their pathways to the environment, and exposures to receptor organisms are identified. Research

that accounts for the complexities of the effects of contaminant mixtures and multiple stressors, sublethal effects, nonlinear dose-response curves, and the role of contaminant exposure in immune response and subsequent pathogenic disease would help to define relations between contaminant exposures and potential effects in fish and wildlife.

