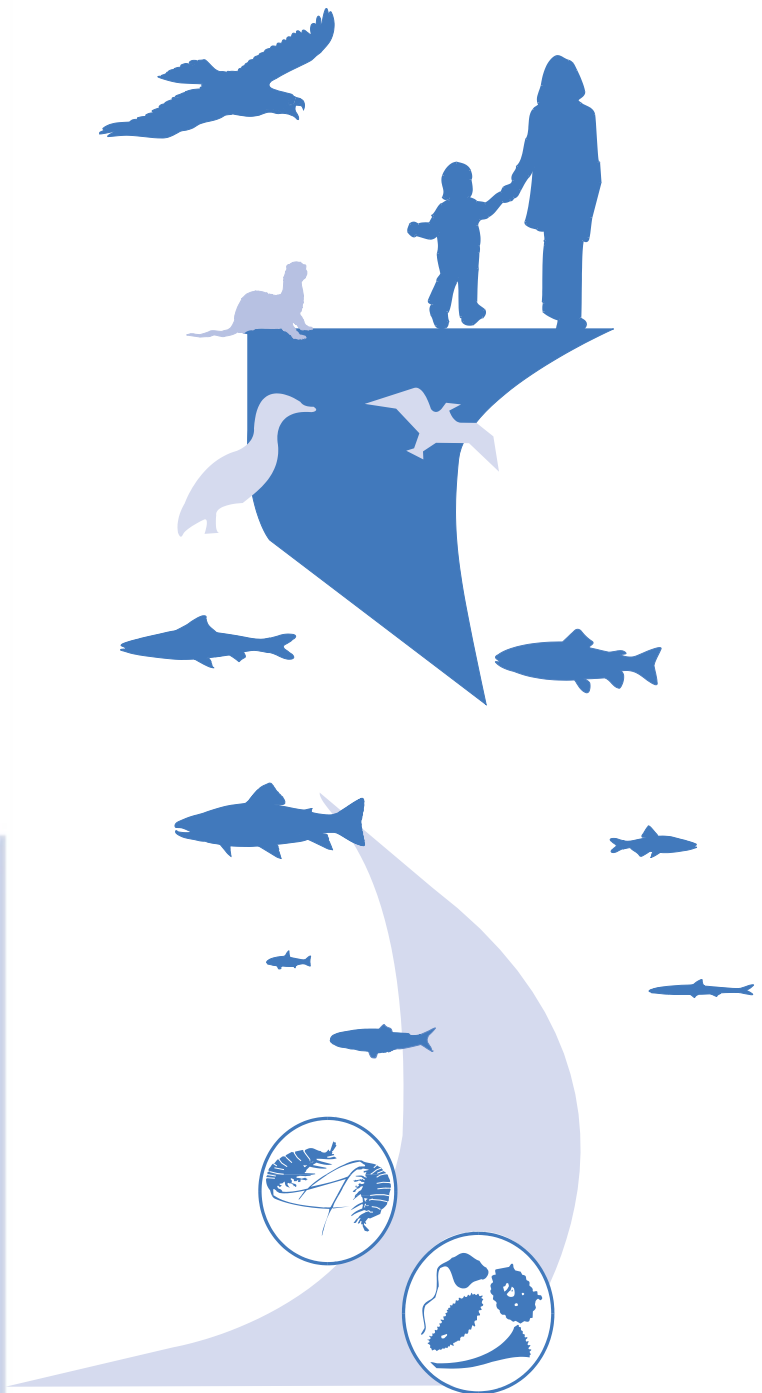




Mercury Research Strategy



On the Cover: This graphic, originally used on the cover of the *Mercury Study Report to Congress (Report to Congress)*, depicts the pathway through which mercury contamination proceeds to humans and wildlife. It emphasizes the transport, transformation, and fate of mercury through the aquatic food web. Such a pathway includes the biological conversion of atmospherically-deposited mercury to an organic form (i.e., methylmercury); the uptake and bioaccumulation of methylmercury in fish, birds, and mammals; and the subsequent health effects on susceptible populations who consume large quantities of methylmercury-contaminated fish such as women of child bearing age (i.e. maternal/fetal pair), and young children. Prepared by the U. S. Environmental Protection Agency (EPA), the *Report to Congress* supports a plausible link between anthropogenic releases of mercury from industrial and combustion sources in the U.S. and the concentration of methylmercury in fish. The *Report to Congress*, along with several other EPA reports, serve as drivers for the preparation of the *Mercury Research Strategy*.

EPA/600/R-00/073
September 2000

Mercury Research Strategy

Office of Research and Development
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

NOTICE

This document has been reviewed in accordance with U. S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's Office of Research and Development (ORD) is providing data and technical support for solving environmental problems today, and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The 1996 *Strategic Plan for the Office of Research and Development*, and subsequent updates, sets forth ORD's vision, mission, and long-term research goals. The Strategic Plan thus serves as the foundation for all of the research strategies and plans that ORD has developed, or is in the process of developing. As part of its strategic planning process, ORD uses the risk paradigm to identify EPA's top research priorities for the future. This focus on the risk paradigm helps in establishing the individual, high priority topics for which research strategies are prepared. One of the high priority research topics identified as part of the strategic planning process deals with the assessment and management of mercury and methylmercury risks.

The *Mercury Research Strategy* describes the strategic approach for ORD's mercury research program. Using as a technical foundation the EPA 1997 *Mercury Study Report to Congress*, the *Mercury Research Strategy* presents the key scientific questions to be addressed over the next five years. It also describes the research needed to answer those questions. The *Mercury Research Strategy* not only provides strategic directions, but serves as an important budget tool. It is central to the preparation of a multi-year implementation plan for mercury and methylmercury research. This multi-year plan enables EPA to track the progress being made in the mercury research program, as required by the 1993 Government Performance and Results Act.

Much of the research described in the *Mercury Research Strategy* will be conducted by ORD's in-house laboratories and assessment center. ORD's Science to Achieve Results (STAR) Grants Program is also sponsoring research to investigate several of the identified research needs. In some cases, ORD scientists and engineers are already working in close cooperation with federal and state organizations in conducting research on mercury and methylmercury. Many organizations may see opportunities to collaborate in one or more of the research areas described in the *Mercury Research Strategy*. ORD welcomes such collaborations in addressing the needs identified and invites those interested to suggest joint activities.

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PEER REVIEW

Peer review is an important component of research strategy development. The peer review history for the *Mercury Research Strategy* is as follows:

Initial Internal Agency Review: September 1998

ORD Science Council: Final clearance
November 1998

Lead Reviewer: Lee Mulkey, Ecology Associate
National Risk Management Research Laboratory

Submitted for Comments
to the Draft *Mercury
Research Strategy* Peer
Review Panel: October 1999

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Final Acceptance by ORD: September 2000

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ACRONYMS

ACAP	Arctic Council Action Plan
AEPS	Arctic Environmental Protection Strategy
AMAP	Arctic Monitoring and Assessment Program
APGs	Annual Performance Goals
APMs	Annual Performance Measures
ARL	Atmospheric Research Laboratory
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	Best Available Technology
BBDR	Biologically Based Dose-Response
BIFs	Boilers and Industrial Furnaces
BMDL	Benchmark Dose Lower Bound
BNS	Binational Toxics Strategy
CAA	Clean Air Act
CEC	Commission for Environmental Cooperation
CEMs	Continuous Emission Monitors
CENR	Committee on the Environment and Natural Resources
CETEM	Center for Mineral Technology
DOD	Department of Defense
DOE	Department of Energy
DOS	Department of State
ELA	Experimental Lakes Area
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EWG	Environmental Working Group
FDA	Food and Drug Administration
GLI	Great Lakes Water Quality Initiative
GLNPO	Great Lakes National Program Office
GPRA	Government Performance and Results Act
HAPs	Hazardous Air Pollutants
HCl	Hydrochloric Acid
Hg	Mercury
Hg ⁰	Elemental Mercury Vapor
Hg ⁺²	Gas-Phase Ionic Mercury
Hg _p	Particulate-Bound Mercury
HgCl ₂	Mercuric Chloride
HWIs	Hazardous Waste Incinerators
ICR	Information Collection Request
LCA	Life Cycle Assessment
LDRs	Land Disposal Restrictions
LOAEL	Lowest Observed Adverse Effect Level
LRTAP	Long Range Transboundary Air Pollution
MACT	Maximum Achievable Control Technology
MCCAPs	Mercury-Cell Chlor Alkali Plants
MCM	Mercury Cycling Model
MRL	Minimal Risk Level
MRS	Mercury Research Strategy
MTF	Mercury Task Force
MWCs	Municipal Waste Combustors

ACRONYMS (cont.)

MWIs	Medical Waste Incinerators
NAAEC	North American Agreement on Environmental Cooperation
NARAP	North American Regional Action Plan
NAS	National Academy of Sciences
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NCHS	National Center for Health Statistics
NEG/ECP	New England Governors/Eastern Canadian Premiers
NEP	National Estuary Program
NERRS	National Estuarine Research Reserves System
NESCAUM	Northeast States for Coordinated Air Use Management
NETL	National Energy Technology Laboratory
NHANES	National Health and Nutrition Examination Survey
NHEERL	National Health and Environmental Effects Research Laboratory
NIH	National Institutes of Health
NIEHS	National Institute for Environmental Health Sciences
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NO _x	Oxides of Nitrogen
NRC	National Research Council
NRDC	National Resources Defense Council
NRMRL	National Risk Management Research Laboratory
NTI	National Toxics Inventory
NWF	National Wildlife Federation
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
OERR	Office of Emergency and Remedial Response
OIA	Office of International Activities
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORD	Office of Research and Development
ORNL	Oak Ridge National Laboratory
OSTP	Office of Science and Technology Policy
OSW	Office of Solid Waste
OSWER	Office of Solid Waste and Emergency Response
OW	Office of Water
PAC	Powdered Activated Carbon
PAME	Protection of the Arctic Marine Environment
PBPK	Physiologically-Based Pharmacokinetics
PBTs	Persistent, Bioaccumulative Toxics
PCBs	Polychlorinated Biphenyls
PM	Particulate Matter
ppb	Parts Per Billion
ppm	Parts Per Million
RCRA	Resource Conservation and Recovery Act
RELMAP	Regional Lagrangian Model of Air Pollution
RFA	Request for Application
RfD	Reference Dose
RGM	Reactive Gaseous Mercury
SMOC	Sound Management of Chemicals

ACRONYMS (cont.)

SO ₂	Sulfur Dioxide
SO ₃	Sulfur Trioxide
STAR	Science to Achieve Results
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TMDLs	Total Maximum Daily Loads
TRI	Toxics Release Inventory
UNECE	United Nations Economic Commission for Europe
USGS	United States Geological Survey
WC	Wildlife Criterion
WHO	World Health Organization

EXECUTIVE SUMMARY

INTRODUCTION

The *Mercury Research Strategy (MRS)* guides the Office of Research and Development (ORD) mercury research program. Mercury has been identified as an important human health and environmental problem in a number of U.S. Environmental Protection Agency (EPA) documents such as the *Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units – Final Report to Congress* (EPA, 1998b) and the *Deposition of Air Pollutants to the Great Waters: Third Report to Congress* (EPA, 2000a). The *MRS*, called for in EPA's draft *Mercury Action Plan* (Federal Register, 1998), covers FY2001–2005. It summarizes the human health and ecological risks posed by mercury and methylmercury, and indicates that mercury needs to be considered on local, regional, and global scales. The *MRS* identifies the key scientific questions of greatest importance to the Agency. It then describes a research program to answer those questions. The goal of the *MRS* is to reduce the scientific uncertainties that limit EPA's ability to assess and manage mercury and methylmercury risks. ORD will use the *Mercury Research Strategy* to develop a multi-year implementation plan in FY 2001 for its mercury research program.

In conducting the mercury research program, in-house research efforts by ORD's laboratories and assessment center will be coupled with those of ORD's Science to Achieve Results (STAR) Grants Program. The STAR Grants Program sponsors extramural research with academic institutions and other not-for-profit entities. Also, some of the research described in the *MRS* will be undertaken in cooperation with organizations such as the Department of Energy and the U.S. Geological Survey. The *MRS* provides information on research needs and priorities that can be used by various stakeholders outside of the Agency, including researchers in other federal agencies, states, private industry, not-for-profit organizations, and academia. It may well assist them in planning their own mercury research activities and programs. Finally, the *Mercury Research Strategy* suggests that other scientific data and information not generally considered "research" are needed, such as inventories of sources and routine multimedia monitoring.

EPA Report: *Mercury Study Report to Congress*

The *Mercury Study Report to Congress (Report to Congress)* (EPA, 1997a) described the magnitude of mercury emissions in the United States, identified mercury emission sources, assessed the health and environmental implications of those emissions, and evaluated the availability and cost of technologies for emission control. It is the most comprehensive human health and environmental investigation of mercury and methylmercury available. The *Report to Congress* serves as the foundation for EPA's understanding of the risk assessment and risk management issues associated with mercury and methylmercury. It contributes significantly to the strategic directions and the key scientific questions posed in the *Mercury Research Strategy*.

In the *Report to Congress*, EPA concluded that a plausible link exists between human activities that release mercury from industrial and combustion sources in the United States and methylmercury concentrations in humans and wildlife. In preparing the report, EPA conducted a quantitative human health risk assessment of methylmercury. The assessment estimated that between one and three percent of women of childbearing age (*i.e.*, between the ages of 15 and 44 years) in the United States eat sufficient amounts of fish for their fetuses to be at risk from methylmercury exposure. The *Mercury Study Report to Congress* also concluded that mercury poses risks to various wildlife, including some birds and fur bearing mammals such as loons, mink, and otters. The *Report to Congress* comprehensively identified research needs to improve both mercury risk assessment and risk management.

NAS Report: *Toxicological Effects of Methylmercury*

The National Academy of Sciences (NAS) report on the *Toxicological Effects of Methylmercury* (NRC, 2000) confirmed EPA's Reference Dose (RfD) of 0.1 micrograms per kilogram of body weight per day. It viewed this RfD as a scientifically justifiable level for protecting human health from the adverse effects

of methylmercury. The NAS report estimated that more than 60,000 U.S. children are born each year with a risk of damaged nervous systems from methylmercury exposures in the womb. It also noted reduced performance on neuropsychological tests in recent epidemiological studies, suggesting that prenatal methylmercury exposure is likely to be associated with poorer school performance. The NAS report identified research needs related to: better characterization of methylmercury health effects, enhanced estimation of methylmercury dose-response relationships, and improved characterization of risk from current methylmercury exposures. Finally, the NAS report recommended that every effort be made to establish a common scientific basis for exposure guidance among federal agencies, recognizing that each is responsible under differing legal and regulatory authorities.

MERCURY IN THE ENVIRONMENT

As a liquid at room temperature, mercury is a unique metal that has proven itself useful for centuries in both industrial and consumer applications. Mercury is released in elemental and oxidized forms from a variety of human (i.e., anthropogenic) activities and natural sources. The *Mercury Study Report to Congress* (EPA, 1997a) found that the exposure pathway of greatest concern is that of fish consumption. This pathway is the one emphasized in the *Mercury Research Strategy* and involves the following: (1) emission of mercury to the air; (2) mercury air transport, transformation, and deposition on land and water; (3) transformation of mercury to methylmercury in water bodies; (4) methylmercury uptake and bioaccumulation in fish; and (5) consumption of contaminated fish by mammals, including humans. Mercury and methylmercury exposures can result in permanent damage to the brain and kidneys in both humans and wildlife.

The intentional use of mercury in products (e.g., batteries, paints) in the United States has decreased significantly in the past twenty years (Sznopce and Goonan, 2000). Since the 19th Century, however, the total amount of mercury in the environment has grown by a factor of two to five above pre-industrial levels (Mason, et. al., 1994). This situation raises concerns about increasing amounts of mercury in the global pool and the implications of mercury emissions and their impacts on both people and ecosystems worldwide. In the United States, the most significant releases of mercury to the environment are emissions to the air. These air emissions come from combustion sources, such as power plants or incinerators (mercury from human activities). Mercury is also released from geologically bound sources through natural processes (e.g., volcanos, fires) and through mass transfer to the atmosphere by biologic and geologic processes from mercury that has been previously deposited (i.e., re-emitted sources). In addition to air emissions, mercury is also released in other ways, including waterborne discharges and direct disposal to the land. The release of mercury to water and land are believed to be small compared to air emissions, but these releases can have significant local effects.

Depending on the chemical form in which it is released, the stack height of the source, air movement patterns, and other factors, mercury can deposit at local, regional and global scales.

- Locally, the 30-mile radius from some sources can have a relatively high percentage of mercury depositing on land and water.
- Regionally, different areas of the country experience different amounts of mercury deposition; the combined emissions of several mercury sources can travel hundreds of miles and deposit in other regions of the United States.
- Globally, mercury from other countries deposits in the United States, and U.S. emissions can travel around the world and then deposit back on U.S. soil and water.

Modeling by EPA concluded that the highest regional deposition rates from U.S. anthropogenic mercury sources occur in the southern Great Lakes and Ohio Valley, the Northeast, and scattered areas in the Southeastern United States (EPA, 1997a).

The particular form of mercury emitted is important in determining whether it is deposited near its emission source or travels great distances, perhaps circling the globe several times before eventually depositing. Mercury emissions from human activities are comprised of various inorganic forms, including elemental mercury vapor, gas-phase ionic mercury, and particulate-bound mercury. Once deposited in the environment, these inorganic forms can be converted by naturally occurring processes into the highly toxic organic form — methylmercury. The greatest concern regarding methylmercury is the neurotoxic health effects associated with in utero exposures. Children exposed after birth are potentially more sensitive to the toxic effects of methylmercury than adults because their nervous systems are still developing. Mercury also poses risks to wildlife, including some birds and mammals, such as loons, mink, and otters.

Mercury Research Strategy Goal

To provide information and data that reduce scientific uncertainties limiting the Agency's ability to assess and manage mercury and methylmercury risks.

MERCURY RESEARCH STRATEGY SCOPE

ORD's mercury research program provides information, methods, models and data to address the key scientific questions of greatest concern to EPA. The *Mercury Research Strategy* goal seeks to reduce scientific uncertainties related to mercury and methylmercury. The *MRS* presents the strategic directions for the mercury research program over the next five years. It will assist ORD in the development of a multi-year implementation plan and will help in making decisions about future mercury research priorities. The results of the research program will inform the Agency's Program Offices and Regions on their actions to assess and manage mercury and methylmercury risks. The *Mercury Research Strategy* is oriented to domestic mercury and methylmercury issues, although most of the research results will also be useful internationally. In preparing the *Mercury Research Strategy*, six key scientific questions, associated research areas, and related research needs were identified. While it is a five-year research strategy, the *MRS* will undergo updates and adjustments based on ORD's annual research planning process.

While the NAS report confirmed EPA's reference dose for methylmercury, additional data and information are needed to answer a number of key scientific questions on risk assessment and risk management of mercury and methylmercury. ORD's *Mercury Research Strategy* is part of the Agency's *Sound Science, Improved Understanding of Environmental Risk, and Greater Innovation to Address Environmental Problems Goal (Goal 8)*. Implementation of Goal 8 is the responsibility of EPA's Office of Research and Development under the Government Performance and Results Act (GPRA) (EPA, 2000b). Although assigned to Goal 8, ORD's mercury research program supports a number of other GPRA goals including those related to clean air, clean water, and safe waste management.

Mercury Research Strategy Research Areas

- Transport, Transformation, and Fate
- Risk Management for Combustion Sources
- Risk Management for Non-Combustion Sources
- Human Health Effects and Exposure
- Ecological Effects and Exposure
- Risk Communication

Setting Research Priorities

The *MRS* was developed by a group of EPA scientists and engineers representing ORD and the Agency's Program Offices and Regions. To draft the strategy, the group was divided into eight writing teams focusing on a number of different aspects of mercury and methylmercury risk assessment and risk management. The teams consulted a number of documents and individuals in preparing the *MRS*; the most influential was the *Mercury Study Report to Congress* which identified research needs across a number of areas. The writing teams developed six scientific questions formed around the research needs identified in the *Report to Congress* and from other sources, including the Agency's Mercury Task Force (MTF).

The writing teams established the research needs for each of the six key scientific questions. The MTF assisted in this effort by identifying the regulatory and voluntary drivers for mercury and methylmercury facing the Agency over the next five years. The writing teams integrated relevant international research issues into each research area. Research needs under each key scientific question were prioritized using three criteria. These criteria were: (1) provides timely scientific information and data needed to inform current and future Agency decisions on mercury, (2) fills data and information gaps on mercury not addressed by other organizations, and (3) supports the goals and objectives of ORD's Strategic Plan and research on risk assessment and risk management. Finally, an expert panel of ten external peer reviewers offered their individual and collective opinions of the draft *Mercury Research Strategy* and its priorities in December of 1999. Many of the recommendations made by the peer panel have been incorporated into this final version of the *MRS*.

Every attempt was made by the writing teams to strike a balance in terms of priorities across the six key scientific questions. The priorities described in the *MRS* are only a snapshot in time and may well require adjustment in the coming five years. Priorities can change depending on a number of factors including: progress in answering the key scientific questions, changes in regulatory deadlines, and research contributions by other organizations. These factors require that priorities and resource allocations be revisited on a year-to-year basis and that flexibility be a guiding principle in the annual budgeting process for the mercury research program.

In the near term, ORD plans to focus on combustion risk management. In the longer term, ORD will emphasize research that enhances the fundamental understanding of: non-combustion risk management, ecological effects and exposure, human health effects and exposure, and risk communication. Mercury fate and transport research will be a focus throughout the five-year time frame of the *MRS*. The *Mercury Research Strategy* is aligned with current EPA Program Office and Regional priorities and emphasizes mercury sources resulting from human activities in the United States. It does, however, recognize the global nature of the mercury problem and the need for addressing impacts in the United States from emissions generated by other nations. The *Mercury Research Strategy* is designed to be flexible and can accommodate redirections as a result of changing Agency priorities and perspectives.

TRANSPORT, TRANSFORMATION AND FATE RESEARCH AREA

Key Scientific Question

How much methylmercury in fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of mercury (such as natural sources, emissions from sources in other countries, and re-emissions from the global pool); how much and over what time period, will levels of methylmercury in fish in the U.S. decrease due to reductions in environmental releases from U.S. sources?

Prioritized Research Needs

- Improved understanding of the transport, transformation, and fate of mercury in the atmosphere
- Enhanced monitoring of atmospheric mercury deposition for model application
- Improved understanding of the transport, transformation, and fate of mercury in the aquatic and terrestrial media
- Enhanced monitoring of mercury and methylmercury in the aquatic and terrestrial media for improved risk management

Research on transport, transformation, and fate is highly supported throughout the life of the *Mercury Research Strategy*. Research needs in this area will take some time to fully address because the transport, transformation, and fate of mercury is so complex once it enters the environment. This research will allow for an improved understanding of mercury in air and water, and on land. As fundamental understanding is improved, this research will inform the development of more cost-effective risk management approaches for mercury and methylmercury.

RISK MANAGEMENT FOR COMBUSTION SOURCES RESEARCH AREA

Key Scientific Question

How much can mercury emissions from coal-fired utility boilers and other combustion systems be reduced with innovative mercury and multi-pollutant control technologies; what is the relative performance and cost of these new approaches compared to currently available technologies?

Prioritized Research Needs

- Improved understanding of managing mercury species in combustion processes
- Improved understanding of performance and cost of mercury emissions controls
- Increased testing and evaluation of mercury continuous emission monitors
- Improved characterization of, and management approaches for, mercury controls residuals

Research to manage risks from combustion sources addresses the most immediate mercury priority for the Agency and is highly supported during the first years of the *Mercury Research Strategy*. Combustion risk management research, including research on mercury in controls residuals, will provide the Agency with the latest information on control technology performance and cost. This research will result in data and information that informs the preparation of a regulatory proposal for controlling mercury emissions from coal-fired utilities.

RISK MANAGEMENT FOR NON-COMBUSTION SOURCES RESEARCH

Key Scientific Question

What is the magnitude of contributions of mercury releases from non-combustion sources; how can the most significant releases be minimized?

Prioritized Research Needs

- Characterization of the mercury life cycle in human activities
- Improved understanding of mercury releases from sources and sinks
- Approaches for minimizing mercury releases from non-combustion sources

Research to manage risks from non-combustion sources is modestly supported in the early years of the *Mercury Research Strategy*. Work in this area then increases as the need for risk management research on coal-fired utilities declines and other sources of mercury releases come to the fore. Initial activities will focus on characterizing sources and identifying alternatives to mercury-containing waste incineration. Work in later years will address pollution prevention, source control, stockpile retirement, and remediation of contaminated media. With thorough source characterization, this research will focus on mercury sources posing the greatest risks to both humans and wildlife. This research will provide information to support future assessments, rulemaking, and voluntary actions across the Agency.

ECOLOGICAL EFFECTS AND EXPOSURE RESEARCH

Key Scientific Question

What are the risks associated with methylmercury exposure to wildlife species and other significant ecological receptors?

Prioritized Research Needs

- Improved understanding of methylmercury toxicity effects on avian and mammalian wildlife
- Refined ecological assessments for avian and mammalian wildlife risks
- Improved understanding of ecological impacts of methylmercury on avian and mammalian wildlife
- Improved understanding of ecological impacts of methylmercury on non-avian and non-mammalian species
- Identification of interactions among methylmercury with other chemical and non-chemical stressors on all ecological receptors

The effects of methylmercury on ecological systems have been demonstrated, but there is a need to learn more about these effects, particularly with respect to fish-eating wildlife. Support for this research area gradually increases over the life of the *Mercury Research Strategy*. This research will assist the Agency in understanding the effects and exposures of mercury and methylmercury on birds, fur-bearing mammals, and other forms of animal life. This research will also assist in the development of improved ecological assessments.

HUMAN HEALTH EFFECTS AND EXPOSURE RESEARCH

Key Scientific Question

What critical changes in human health are associated with exposure to environmental sources of methylmercury in the most susceptible human population; how much methylmercury are humans exposed to, particularly women of child-bearing age and children among highly-exposed population groups; what is the magnitude of uncertainty and variability of mercury and methylmercury toxicokinetics in children?

Prioritized Research Needs

- Improved understanding of mechanisms of developmental neurotoxicity from methylmercury
- Improved understanding of persistent and delayed neurotoxicity resulting from developmental exposures to methylmercury
- Identification of impacts from aggregate exposures and synergistic effects of methylmercury and other pollutants
- Improved understanding of the modulation of immune system response from methylmercury exposure
- Improved understanding of the effects on cardiovascular function as a result of methylmercury exposure
- Biological monitoring for model development and improvement
- Development of toxicokinetic data on methylmercury tissue distribution

The National Academy of Sciences (NAS) report on the health effects of methylmercury supported EPA's reference dose (RfD) of 0.1 micrograms per kilogram body weight per day as a scientifically-justified level to protect human health. There remain, however, questions that need to be answered. Research in this area is supported at a relatively modest, but consistent, level throughout the life of the *Mercury Research Strategy*. There is a continuing need for ORD to provide scientific and technical assistance to the Agency in developing regulations and criteria based on the NAS-supported RfD.

RISK COMMUNICATION RESEARCH

Key Scientific Question

What are the most effective means for informing susceptible populations of the health risks posed by mercury and methylmercury contamination of fish and seafood?

Prioritized Research Needs

- Synchronization of fish consumption advisory messages for methylmercury
- Improved understanding of exposure patterns in targeting of risk messages
- Understanding the use of risk information in making decisions about methylmercury exposures

Research on improved communication to populations at risk from eating fish contaminated with methylmercury is supported at a relatively modest, but consistent, level over the life of the *Mercury Research Strategy*. Research in this area will help the Agency in developing improved risk communication approaches targeted at populations that consume large quantities of fish. One of the most challenging populations will be those individuals at greater risk due to possible nervous system damage such as the maternal-fetal pair, nursing mother-infant pair, and young children. This research area as one that is particularly amenable to collaborations with other organizations.

MERCURY RESEARCH STRATEGY IMPLEMENTATION

A number of groups, both internal and external to EPA, have a stake in the *Mercury Research Strategy* and its implementation over the next five years. These groups are particularly interested in research program sequencing and timing in order to determine whether they are consistent with their needs, interests, and with Agency target dates for regulatory and voluntary actions. The *MRS* is designed to provide broad strategic directions for ORD's mercury research program, not schedules and time lines. More specific information will be forthcoming in ORD's multi-year implementation plan to be developed in FY 2001.

The *Mercury Research Strategy* encourages engagement and partnering with various stakeholders. ORD believes that joint ventures enhance the Agency's own mercury research program, as well as other mercury research efforts either planned or underway in the United States. It wants to strengthen research collaborations with the regulated community and other interested entities and gain their participation in mutually beneficial mercury research. ORD is seeking linkages to federal agencies, States, communities, tribes, and other public and private organizations in order to gather insights from decision makers at various levels. Of particular interest are their mercury research needs and the actions they expect to take in both assessing and managing mercury risks. ORD welcomes input from any organization concerning the *Mercury Research Strategy* and the mercury research program described herein.